

ASSESSING THE COMPLIANCE STATUS OF LANDFILLS IN TÜRKİYE
WITH LEGAL REQUIREMENTS AND BEST AVAILABLE TECHNIQUES

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

ASSESSING THE COMPLIANCE STATUS OF LANDFILLS IN TÜRKİYE WITH LEGAL REQUIREMENTS AND BEST AVAILABLE TECHNIQUES

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Integrated pollution prevention and control, abbreviated as “IPPC”, is a European approach to reducing pollution from different industrial activities. In the EU Member States, the main legal means of controlling industrial emissions with this approach is the Industrial Emissions Directive (IED) of the European Council (2010/75/EU). The IED that aims to protect human health and the environment from adverse effects of industrial emissions, requires industrial installations including waste treatment plants to comply with the best available techniques (BATs) to control their emissions. In addition to controlling emissions, IED cover industrial processes from many other aspects such as environmental performance, raw material consumption, energy efficiency, and accident prevention. As part of the harmonization efforts with the EU legislation, the Turkish Ministry of Environment, Urbanization, and Climate Change (MoEUCC) has published the draft IPPC Regulation in 2018. Since then, the MoEUCC has made considerable progress in harmonizing and implementing the IED and launched the IPPC-WASTE (EKOK-ATIK) Project in 2020 that aims the status of waste treatment facilities regarding the IED compliance. This thesis carried out within the scope of the IPPC-WASTE project aims to investigate the compliance status of landfill facilities falling under the IED with the IED and BATs and reveal

compliance requirements. For this purpose, field studies were carried out at 4 landfills and online surveys were conducted with 12 landfills. Based the information gathered, in addition to the IED compliance status of landfills, their compliance with the Turkish Regulation on Landfilling of Waste and additional BATs applicable to landfills were also assessed. The IED and BAT compliance data was then used for the evaluation of the possible costs for full compliance with the IED and additional BATs. The overall IED compliance level of landfill facilities covered by the IED was calculated as over 75%. The total investment needed for full compliance of all the landfills covered by the IED and the average investment needed per landfill facility was estimated as 193,375,488 Euros, and 8,057,312 Euros, respectively. The results of the study are expected to be a reference point for decision makers who will develop policy options that can promote sectoral alignment with the IED.

Keywords: IED, IPPC, Best Available Techniques, Landfill, BAT Compliance

ÖZ

TÜRKİYE'DEKİ DÜZENLİ DEPOLAMA SAHALARININ YASAL GEREKSİNİMLERE VE MEVCUT EN İYİ TEKNİKLERE UYUM DURUMUNUN DEĞERLENDİRİLMESİ

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EKÖK olarak kısaltılan Entegre Kirlilik Önleme ve Kontrol, farklı endüstriyel faaliyetlerden kaynaklanan kirliliğin azaltılmasına yönelik bir Avrupa yaklaşımıdır. AB Üye Devletlerinde, bu yaklaşımla endüstriyel emisyonları kontrol etmenin ana yasal yolu, Avrupa Konseyi'nin Endüstriyel Emisyonlar Direktifi (2010/75/EU) (EED)'dir. İnsan sağlığını ve çevreyi endüstriyel emisyonların olumsuz etkilerinden korumayı amaçlayan EED, atık işleme tesisleri de dahil olmak üzere endüstriyel tesislerin emisyonlarını kontrol etmek için mevcut en iyi tekniklere (MET'ler) uyulmasını şart koşmaktadır. EED, emisyonları kontrol etmenin yanı sıra, endüstriyel süreçleri çevresel performans, ham madde tüketimi, enerji verimliliği ve kaza önleme gibi birçok yönden ele almaktadır. AB mevzuatına uyum çalışmalarının bir parçası olarak, Türkiye Cumhuriyeti Çevre, Şehircilik ve İklim Değişikliği Bakanlığı (ÇŞİDB), 2018 yılında taslak EKÖK Yönetmeliğini yayınlamıştır. O zamandan bu yana, ÇŞİDB, EED'nin uyumlaştırılması ve uygulanması konusunda önemli ilerleme kaydetmiştir ve atık işleme tesislerinin EED uyum durumunu hedefleyen EKOK-ATIK projesini 2020 yılında hayata geçirmiştir. EKOK-ATIK

projesi kapsamında yürütülen bu tez, depolama tesislerinin EED'ne uyum durumun araştırılmasını ve uyum gereksinimlerinin ortaya konması amaçlanmaktadır. Bu amaçla 4 adet düzenli depolama sahasında saha çalışması ve 12 adet düzenli depolama sahasında online anket çalışması yapılmıştır. Toplanan bilgilere dayanarak, depolama sahalarının MET uyum durumu ve MET'lere tam uyum için olası maliyetler, düzenli depolama için geçerli tüm MET'leri kapsayan bir MET kontrol listesi kullanılarak belirlenmiştir. EED kapsamındaki düzenli depolama tesislerinin genel MET uyum düzeyi %75'in üzerinde olarak hesaplanmıştır. EED kapsamındaki tüm düzenli depolama sahalarının tam uyumluluğu için gereken toplam yatırım maliyeti ve düzenli depolama tesisi başına ihtiyaç duyulan ortalama yatırım maliyeti sırasıyla 193.375.488 Euro ve 8.057.312 Euro olarak bulunmuştur. Bu çalışmanın sonuçlarının, EED ile sektörel uyumu teşvik edebilecek politika seçenekleri geliştirecek karar vericiler için bir referans noktası olması beklenmektedir.

Anahtar Kelimeler: EED, EKÖK, Mevcut En İyi Teknikler, Düzenli Atık Depolama Sahaları, MET Uyumu



To my family

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LIST OF ABBREVIATIONS

ABBREVIATIONS

BAT	Best Available Technique
BATAELs	Emission Levels Associated with the BATs
BREF	BAT Reference Document
CAPEX	Capital Expenditures
EPA	Environmental Protection Agency
EU	European Union
IED	Industrial Emissions Directive
IPPC	Integrated Pollution Prevention and Control
IPPC-WASTE or EKÖK- ATIK Project	The Evaluation of Waste Processing Facilities within the Scope of Integrated Pollution Prevention and Control, Investigation of Compliance Status and Development of Adaptation Requirement Models Project
LD	Council Directive on the Landfill of Waste (1999/31/EC)
MoEUCC	Ministry of Environment, Urbanization and Climate Change
RoLW	Regulation on Landfilling of Waste
USEPA	United States Environmental Protection Agency
WT	Waste Treatment

CHAPTER 1

INTRODUCTION

The Council Directive 96/61/EC on Integrated Pollution Prevention and Control, commonly known as the 'IPPC Directive' came into force by the European Union (EU) Council of Ministers in 1996. The goal of the directive is to accomplish integrated pollution prevention and control of pollution arising from the industrial activities described in Annex I of the Directive (see Appendix A). The Directive governs around 50,000 installations in the EU dealing with a variety of industrial and agricultural operations.

The IPPC Directive includes general guidelines defining the fundamental responsibilities of industrial installation administrators stating the need for “establishing a general framework for the control of the main industrial activities, giving priority to intervention at source, ensuring prudent management of natural resources and taking into account, when necessary, the economic situation and specific local characteristics of the place in which the industrial activity is taking place”. The term “integrated”, refers to taking into account “the whole environmental performance of an industrial plant covering emissions to air, water and land, generation of waste, use of raw materials, energy efficiency, noise, prevention of accidents, and restoration of the site upon closure”. The IPPC Directive further indicates the need for using the ‘polluter pays’ principle and the principle of ‘pollution prevention’ for the control of pollution arising from industrial activities. This pollution can be caused by substances, temperature, vibration, noise, or human activities. Pollution can be dangerous for environmental receptors such as water, air, and soil, as well as harm human health (Wicks, 1998).

According to the Directive, facilities must implement measures to prevent negative environmental impacts resulting from their activities. Facilities should apply cleaner

technologies taking into account resource efficiency, energy use, and water reuse minimizing waste generation and ensuring waste recovery where possible. Techniques should be applied to prevent and reduce the negative effects that may occur in waste disposal. In addition, industrial facilities should pay attention to taking measures to prevent accidents. The IPPC Directive is a pioneer in these areas, focusing on different concerns such as energy, waste minimization, reuse and recycling, and raw material utilization. The Directive aims to promote not only environmental benefits but also improved business efficiencies (O'Malley, 1999).

In 2010, the EC amended the IPPC Directive casting six other directives¹ and published the Industrial Emissions Directive (2010/75/EU, IED) (Vazquez Calvo, Giner-Santonja, Alonso-Farinas, & Morillo Aguado, 2021). According to the IED, industrial and agricultural facilities with significant pollution potential should only be operated if the operator obtains a permit that is linked to BAT conclusions. “BATs” refer to the technology and organizational measures that are most successful at providing the overall protection of environmental receptors, such as air, water, and soil, and that can be implemented under economically and technically viable conditions (Huybrechts, Derden, Van den Abeele, Vander Aa, & Smets, 2018).

BATs have an important role in increasing industrial sustainability in terms of energy and resource efficiency, pollution management, and financial benefits. When assessed separately, the term of "techniques" refers to technology applied and the manner in which the installation is designed, constructed, maintained, operated, and decommissioned, while the term of "available" techniques means established methods on a scale that enables an application in the industrial sector, under

¹ Directive 78/176/EEC of 20 February 1978 on waste from the titanium dioxide industry; Directive 82/883/EEC on the surveillance and monitoring of titanium dioxide waste; Directive 92/112/EEC on the reduction of titanium dioxide industrial waste; Directive 1999/13/EC on reducing emissions of volatile organic compounds; Directive 2000/76/EC on waste incineration (Waste Incineration Directive); Directive 2001/80/EC on the limitation of emissions of certain pollutants from large combustion plants (LCP Directive)

technically and financially viable conditions. In addition, the term of "best" techniques represents the most efficient technique to reach a high general level of protection of the environment in an integrated way (Vazquez Calvo, Giner-Santonja, Alonso-Farinas, & Morillo Aguado, 2021).

The Directive covers six main industrial sectors which are waste management, chemical industry, metal industry, energy production, mineral industry, and other operations such as pulp and paper production, textile production, and agricultural activities, etc (see Appendix A). The Directive explains various negative environmental impacts arising from these industrial activities. These adverse impacts include emissions to water, air, and soil, as well as issues such as the generation and disposal of waste, site contamination, energy use, and efficiency (O'Malley, 1999).

Both the IED and its former version; the IPPC Directive, require the adaptation of BAT reference documents (called as BREFs) to identify BATs and the level of emissions from industrial activities on a sectoral basis. BREFs are drawn up through an exchange of information with stakeholders and contain the key elements of BAT conclusions. Up to now, the European Commission adopted 32 BREFs (EC, European Commission, 2023). Three of these 32 BREFs are horizontal BREFs and address cross-sectoral challenges such as cooling, storage, and energy efficiency. The other 29 BREFs as vertical BREFs each correspond to a different industrial or agricultural activity. The BREF for waste treatment activities is among the vertical BREFs and covers almost all waste treatment activities but landfilling (Pinasseau, Zerger, Roth, Canova, & Roudier, 2018).

The BREF documents cover applicable techniques, current emissions and consumption levels, methodologies followed in BAT determination, and "BAT Conclusions". The BAT Conclusions parts of the BREFs, determined in Commission Implementing Decisions within the IED (Huybrechts, Derden, Van den Abeele, Vander Aa, & Smets, 2018) and published as Commission Decisions are the final evaluations of BATs. They include BATs and their descriptions along with an assessment of their appropriate application; emission levels associated with the

BATs (BATAELs); relevant monitoring requirements; resource/raw material consumption levels; and if relevant, site remediation measures (SEPA, 2023). The number of BAT Conclusions published so far is 20 and one of these BAT Conclusions is for the waste sector entitled “Best Available Techniques (BAT) Conclusions for Waste Treatment”².

The Turkish National Action Plan for EU Accession Phase-II (June 2015-June 2019) stated that the industrial pollution sub-sector is crucial for transposing the EU acquis in the field of industrial pollution control. The MoEUCC is the responsible body for the harmonization of the IED with national legislation. To this end, the MoEUCC published a draft regulation entitled “Regulation on Integrated Pollution Prevention and Control (IPPC)” in 2018. According to this draft legislation; the industrial installations falling under the IED are required to obtain an IPPC permit from the Ministry complying with the sectoral communiqués that are to be prepared in line with the BAT Conclusions.

In 2020, the MoEUCC started a 2-year project entitled in short “the IPPC-Waste Project” that aims to increase the technical and institutional capacity of the Ministry for the effective implementation of an IPPC approach in the Turkish waste management sector, in line with the EU IED. The specific aim was to determine the current IED compliance status and the waste management industry’s needs to meet the IED requirements. The main activities involved in the Project were as follows;

- The revision of the inventory of waste management installations falling under the IED,
- The IED compliance assessment for the waste management sector, determination of the compliance status of the waste management installations with the IED requirements,

² COMMISSION IMPLEMENTING DECISION (EU) 2018/1147 of 10 August 2018 establishing best available techniques (BAT) conclusions for waste treatment, under Directive 2010/75/EU of the European Parliament and of the Council.

- The preparation of compliance reports for each sub-sector in the waste management industry and the estimation of the compliance gap,
- The compliance cost estimation that considers the compliance gap and the unit costs. (The compliance costs will consist of substantive compliance costs and administrative costs for business),
- The expected compliance period for waste management installations,
- The preparation of an action plan concerning the compliance of the waste management sector with the IED,
- The preparation of draft sectoral legislation (two draft communiques, corresponding to the EU's BAT Conclusions for waste treatment³ and waste incineration⁴ sectors) which include BATs, sectoral emission limit values, general binding rules, etc.

1.1 Aim of the Study

This thesis study was conducted as a part of the above-mentioned IPPC-WASTE Project and aimed to evaluate the current implementation status of the IED in landfills in Türkiye as well as the compliance of landfills with the major piece of EU legislation, the Directive Council Directive on the Landfill of Waste (LD, 1999/31/EC).

As the Turkish Regulation on Landfilling of Waste (RoLW) (Official Gazette dated 26/03/2010 and numbered 27533) was prepared within the framework of the transposition of the LD into national legislation, and includes a significant part of the provisions of the LD Directive, the LD compliance assessment also corresponds to the RoLW compliance assessment.

³ COMMISSION IMPLEMENTING DECISION (EU) 2018/1147 of 10 August 2018

⁴ COMMISSION IMPLEMENTING DECISION (EU) 2019/2010 of 12 November 2019

1.2 Objectives and Scope of the Study

The objectives of this study are:

- To determine the current level of IED or BAT compliance status of landfills in Türkiye,
- To determine the current level of LD (1999/31/EC) (and also RoLW), compliance of the landfills,
- To assess their needs to make them fully compliant with the LD and BATs,
- To estimate the overall costs of full compliance with the LD and the IED considering the present compliance level.
- To determine the extent to which landfill operators find the BATs and the LD compatible.

In the first part of the thesis, a checklist that included operational requirements⁵ taken from the LD (1999/31/EC) and BATs taken from “BAT Guidance Note on BATs for the Waste Sector: Landfill Activities” published by the Environmental Protection Agency (EPA) of Ireland was prepared and used for compliance assessment. This document published by the EPA of Ireland is the only BAT guidance document for landfill activities published by an EU member state. Although landfilling is a waste management activity, it is not included in the WT BREF; therefore no BATs relevant to the WT BREF exist in the checklist.

The BAT Checklist prepared was shared with all the landfills falling under the IED for the collection of data regarding their IED and LD compliance and also the cost of compliance via a web-based survey. In addition to the survey, a number of field study visits were made to the selected landfills for the collection of more realistic data on the level of compliance of the landfills in Türkiye with the IED and LD and also the cost of compliance with the IED and LD. As the provisions of the RoLW

⁵ In the thesis, the term “technique” is used to express each operational requirement of the LD.

overlap with the BATs and techniques listed in the BAT Checklist, the compliance assessment was extended to the RoLW as well.

The second part of the study includes analyzing whether BATs and techniques are found applicable by facilities. At this stage, in line with the information taken from the facilities, it was found whether the BATs and techniques are applicable in the conditions of Türkiye.

Finally, the third part of the study included a sectoral cost analysis for the facilities to implement BAT and the techniques that they do not fully apply. In this part of the study, cost of compliance data gathered from the sector itself or the literature was used and the cost of compliance at the national level was estimated.

According to the IED, a landfill that accepts more than 10 tons of waste per day or has a total capacity of more than 25,000 tons is covered by the Directive. However, landfills that accept only inert wastes are not considered in the scope of the IED. According to the inventory carried out within the scope of the IPPC-Waste Project, in Türkiye, 24 landfill facilities meet these criteria. Although the present thesis study aimed to cover all of these 24 landfills, it was possible to cover 16 landfills that accepted to participate in the IPPC-Waste Project. A sample size of 16 landfills was considered to be big enough to give statistically valid data on the IED and LD compliance of the entire population of 24 landfills.

Within the context of this thesis, Chapter 1 presents the overall objective and scope of the thesis. Chapter 2 provides general information on the IED, the BATs and techniques that are addressed to assess the IED and LD compliance of the landfills in Türkiye, and the IPPC-WASTE Project. In Chapter 3, the methodology followed in the study and the preparation of the BAT Checklist that is used as the main instrument for the collection of data is described. Chapter 4 presents the results of the data analysis; a discussion of the compliance status of the landfills with the LD and BATs, the applicability of BATs/techniques, and, compliance costs for the implementation of BATs and techniques. In Chapter 5, the overall outcomes of the study are summarized and recommendations for future research are given.

CHAPTER 2

LITERATURE REVIEW

2.1 Landfills and Their Environmental Impacts

Waste generation has increased significantly as a result of economic developments and urbanization with the rise in population in the world. In this context, waste management has become an important issue (Tenodi, et al., 2020). Waste disposal is also a significant part of this waste management process (Cudjoe & Han, 2021). Landfilling, which is one of the cheapest and thus the most common methods of waste disposal, is highly preferred all over the world. 70% of the waste in the world is disposed of in landfills. When looking at developing countries, it is seen that this rate is more than 90% (Shi, et al., 2021).

2.1.1 Basic Information about Landfills

Landfills are engineered waste disposal sites where wastes are deposited for final disposal and covered. They are designed and operated to protect the environment against contaminants that might be present in the waste stream.

Landfills are typically divided into three; landfills for hazardous waste, landfills for non-hazardous waste, and landfills for inert waste. Landfills for hazardous waste are specifically for the disposal of hazardous waste. These landfills are not used for the disposal of municipal solid waste. For the disposal of municipal solid waste, non-hazardous waste landfills that are designed specifically to receive household wastes are used. Inert waste landfills can accept wastes that do not undergo any significant decomposition naturally.

Landfills are built taking severe precautions concerning the protection of the groundwater and underlying soil over which they are located. They are lined to ensure that there will be no untreated emissions to the environment and leachate and landfill gas should be collected and treated properly.

The main components in a landfill are the bottom liner, intermediate covers, and final cover as well as the leachate and gas management systems (see Figure 2.1). Bottom liners are used to avoid the transportation of leachate from the landfill to the underlying soil. As bottom liners, geomembranes and/or natural materials having low permeability are preferred. Landfills are constructed to have single, composite, or double liners based on the geology of the site and the environmental requirements of the facility. For example, composite liners may be preferred to have higher protection in landfills where both leachate and gas must be managed. In this regard, geosynthetic liners and clay liners can be used together. On the other hand, if there is no contamination risk to groundwater, only a compressed clay liner can be applied (Danthurebandara, 2015).

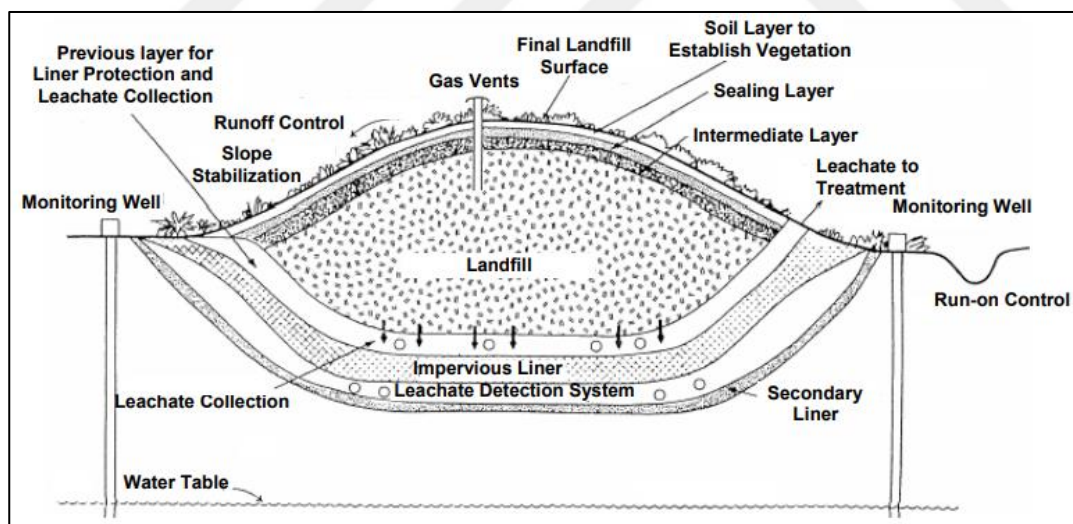


Figure 2.1 Cross Section of Landfill (Qrenawi, 2006)

To collect the leachate, the landfill base is made in a sloped structure. In addition to this sloped structure, collection pipes are positioned at the bottom. The collected leachate is transferred to the treatment system or it can be directed to the landfill

surface for reapplication. In addition, a piping system is built for the gas collection as well. This system is connected to horizontal or vertical collection wells that remove the landfill gas with the vacuum generated by a central blower (Danthurebandara, 2015).

During the operation of landfills, an intermediate cover layer is applied to minimize the surface infiltration into landfills. Many various materials are preferred as intermediate cover layers. Materials such as native soils, geomembrane, synthetic foam, construction waste, and composted solid waste can be used for this purpose (Danthurebandara, 2015).

A final cover is applied when the landfill is filled. The purpose of this final cover is to reduce the infiltration of rainwater and minimize the spreading of waste. This final cover that is located at the top of the landfill has different layers within itself. Firstly, there is a gas management layer and a hydraulic barrier above the gas management layer. On these two layers, there is a filler and drainage layer. Finally, the soil and vegetation layers are placed at the top of the landfill (Danthurebandara, 2015).

2.1.2 Environmental Impacts of Landfills

Although landfills have advantages such as being economical and simple to manage, if they are not managed properly, they can cause many adverse environmental impacts. Most of the adverse effects are due to leachate formation and its improper management. Water from precipitation can be added to the water formed by the decomposition of organic materials in the landfill. Also, the free water in waste and infiltrated groundwater can be a part of this liquid mixture. As a result of the combination of all these components, leachate occurs. Leachate has significant effects on surface water and groundwater. According to the research of the United States Environmental Protection Agency (USEPA), 75% of the landfills in the USA lead to pollution in the groundwater. In the rest of the world, leachate damages groundwater at similar rates (Shi, et al., 2021). Leachate is a liquid that contains

inorganic compounds such as metals and sulfates but also contains organic substances such as volatile fatty acids. In addition to these, there are also microorganisms in the leachate. When not properly controlled, it disrupts the ecological balance by decreasing the quality of surface water, groundwater, and soil. In order to prevent possible adverse effects, leachate should be collected and treated appropriately (Tenodi, et al., 2020).

In landfills, apart from leachate formation, there is also landfill gas formation. This gas causes serious environmental effects by containing substances such as carbon dioxide, methane, carbon monoxide, and hydrogen sulfide (Tenodi, et al., 2020). Factors such as waste components, temperature, oxygen, and humidity are effective in the formation of landfill gas, which is formed as a result of the exposure of organic components in solid waste to biological and chemical reactions (Cudjoe & Han, 2021).

The diagram showing the landfill activities and emission sources is given in Figure 2.2.

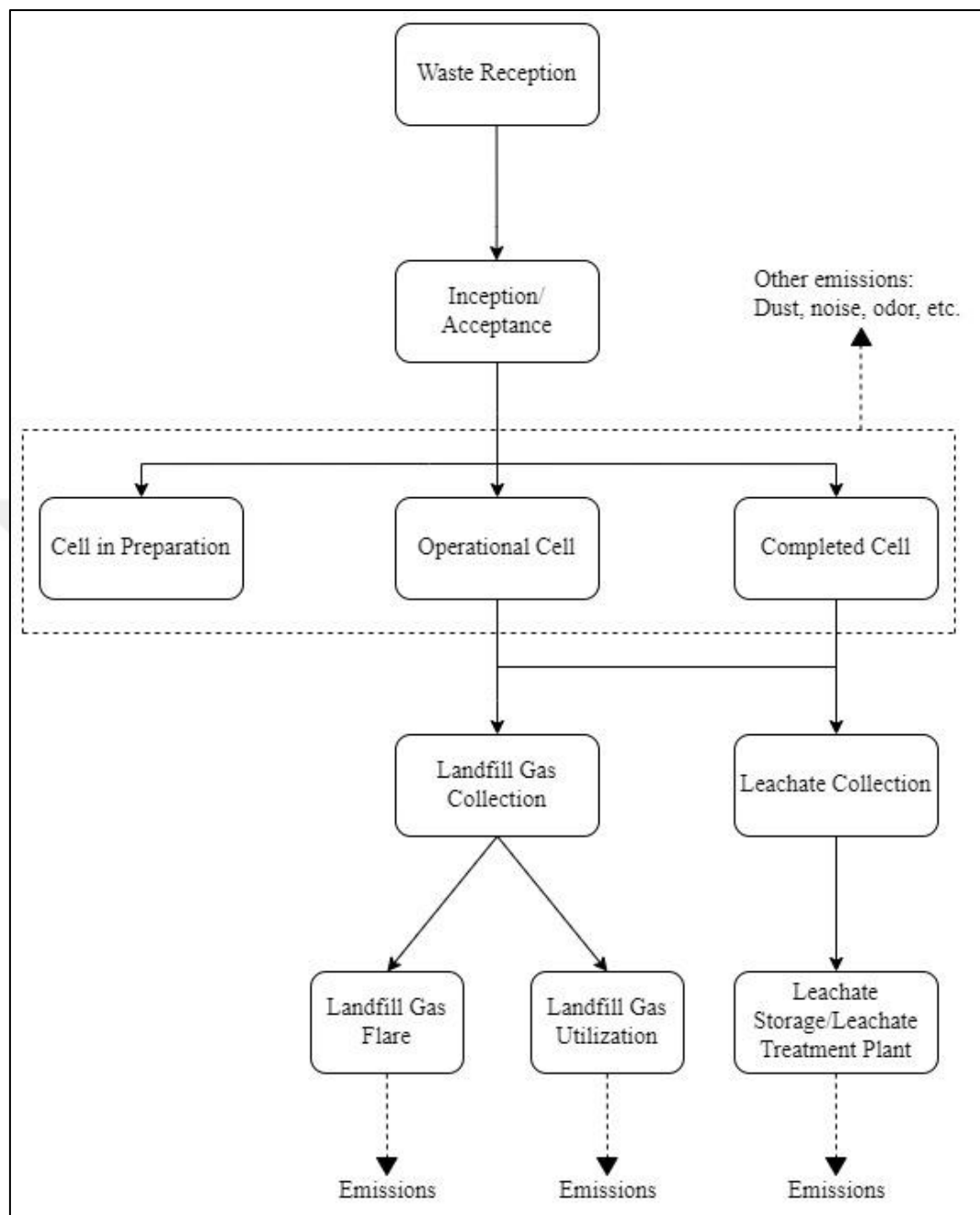


Figure 2.2 The Landfill Activities and Emission Sources (Environmental Protection Agency, EPA, 2011).

2.2 Industrial Emissions Directive (IED) and the Waste Management Sector

As a protective aim, cleaner production is an approach that focuses on avoiding generating emissions and wastes at the industrial level and preventing excess resource consumption. In recent years, there have been new approaches that have gained importance with this perspective. In addition to pollution control, pollution prevention has become very significant. Within this respect, in particular, EU countries have conducted regulatory studies on this issue. Thus, in the EU, the IPPC Directive was published in 1996 (Şimşek, Demirel, Öztürk, & Kitis, 2022).

The purpose of the IPPC Directive is to approach pollution control in an integrated way. That is, preventing air, water, and soil emissions is its primary goal. Waste management plays an essential role in this context. According to the directive, where emissions cannot be reduced, it aims to minimize them as much as possible, thus creating a minimal environmental impact. As a result, the IPPC Directive is the general framework for controlling and preventing pollution from many industrial activities in an integrated way and providing sustainable development. The mentioned industrial activities include sectors such as metals, leather, paper, and chemicals, as well as the waste management sector (Ramos Peralonso, 2022).

After the IPPC Directive was published, the transposition of the directive into the national legislation of the EU member states continued until 30 October 1999. As a result of several amendments, it was issued in 2010 as the IED (2010/75/EU) (Ramos Peralonso, 2022).

The IED has become a directive that includes six directives in addition to the IPPC Directive. These other directives cover the titanium dioxide industry (96/61/EC, 82/883/EEC, 78/176/EEC), volatile organic compounds (1999/13/EC), large combustion plants (2001/80/EC), and waste incineration (2000/76/EC) (Ramos Peralonso, 2022).

The main pillars of the IED are as follows:

1. The integrated approach: “The IED permits must take the whole environmental performance of the plant, covering e.g. emissions to air, water and land, generation of waste, use of raw materials, energy efficiency, noise, prevention of accidents, and restoration of the site upon closure.”

2. Best Available Techniques: “The permit conditions including emission limit values must be based on the BAT.”

3. Flexibility: “The IED allows competent authorities some flexibility to set less strict emission limit values. This is possible only in specific cases where an assessment shows that achieving the emission levels associated with BAT described in the BAT conclusions would lead to disproportionately higher costs compared to the environmental benefits due to the geographical location or the local environmental conditions or the technical characteristics of the installation.”

4. Inspections: “Member States shall set up a system of environmental inspections and draw up inspection plans accordingly. The IED requires a site visit to take place at least every 1 to 3 years, using risk-based criteria.”

5. Public Participation: “The IED ensures that the public has a right to participate in the decision-making process, and to be informed of its consequences, by having access to permit applications, permits and the results of the monitoring of releases.”

The IED includes various regulations for the control and prevention of industrial pollution. As the IPPC Directive, it covers rules for preventing and reducing air, water, and soil emissions with a holistic approach. There are also other approaches for environmental protection that aim to control emissions to air, water, and soil separately. However, such methods may cause undesirable results, such as the transfer of pollution to another environment. Therefore, it is environmentally better to assess and address pollution in an integrated way. In addition, this method

contributes to providing energy efficiency and sustainability (European Union, EU, 2010). In this context, the IED focuses on preventing pollution at its source by using BATs. According to the Directive, all industrial facilities have to apply BATs that are applicable to their circumstances (Cui, Yang, Shi, Liu, & Wang, 2022).

2.2.1 Waste Management Activities Covered by the IED

According to the IED, industrial facilities must take the necessary precautions regarding pollution and apply appropriate BATs. These facilities should not cause significant pollution. Also, they should prevent waste generation and use energy efficiently. In addition, industrial activities should be carried out carefully to prevent accidents. The mentioned industrial activities are listed in Annex I of the IED (see Appendix A). These industrial activities include some waste treatment and waste disposal activities in the waste management sector. Waste treatment activities falling under the IED are given in Table 2.1.

Table 2.1 Waste Treatment Activities Covered by the IED (European Parliament, 2010).

Categorization Number in Annex I of IED	Waste Treatment Activity
5	Waste management
5.1	Disposal or recovery of hazardous waste with a capacity exceeding 10 tonnes per day involving one or more of the following activities:
5.1 (a)	Biological treatment
5.1 (b)	Physico-chemical treatment
5.1 (c)	Blending or mixing prior to submission to any of the other activities listed in points 5.1 and 5.2
5.1 (d)	Repackaging prior to submission to any of the other activities listed in points 5.1 and 5.2

Table 2.1 (cont'd)

Categorization Number in Annex I of IED	Waste Treatment Activity
5.1 (e)	Solvent reclamation/regeneration
5.1 (f)	Recycling/reclamation of inorganic materials other than metals or metal compounds
5.1 (g)	Regeneration of acids or bases
5.1 (h)	Recovery of components used for pollution abatement
5.1 (i)	Recovery of components from catalysts
5.1 (j)	Oil re-refining or other reuses of oil
5.1 (k)	Surface impoundment
5.2	Disposal or recovery of waste in waste incineration plants or in waste co-incineration plants
5.2 (a)	For non-hazardous waste with a capacity exceeding 3 tonnes per hour
5.2 (b)	For hazardous waste with a capacity exceeding 10 tonnes per day
5.3 (a)	Disposal of non-hazardous waste with a capacity exceeding 50 tonnes per day involving one or more of the following activities, and excluding activities covered by Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment
5.3 (a) (i)	Biological treatment
5.3 (a) (ii)	Physico-chemical treatment
5.3 (a) (iii)	Pre-treatment of waste for incineration or co-incineration
5.3 (a) (iv)	Treatment of slags and ashes
5.3 (a) (v)	Treatment in shredders of metal waste, including waste electrical and electronic equipment and end-of-life vehicles and their components

Table 2.1 (cont'd)

Categorization Number in Annex I of IED	Waste Treatment Activity
5.3 (b)	Recovery, or a mix of recovery and disposal, of non-hazardous waste with a capacity exceeding 75 tonnes per day involving one or more of the following activities, and excluding activities covered by Directive 91/271/EEC:
5.3 (b) (i)	Biological treatment
5.3 (b) (ii)	Pre-treatment of waste for incineration or co-incineration
5.3 (b) (iii)	Treatment of slags and ashes;
5.3 (b) (iv)	Treatment in shredders of metal waste, including waste electrical and electronic equipment and end-of-life vehicles and their components.
5.4	Landfills, as defined in Article 2(g) of Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste, receiving more than 10 tonnes of waste per day or with a total capacity exceeding 25 000 tonnes, excluding landfills of inert waste
5.5	Temporary storage of hazardous waste not covered under point 5.4 pending any of the activities listed in points 5.1, 5.2, 5.4, and 5.6 with a total capacity exceeding 50 tonnes, excluding temporary storage, pending collection, on the site where the waste is generated
5.6	Underground storage of hazardous waste with a total capacity exceeding 50 tonnes

2.2.2 Waste Treatment BREF and Best Available Techniques (BATs)

Best Available Techniques, abbreviated as BATs, are the industrial methods created by improving the methods used in the installations and helping to decrease the effects of emissions on the environment. BATs also provide a basis for emission limit values in this context (Ramos Peralonso, 2022).

"Best" refers to the methods in which the environment is most effectively protected with a holistic approach. "Available techniques" refers to the most applicable methods developed in industrial sectors, depending on the economic and technical conditions of the facilities. While assessing applicability, considerations such as cost and usage advantages are taken into account. 'Techniques' refers to the methods applied at every stage of the facility, from the design stage to the operation and decommissioning stage, in addition to the technology used in installations (Ramos Peralonso, 2022).

According to the IED, all industrial facilities must adopt BATs based on their technology and economic status and comply with the emission limits defined in the BREF documents (Cui, Yang, Shi, Liu, & Wang, 2022). BREFs are the documents prepared by experts and institutes by the European Commission, containing the facilities' emission levels and energy consumption as well as the techniques applied. In BREFs, there is a section describing the methods and techniques followed when deciding on BATs and a conclusion section summarizing BATs. BREFs provide a reference for determining emission values for industrial sectors and have been prepared for many sectors. Waste Treatment BREF, known as WT BREF, is the one used in waste management sectors (Ramos Peralonso, 2022).

In the WT BREF; waste treatment process details, BATs, and BATAELs specific to many waste management activities are described in detail. Although landfilling is a waste management activity and included within the scope of the IED, it is not included in the WT BREF, and therefore no BAT conclusions exist for landfills. In the EU, landfills are evaluated within the scope of the Council Directive on the Landfill of Waste (1999/31/EC) and the requirements of this directive are deemed to constitute a part of BATs that landfills should comply with.

Although there are no BATs or BATAELs defined specifically for landfills in the WT BREF or the BAT Conclusions for the waste treatment sector⁶, the BATs listed under the title of “General BAT Conclusions” may apply to landfills. The WT BREF includes two sets of BATs; general BATs which are valid for all waste treatment facilities and activity-specific BATs which are defined for each waste treatment activity separately. The general BATs are given under the subtitles of i) overall environmental performance, ii) monitoring requirements, iii) noise and vibrations, iv) emissions to air, v) emissions to water, vi) emissions from accidents and incidents, vii) material efficiency, viii) energy efficiency and ix) reuse of packaging, some of which should apply to landfills as well. However, all these issues are addressed in the Council Directive on the Landfill of Waste and therefore constitute BATs for landfills.

The IED is currently being revised by the European Commission (EC, 2023). It is suggested to extend the IED to landfills for the control of methane emissions (ESWET, 2021). In this revision, the European Commission proposes adopting BAT conclusions under the IED to address the key environmental issues associated with the operation of waste landfills, including emissions of methane (FEAD, 2022). In addition, the German Environment Agency suggests that a more effective IED could be created with the principles of increasing the ambition in permits and tightening flexibilities. They propose the transformation of the IED into forward-looking legislation to accompany the industrial transformation by improving resource efficiency and adopting a circular economy. In this context, it is intended to close gaps in the current scope of the IED, including landfills (Suhr, 2023). Accordingly, in near future, the BAT Conclusions for the waste treatment sector is expected to cover landfills, and in turn, include BATs specifically defined for landfilling activity.

⁶ COMMISSION IMPLEMENTING DECISION (EU) 2018/1147 of 10 August 2018 establishing best available techniques (BAT) conclusions for waste treatment, under Directive 2010/75/EU of the European Parliament and of the Council.

2.3 Council Directive on the Landfill of Waste and the Relevant Techniques Defined

In the EU, waste management of landfills is regulated by the LD. General requirements for landfills and also the criteria and procedures to be followed for waste acceptance are described in this directive. The LD includes the rules to be followed while controlling and monitoring a landfill for the operation and after-care phases as well. The Turkish Regulation on Landfilling of Waste is a piece of national legislation that is a transposition of the Council Directive on the Landfill of Waste (1999/31/EC) and therefore it is mostly in line with it.

In the LD, the criteria and operational procedures to be followed for waste acceptance are expressed. The Directive includes the rules to be followed while controlling and monitoring a landfill for the operation and after-care phases as well.

The list of techniques created in line with the operational requirements of the Directive is given in Table 2.2. As previously indicated in Section 1.2, since they are not included in WT BAT Conclusions, these requirements are named as “techniques” instead of “BATs”.

Table 2.2 Techniques in the Council Directive on the Landfill of Waste (1999/31/EC)

Technique No	Description
1	Using a three-level hierarchy that includes characterization and testing of waste for their acceptance
	Level 1: The process of defining and characterizing the main characteristics of the waste
	Level 2: Compliance tests to meet the waste acceptance criteria given for landfill classes

Table 2.2 (cont'd)

Technique No	Description
	Level 3: Verification tests carried out at the facility to confirm that the wastes transferred to the facility are the same as the declared wastes with basic characterization and compliance tests.
2	Taking measures on the following issues to minimize the adverse environmental effects and hazards arising from the landfill
	Odor and dust emissions to the environment
	Spread of wastes with the effect of the wind
	Noise and traffic density
	Birds, insects, and other animals reproduce in the area and carry pathogens to the environment.
	Aerosol formation
	Possibility of fire
3	Taking measures to control environmental pollution originating from the landfill
4	Taking security measures to prevent free access to the landfill
5	Having a control and access system for the facility, including a program of action to detect and deter illegal dumping at the facility
6	The placement of waste on the landfill in a way providing the stability of the waste mass and associated structures, especially to prevent slippage
7	If an artificial layer is used, ensuring that the geological substratum is stable enough not to damage the artificial impermeability layer taking into account the morphology of the landfill
8	Controlling the water coming from precipitations to the landfill

Table 2.2 (cont'd)

Technique No	Description
9	Preventing surface water and/or groundwater from entering landfill waste
10	Collection of wastewater and leachate
11	Treatment of wastewater and leachate collected from the landfill according to the appropriate standards required for their discharge
12	Completion of a geological impermeable layer artificially if necessary to protect soil, groundwater, and surface water
13	Preserving the excavated soil to use as a top cover after the closure phase of a landfill to protect the soil, groundwater, and surface water
14	In order to prevent leachate, in addition to the geological barrier, the application of the following recommendations for surface sealing
	Gas drainage layer
	Artificial sealing liner
	Geological impermeable layer
	Drainage layer > 0.5 m
	Topsoil cover > 1 m
15	Taking appropriate measures to control the gas generated
16	Collection and treatment of the gas generated
17	Using the collected gas to generate energy
18	Flaring the gas, if the collected gas is not used to generate energy

2.4 BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by the EPA of Ireland and Defined BATs

Apart from the LD, another document published in the European Union that identifies and explains BATs is “BAT Guidance Note on BATs for the Waste Sector: Landfill Activities” prepared by the Environmental Protection Agency (EPA) of Ireland. Ireland as a member of the EU applies the Council Directive on the Landfill of Waste; but, still has a guidance note on BATs for landfills.

This guide includes many process descriptions such as environmental management systems specific to landfills, waste acceptance procedures, and activities applied in landfills. It also contains a section where possible environmental risks are identified, such as emissions to air and water. In addition, certain control techniques are included, containing energy and raw material consumption. There is also a section in this guidance where the BATs are identified and explained.

The BAT Checklist prepared using this guidance is given in Table 2.3. The numbering of BATs is continued from the techniques in the previous section.

Table 2.3 BATs from “Guidance Note on BATs for the Waste Sector: Landfill Activities” by the Ireland EPA

BAT No	Description
19	Conducting a risk assessment for known and unknown obligations to understand and manage environmental risk
20	The preparation to ensure that the following pollution control systems are maintained and effective after the waste storage process is completely finished:
	Gas control system
	Leachate collection, treatment, and discharge system
	Landfill top layer
	Groundwater monitoring
	Slope stability

Table 2.3 (cont'd)

BAT No	Description
	All above-ground components, such as gas well covers, leachate pumping manholes, and monitoring boreholes
21	Having financial provision for environmental obligations (known and unknown) after restoration and waste storage process is completed
22	Controlling surface water flow within the landfill, including collection and monitoring activities
23	Quality control of the artificial impermeability layer used in the landfill
24	Ensuring that all wastes generated in the landfill are properly stored and transported
25	Treatment of wastewater before discharge to the receiving environment
26	Having an infrastructure regarding the monitoring of discharges to the receiving environment
27	Treatment to meet the relevant discharge standards, if discharged to sewers
28	Groundwater monitoring to identify any groundwater contamination from the landfill as soon as possible and to set alarm levels and upper limits
29	Implementation of the following management techniques to prevent emissions to groundwater
	Waste storage by controlling the impermeability layer
	Regular monitoring of the topsoil condition (at least 1 in 3 years)
	Checking the bottom height of the leachate at the floor of the cell (at least 0.5 m)
	Deciding and determining alarm levels for groundwater quality for all landfills, based on the specific hydrogeological conditions of the area, considering the direction and slope of groundwater flow
	Ensuring the safety of groundwater monitoring wells

Table 2.3 (cont'd)

BAT No	Description
30	Application of the following management techniques to minimize leachate emissions
	Keeping the active fill area as small as possible with a maximum of 25m*25 m and 1:3 slope, unless specifically agreed
	Usage of daily and intermediate cover and proper compaction to decrease the amount and quality of leachate and water infiltration level
	Procedures to ensure that the containment system is not damaged by the placement of soil remediation layers or the environmental control systems
	Leachate recirculation
	Developing procedures to ensure that the top cover system is not damaged, comprehensive monitoring and repair program
	Applying waste acceptance procedures regularly
31	Application of the following control techniques to minimize leachate emissions
	Reducing rain seepage into accumulated waste by using soil, recycled/recovered materials, or artificial cover materials
	Composition and depth of leachate monitoring
	Covering and restoration of the filled parts of the landfill as soon as possible
	Collecting and reusing uncontaminated rainwater
32	Implementation of the following gas management systems to prevent uncontrolled gas escape from the landfill
	Pretreating the waste before it is accepted for the landfill for minimization of gas generation potential of landfill
	Avoiding landfill gas from passing to the ground in both dissolved and gas states
	Avoiding methane emission to the atmosphere
	Management of odor risks
	Avoiding condensation in the gas collection network

Table 2.3 (cont'd)

BAT No	Description
	Implementation of horizontal and vertical gas collection piping
	Balancing of gas wells regularly
	Monitoring and balancing of gas extraction wells regularly
	Using the automatic warning system for fault detection.
	Managing condensation to prevent emissions
33	Application of the following techniques for process gas emissions
	Pretreating waste for biodegradable removal or reduction
	Choosing appropriate cell sizes
34	Implementation of the following management techniques to minimize the risk of odor in the landfill facility
	Pretreating odor-producing wastes
	Application of proper waste acceptance procedures
	Odor Management Plan preparation and implementation
	Review of gas management and measurement protocols regularly
	Management of cell staging and size effectively
	Monitoring of closed areas regularly for fugitive volatile organic carbon emissions
35	Application of the following techniques for the control of odors in the landfill facility
	Open tipping area minimization
	Storage, compaction, and covering of waste quickly
	Providing a 750 m buffer distance from the landfill footprint to any sensitive receptor for a new landfill facility accepting a significant part of the potentially odorous waste
	Restriction of especially odorous waste loads and burial of them immediately
	Restriction of waste disposal activities in adverse weather conditions

2.5 Turkish Regulation on Landfilling of Waste

The Turkish Regulation on Landfilling of Waste (RoLW) which has been effective since 2010, is a transposition of the LD into the national legislation, and therefore a significant part of it is in line with the LD. When the operational requirements of the LD (Table 2.2) are compared with those of the RoLW, it is seen that 15 of these techniques are also included in the RoLW (see Appendix E). Only the Techniques 4, 5, and 7 of the LD are not covered by the RoLW.

Similarly, when the BATs defined by the “BAT Guidance Note on BATs for the Waste Sector: Landfill Activities” by the EPA of Ireland, are compared with the provisions of the RoLW, it is seen that the BATs listed by the Ireland EPA are partially covered by the RoLW. The BATs missing in the RoLW are the ones with the numbers of 19, 23, 26, 27, 31, 32, 33, 34, and 35.

The distribution of the provisions of the RoLW overlapping with the LD, with respect to their subjects is shown in Figure 2.3. As shown, the operational requirements concerning landfill gas management and leachate management correspond to almost 60% of the requirements of the RoLW overlapping with the LD.

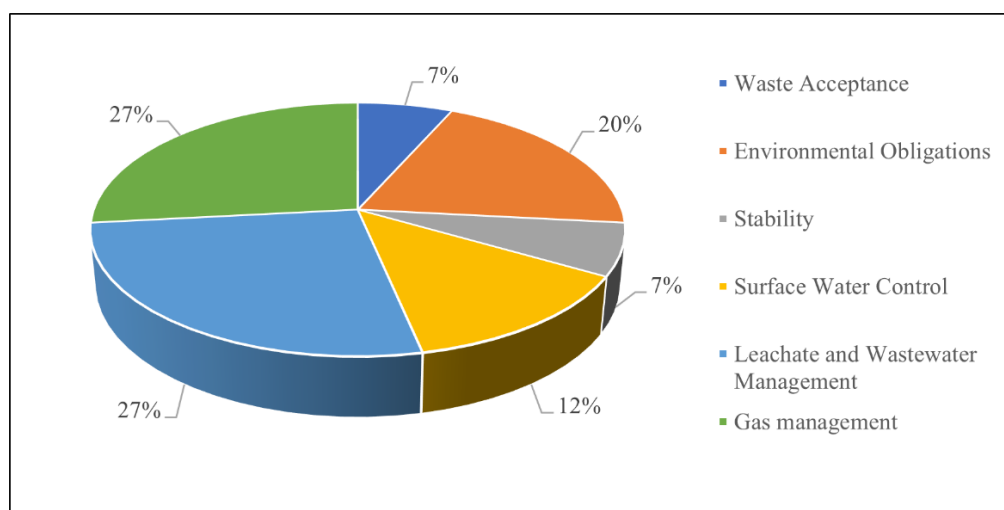


Figure 2.3 The Distribution of the Provisions of the RoLW with respect to Their Subjects

2.6 The IPPC-WASTE Project

The Evaluation of Waste Processing Facilities within the Scope of Integrated Pollution Prevention and Control, Investigation of Compliance Status and Development of Adaptation Requirement Models Project (IPPC-WASTE or EKÖK-ATIK Project) was supported by the MoEUCC and carried out by the Middle East Technical University. This project includes a study to investigate the compliance of waste management facilities within the scope of the Industrial Emissions Directive with the BATs, to reveal the requirements for compliance, to research the literature, and to develop compliance models for waste treatment facilities in Türkiye.

In the strategy document presented at the opening negotiations for the Environment Chapter in the EU membership process in 2009, the year 2012 for compliance with the IPPC legislation, the year 2015 for the first implementation, and the year 2018 for the full implementation, provided that it is open to negotiations, are committed. In this context, a project consisting of matching and technical assistance components was carried out by MoEUCC within the scope of the financial support provided by the EU Instrument for Pre-accession Assistance IPA-I 2008 Programming. According to the results of the analysis made in this project, it is recommended that the transition to implementation be linked to a sectoral transition calendar. In this context, the IPPC-WASTE Project aims to increase the awareness of the institutional infrastructure, target sectors, and relevant stakeholders, strengthen the capacity and determine the technical and financial needs for the transition to Integrated Environmental Permit Application in the waste management sector. In addition, at the stage of establishing an integrated permit infrastructure in the waste management sector and determining the transition date, it is aimed to determine the current compliance status, technology changes, and improvements that will be necessary for the transition to full compliance, and investment needs and to develop compliance models by conducting research specific to the facilities.

Within the scope of the project, BAT checklists were prepared by researching the BREF and literature for each waste management sub-sector in order to compare the

current status of the facilities and the BAT Reference documents. According to the inventory created in the project, field study visits were made by the project team to the facilities operating in Türkiye and included in the scope of IED Annex I. During these field study visits, information was obtained about the existing technology and applications of the facilities, and comparisons could be made with BATs/techniques in line with the BAT checklists prepared. In addition, at the field study visits, the compliance status of the facilities with BATs/techniques was examined on-site, and it was possible to discuss with the people working in the sector what should be done for compliance.



CHAPTER 3

STUDY APPROACH & METHODOLOGY

This part of the thesis presents the study approach and methodology used throughout the thesis.

3.1 Landfills Covered by the IED and by the Study

In the present thesis, only the landfills that should comply with the IED were covered. A landfill must accept more than 10 tons of waste per day or have a total capacity of more than 25,000 tons in order to be covered by the IED. Landfills that accept inert waste are not considered in the scope of the IED. In Türkiye, there are 24 landfill facilities that meet these criteria and therefore fall under the IED. A list of these landfills is given in Table 3.1.

Table 3.1 The List of the Landfills in Turkey that Fall under the IED

#	Facility Name	City where the Facility is Located
1	EVRA Enerji San. Tic. Ltd. Şti.	Trabzon
2	İÇDAŞ Çelik Enerji Tersane ve Ulaşım San. A.Ş. - Kocaalan	Çanakkale
3	Ekolojik Enerji A.Ş. - Çorlu	Tekirdağ
4	HİDRO-GEN Enerji İthalat İhracat Dağıtım ve Ticaret A.Ş.- Soma Kolin Termik Santrali	Manisa
5	Öztürk Enerji A.Ş.	Kahramanmaraş
6	Koza Altın İşletmeleri A.Ş.-Kaymaz Şube Müdürlüğü	Eskişehir

Table 3.1 (cont'd)

#	Facility Name	City where the Facility is Located
7	Kangal Termik Santral Elektrik Üretim A.Ş.	Sivas
8	Glc Enerji San. Ve Tic. Ltd. Şti. Süloğlu	Edirne
9	Koza Altın İşletmeleri A.Ş. - Bergama	İzmir
10	Iğdır İli Çevre Hizmetleri Birliği/Katı Atık Düzenli Depolama Tesisleri	Iğdır
11	İÇDAŞ Elektrik Enerjisi Üretim ve Yatırım A.Ş. - Bekirli	Çanakkale
12	Zamantı Madencilik ve Tic. Ltd. Şti. - Kabadüz	Ordu
13	Altıntepe Mad. San. ve Tic. A.Ş. - Fatsa	Ordu
14	Ordu Yenilenebilir Enerji Elektrik Üretim San. Tic. A.Ş.- Çaybaşı	Ordu
15	İSTAÇ İstanbul Çevre Yönetimi Sanayi Ve Ticaret A.Ş. - Kömürcüoda	İstanbul
16	Çorum Belediyeler Çevre Birliği Katı Atık Bertaraf Tesisleri	Çorum
17	Kar Mineral Madencilik İnşaat Turizm Sanayi Ve Ticaret A.Ş. Emirdağ	Afyonkarahisar
18	Eti Alüminyum A.Ş.- Kırmızı Çamur Düzenli Depolama Tesisleri	Konya
19	ITC Invest Trading & Consulting AG – Sincan	Ankara
20	Biosun Bilecik Katı Atık İşleme Enerji Ve Çevre Sanayi Ticaret A.Ş.	Bilecik
21	Süreko Atık Yönetimi Nakliye Lojistik Elektrik Üretim A.Ş. - Kula	Manisa
22	İzaydaş İzmit Atık ve Art.Arıtma Yak .Ve Değer.A.Ş.	Kocaeli

Table 3.1 (cont'd)

#	Facility Name	City where the Facility is Located
23	Eti Soda Üretim Pazanak.Ve Elekt.Üre San.Ve Tic.A.Ş.	Ankara
24	Kartallar Ege Geri Dönüşüm Enerji Üretim A.Ş.	Manisa

3.2 Preparation of the BAT Checklist

For the determination of the compliance status of landfills in Türkiye with the BATs and the LD; a questionnaire shortly called “BAT Checklist” was prepared in MS Excel. The BAT Checklist is made up of several Excel worksheets. The first worksheet is an introductory page with explanations for the questionnaire. On the second worksheet of the BAT Checklist, there is a form asking for general information about the facility and the waste treatment process applied. The third worksheet is where the BATs and techniques are given with their origin. On this worksheet, there are columns that facilities must respond to regarding BAT application status, BAT applicability, investment and maintenance costs for BAT compliance, time required for compliance, and benefits gained from the application of BATs/techniques. On the fourth worksheet of the BAT Checklist, there are tables to be filled for monitoring activities, while on the fifth worksheet, emission measurement values are asked. Screenshots of the worksheets of the BAT Checklist are presented in Appendix B.

This BAT Checklist includes a total of 35 BATs and techniques; 18 taken from the Council Directive on the Landfill of Waste and 17 taken from BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by the EPA of Ireland. In addition, the BAT Checklist contains sub-techniques of these BATs. The number of BATs/techniques and their sub-techniques are summarized in Table 3.2.

Table 3.2 The Number of BATs/Techniques and Sub-techniques in the BAT Checklist

Source of BAT/Technique	Number of BAT/Techniques	Number of Sub-Techniques
Council Directive on the Landfill of Waste	18	14
BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by Ireland EPA	17	44

3.3 Field Study Visits and Online Surveys

Within the scope of this study, the information needed for the BAT and LD compliance assessment was obtained through field study visits made to four landfills and online surveys conducted with 12 landfills using the BAT Checklist. These landfill facilities are located in 10 different cities in Türkiye that are Trabzon, Edirne, Manisa, Çanakkale, Ankara, Bilecik, Eskişehir, Kocaeli, Istanbul, and Sivas.

The information obtained from both field study visits and online survey studies is used in this thesis. It was assumed that the 16 facilities where the study was carried out represent 24 landfills within the scope of the IED in Türkiye.

3.3.1 Field Study Visits

Field study visits to the facilities, primarily include a tour of the facility and an on-site understanding of the processes. During this field tour, information about the techniques and technologies available at the facility was obtained from the facility officials. Therefore, the advantages and disadvantages of the techniques were examined in situ. The facility officials explained what kind of measures they have taken and will take in order to reduce the negative environmental impact. After a field tour of the facility, an interview was conducted with the facility officials on the BAT checklists prepared based on “the Council Directive on the Landfill of Waste

and BAT Guidance Note on BATs for the Waste Sector: Landfill Activities” by Ireland EPA. Information was obtained about whether the BATs and techniques in the BAT Checklist are applied by the facility visited. In addition, estimates of how much cost a facility that does not implement BATs/techniques will need to achieve full compliance with the BATs and techniques in the checklists have been studied separately for each BAT/technique.

3.3.2 Online Survey

In addition to the field study visits, an online survey was conducted with the unvisited landfills sharing the BAT Checklist with them. The survey covered 20 landfills unvisited.

First, the BAT Checklist was sent to the facilities online, and then communication was accomplished via telephone calls and e-mails for arranging online meetings. During these online meetings, the facilities were first informed about the BAT Checklist and as in the field study visits, giving detailed information about the IPPC Waste Project, the IED, BATs and techniques and then the BAT Checklist that they are expected to respond. Facilities were constantly contacted and an attempt was made to get them to respond to the BAT Checklist and ensure that the facilities respond to all questions in the BAT Checklist. As a result of continuous interviews with them, data were collected from 12 landfills.

3.4 BAT and LD Compliance Assessment

While determining the compliance status of the landfills, the responses of the facilities to the BATs and techniques were evaluated in five groups. These five groups of answers are “Yes”, “No”, “Partially yes”, “Not necessary” and “Not answered”. In line with these answers given by the facilities, the compliance percentage and partial compliance percentage of landfills with BATs and techniques were revealed. Therefore, the compliance status of the facilities within the scope of

the IED and also the LD was understood. After determining the level of compliance with each BAT and technique, an overall compliance assessment was made for the IED and the LD.

The compliance assessment part of the study was carried out separately for two lists (a list of BATs defined by the Ireland EPA and a list of techniques corresponding to the operational measured of the LD) and the level of compliance was separately investigated for the BATs and the techniques listed.

The compliance assessment for the RoLW was a subset of the compliance assessment for the LD and the BATs since the requirements of the RoLW are mostly covered by the LD and the BATs.

3.5 Determination of Applicability of BATs/Techniques

Facilities were also asked whether the BATs and the techniques in the BAT Checklist were applicable under the conditions of Türkiye. Facilities were expected to answer this question for each BAT and technique with three different options that are “Applicable”, “Not applicable”, and “Partially applicable”. Based on the facility responses, it was determined what percentage of the facilities consider the BATs and techniques to be applicable, partially applicable or not applicable.

3.6 BAT and LD Compliance Cost Assessment

The next step of this thesis study is the estimation of the investment needed (CAPEX) for full compliance with BATs and techniques for the landfill sector. The cost information obtained from field study visits and online surveys were used and a CAPEX range for each BAT was prepared. These cost ranges were evaluated by the IPPC-WASTE Project team taking into consideration the evaluations made by some landfill operators and the minimum and maximum CAPEX estimates for each BAT/technique were determined. The average investment cost for each BAT and

technique was calculated by taking the arithmetic average of the minimum and maximum cost figures and further calculations for the cost assessment were made with these cost figures. After determining the average cost figure for each BAT and each technique, the sectoral investment requirement was estimated. In calculating the sectoral investment requirement for a BAT or technique, the present compliance rate for that BAT and the total number of landfills that should comply with the IED were considered.

In sectoral cost analysis, the total investment cost (CAPEX) was calculated using the following equation considering the data gathered:

Sectoral total investment cost

$$= \sum_{n=1}^n \# \text{ of landfills covered by the IED} \times CAPEX_{BAT / Technique n} \times (1 - Compliance Level_{BAT / Technique n})$$

Where;

Total # of landfills covered by the IED = 24 (see Appendix B)

CAPEX_{BAT/Technique n}: Capital cost for compliance with BAT/Technique n

Compliance Level_{BAT/Technique n}: Fraction of landfills that comply with BAT/Technique n.

n: number of BATs to comply with

Despite the efforts made towards collecting cost data for each BAT and technique, for some of the BATs or techniques, landfill operators could not provide any data. While presenting the results, since it will not be possible to determine costs for some techniques, the expression "*" is used instead of the cost corresponding to those BATs or techniques.

The average cost of techniques evaluated under eight headings as waste acceptance, environmental obligations, surface water control, stability and quality control, security, leachate and wastewater management, gas management, and odor

management. A list of BATs/techniques for these different subjects is given in Table 3.3.

Table 3.3 Groups of BATs/Techniques

	BAT/Technique No	
	Council Directive on the Landfill of Waste	BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by EPA
Waste acceptance	1	-
Environmental obligations	2-3-13	19-20-21
Surface water control	8-9	22
Stability and quality control	6-7	23-24
Security	4-5	-
Leachate and wastewater management	10-11-12-14	25-26-27-28-29-30-31
Gas management	15-16-17-18	32-33
Odor management	-	34-35

In addition, as part of the cost assessment, the cost analysis was generated for BATs/techniques with legal obligations. In other words, sectoral costs have been calculated for BATs and techniques included in the BAT Checklist and within the scope of RoLW. This study is also presented based on the groups in Table 3.3.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Compliance Status of Landfills in Türkiye with BATs and Techniques from the LD

In order to determine the compliance status of the landfill facilities in Türkiye with the BATs and the operational requirements of the LD, 16 facilities were interviewed and their responses regarding the compliance with BATs and the operational requirements of the LD were collected. In this section of this thesis, the compliance status of the facilities with the BATs and the techniques are presented under separate sub-headings.

4.1.1 Compliance Status of Landfills in Türkiye with the Council Directive on the Landfill of Waste

In the interviews held with 16 facilities, the compliance status of their facilities with 18 requirements, and their sub-requirements, which are defined in the LD was asked. Responses from facilities are tabulated in Appendix C. Based on the answers given by the facilities, the overall sectoral compliance status of the landfills with the provisions of the LD was evaluated.

Table 4.1 presents the compliance status of the landfills with the LD in Türkiye. This table includes percentages for the full compliance, partial compliance, and non-compliance techniques along with the number of facilities. As seen, the overall compliance of the landfills with the LD requirements is high and the percentage compliance for most of the techniques is over 70% and the compliance with Techniques # 3 to 7 is 100%. It is seen that the technique related to waste acceptance procedures is very highly complied with. Similarly, measures concerning the control

of environmental pollution, site security, access to the landfill, landfill stability, control of precipitation, and leachate collection are all with high compliance. However, the techniques concerning gas management are relatively with a low compliance.

As can be seen from Table 4.1, of the 18 techniques and their 14 sub-techniques, facilities have moderate compliance for three techniques with one sub-techniques. On the other hand, low compatibility is shown for only one technique and two sub-techniques.

The facilities are highly compliant with techniques regarding waste acceptance, surface water control, safety, stability, and quality control. However, there is low compliance with the sub-technique of environmental obligations that are taking precautions for aerosol formation. The percentage of landfills having full compliance with the technique of minimizing aerosol formation is 37%, while that for the landfills with partial compliance is 13%. The reason why the facilities have low compliance with this technique is that they do not know how to take action against aerosol formation. Similarly, there is one low and one moderate compliance for the two sub-techniques to prevent leachate. While the facilities show 42% full compliance for the gas drainage layer application, and 57% full compliance for a topsoil cover application with a thickness of more than 1 meter. The reason why the facilities do not perform the gas drainage layer application can be that they do not cause gas formation, and they may also not be able to fulfill the 1-meter criterion for topsoil cover application. In addition, according to the answers received from the facilities on the subject of gas management, moderate compliance is observed for two techniques, while low compliance is observed for one technique. As moderate compliance, facilities are 50% and 67% fully compatible with the techniques of collection and treatment of the gas generated and using the collected gas to generate energy, respectively. According to the response to Technique 17, only 4 landfills out of 6 responding facilities use the collected landfill gas to generate electricity. On the other hand, 20% full compliance with the technique of flaring the gas if the collected gas is not used to generate energy is shown by the facilities. The number of facilities

responding to techniques related to gas management is less when compared to other techniques. The underlying reason for this is that there are not many facilities that cause gas formation in the facilities that respond to the checklist, and they consider that these techniques do not need to be applied. Among the responding facilities, the facilities that collect and treat the gas are in the minority. Therefore, the percentage of full compliance with these techniques is low. This situation indicates relatively poor management of landfill gas in the landfills in Türkiye.



Table 4.1 Compliance Status of Landfills in Türkiye with Techniques from the LD

Technique No	Techniques	Number of responding facilities	Facilities implementing Technique, Number (%)	Facilities partially implementing Technique, Number (%)	Facilities not implementing Technique, Number (%)
1	<i>Using a three-level hierarchy that includes characterization and testing of waste for their acceptance.</i>				
	Level 1: The process of defining and characterizing the main characteristics of the waste	14	13 (93)	0 (0)	1 (7)
	Level 2: Compliance tests to meet the waste acceptance criteria given for landfill classes	14	10 (72)	3 (21)	1 (7)
	Level 3: Verification tests carried out at the facility to confirm that the wastes transferred to the facility are the same as the declared wastes with basic characterization and compliance tests.	10	8 (80)	0 (0)	2 (20)
2	<i>Taking measures on the following issues to minimize the adverse environmental effects and hazards arising from the landfill</i>				
	Odor and dust emissions to the environment	16	13 (81)	2 (13)	1 (6)

Table 4.1 (cont'd)

Technique No	Techniques	Number of responding facilities	Facilities implementing Technique, Number (%)	Facilities partially implementing Technique, Number (%)	Facilities not implementing Technique, Number (%)
	Spread of wastes with the effect of the wind	9	8 (89)	1 (11)	0 (0)
	Noise and traffic density	12	11 (92)	0 (0)	1 (8)
	Birds, insects, and other animals reproduce in the area and carry pathogens to the environment.	8	6 (75)	2 (25)	0 (0)
	Aerosol formation	8	3 (37)	1 (13)	4 (50)
	Possibility of fire	14	12 (86)	1 (7)	1 (7)
3	<i>Taking measures to control environmental pollution originating from the landfill</i>	16	16 (100)	0 (0)	0 (0)
4	<i>Taking security measures to prevent free access to the landfill</i>	16	16 (100)	0 (0)	0 (0)
5	<i>Having a control and access system for the facility, including a program of action to detect and deter illegal dumping at the facility</i>	15	15 (100)	0 (0)	0 (0)

Table 4.1 (cont'd)

Technique No	Techniques	Number of responding facilities	Facilities implementing Technique, Number (%)	Facilities partially implementing Technique, Number (%)	Facilities not implementing Technique, Number (%)
6	<i>The placement of waste on the landfill in a way providing the stability of the waste mass and associated structures, especially to prevent slippage</i>	16	16 (100)	0 (0)	0 (0)
7	<i>If an artificial layer is used, ensuring that the geological substratum is stable enough not to damage the artificial impermeability layer taking into account the morphology of the landfill</i>	13	13 (100)	0 (0)	0 (0)
8	<i>Controlling the water coming from precipitations to the landfill</i>	16	15 (94)	1 (6)	0 (0)
9	<i>Preventing surface water and/or groundwater from entering landfill waste</i>	16	15 (94)	1 (6)	0 (0)
10	<i>Collection of wastewater and leachate</i>	16	15 (94)	1 (6)	0 (0)

Table 4.1 (cont'd)

Technique No	Techniques	Number of responding facilities	Facilities implementing Technique, Number (%)	Facilities partially implementing Technique, Number (%)	Facilities not implementing Technique, Number (%)
11	<i>Treatment of wastewater and leachate collected from the landfill according to the appropriate standards required for their discharge</i>	10	9 (90)	1 (10)	0 (0)
12	<i>Completion of a geological impermeable layer artificially if necessary to protect soil, groundwater, and surface water</i>	15	12 (80)	1 (7)	2 (13)
13	<i>Preserving the excavated soil to use as a top cover after the closure phase of a landfill to protect the soil, groundwater, and surface water</i>	16	13 (81)	2 (13)	1 (6)
14	<i>In order to prevent leachate, in addition to the geological barrier, the application of the following recommendations for surface sealing</i>				
	Gas drainage layer	12	5 (42)	0 (0)	7 (58)
	Artificial sealing liner	14	12 (86)	1 (7)	1 (7)

Table 4.1 (cont'd)

Technique No	Techniques	Number of responding facilities	Facilities implementing Technique, Number (%)	Facilities partially implementing Technique, Number (%)	Facilities not implementing Technique, Number (%)
	Geological impermeable layer	14	10 (71)	0 (0)	4 (29)
	Drainage layer > 0.5 m	15	12 (80)	0 (0)	3 (20)
	Topsoil cover > 1 m	14	8 (57)	1 (7)	5 (36)
15	<i>Taking appropriate measures to control the gas generated</i>	6	5 (83)	0 (0)	1 (17)
16	<i>Collection and treatment of the gas generated</i>	6	3 (50)	1 (17)	2 (33)
17	<i>Using the collected gas to generate energy</i>	6	4 (67)	0 (0)	2 (33)
18	<i>Flaring the gas if the collected gas is not used to generate energy</i>	5	1 (20)	0 (0)	4 (80)

In order to summarize the data presented in Table 4.1 on the compliance status of landfills in Türkiye with techniques from the LD; a compliance rate above 70% is defined as "high compliance", between 50-70% as "moderate compliance", and less than 50% as "low compliance" and the evaluations presented in Table 4.2 were obtained. As shown, landfills in Türkiye highly comply with a great portion of the techniques defined in the LD.

Table 4.2. A Summary of Compliance Status of Landfills in Türkiye with Techniques from the Council Directive on the Landfill of Waste

Technique #	Technique	Level of Compliance
1	Using a three-level hierarchy that includes characterization and testing of waste for their acceptance	High
2	Taking measures to minimize the adverse environmental effects and hazards arising from the landfill	High
3	Taking measures to control environmental pollution originating from the landfill	High
4	Taking security measures to prevent free access to the landfill	High
5	Having a control and access system for the facility, including a program of action to detect and deter illegal dumping at the facility	High
6	The placement of waste on the landfill in a way providing the stability of the waste mass and associated structures, especially to prevent slippage	High
7	If an artificial layer is used, ensuring that the geological substratum is stable enough not to damage the artificial impermeability layer taking into account the morphology of the landfill	High
8	Controlling the water coming from precipitations to the landfill	High
9	Preventing surface water and/or groundwater from entering landfill waste	High
10	Collection of wastewater and leachate	High

Table 4.2 (cont'd)

Technique #	Technique	Level of Compliance
11	Treatment of wastewater and leachate collected from the landfill according to the appropriate standards required for their discharge	High
12	Completion of a geological impermeable layer artificially if necessary to protect soil, groundwater, and surface water	High
13	Preserving the excavated soil to use as a top cover after the closure phase of a landfill to protect the soil, groundwater, and surface water	High
14	In order to prevent leachate, in addition to the geological barrier, the application of the following recommendations for surface sealing	Moderate
15	Taking appropriate measures to control the gas generated	High
16	Collection and treatment of the gas generated	Moderate
17	Using the collected gas to generate energy	Moderate
18	Flaring the gas if the collected gas is not used to generate energy	Low

The distribution of techniques by compliance rate is given in Table 4.3. As shown, the compliance rate is over 90% for half of the provisions of the LD and 75 to 90% for 28 % of the provisions. All these findings indicate quite a high compliance of the landfills in Türkiye with the provisions of the LD.

Table 4.3 Distribution of the Techniques by Compliance Rate

Compliance Rate	# of Techniques	% Distribution of techniques by compliance rate
<%25	18	6
%25-49	-	0
%50-74	14, 16, 17	16
%75-90	1, 2, 12, 13, 15	28
>%90	3, 4, 5, 6, 7, 8, 9, 10, 11	50

4.1.2 Compliance Status of Landfills in Türkiye with BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by Ireland EPA

Seventeen BATs and their sub-techniques, which are listed by the BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by the Ireland EPA document, were asked to the facilities in the interviews held with 16 facilities. Responses from the facilities are given in Appendix D. Based on the answers given by the facilities, the sectoral compliance status was revealed.

The overall sectoral compliance with the BAT prepared for the landfill sector in Türkiye is presented in Table 4.4. This table includes percentages of full compliance, partial compliance, and non-compliance BATs along with the number of facilities. As seen, the overall compliance of the landfills with the BAT requirements is high and the percentage compliance for most of the requirements of BATs is over 70%. The compliance with BAT 24, BAT 28, and 5 sub-techniques of BAT no 30, 32, 34, 35 is 100%. These overall findings indicate that landfills in Türkiye highly comply with the BATs defined in the BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by the Ireland EPA. For example, measures concerning groundwater monitoring, surface water control, applying waste acceptance procedures regularly, and proper storage and transportation of waste are all with high compliance. However, the BATs concerning control of minimization of leachate emission and gas management are relatively with a low compliance.

When the compliance status of landfills in Türkiye with BATs from the BAT Guidance Note on BATs for the Waste Sector: Landfill Activities” by the Ireland EPA is evaluated, it is seen that the number of BATs with high compliance is higher than those with medium and low compliance. As can be seen from Table 4.4; of the 17 BATs and their 43 sub-techniques, the facilities have moderate compliance for 4 BATs and 13 sub-techniques. On the other hand, low compliance is shown for 2 BATs and their 10 sub-techniques.

The facilities are highly compliant with BATs regarding surface water control, stability, and quality control. However, there is low compliance on one BAT and one sub-technique that are “having a gas control system” and “having financial provision for environmental obligations after the waste storage process is completely finished”. It is seen that 43% of the landfill facilities comply with the gas control system requirement and 45% comply with having financial provision for environmental obligations. The reason why facilities do not have high compliance in applying a gas control system can be that they do not cause gas generation. In addition, it is seen that the facilities do not give sufficient importance to the issue of having financial provisions for environmental obligations after the restoration and waste storage process is completed. Similarly, there is moderate compliance for the seven sub-techniques and low compliance for one sub-technique about gas management. The facilities are fully compatible with these sub-techniques at a rate between 33% and 60%. As with techniques from the LD, the number of facilities responding to BATs related to gas management is less when compared to other BATs. The underlying reason for this is that there are not many facilities that cause gas formation in the facilities that respond to the checklist, and they consider that these BATs do not need to be applied.

In addition, according to the answers received from the facilities on the subject of leachate and wastewater management, moderate compliance is observed for one BAT and two sub-techniques, while low compliance is observed for one BAT and four sub-techniques. In case the wastewater is discharged to the sewerage, the facilities fully comply with the practice of performing the treatment in order to meet the relevant discharge limits at a rate of 20%. The reason for this is the lack of facilities to have a wastewater treatment plant. In addition, the facilities have the infrastructure for monitoring discharges to the receiving environment at a rate of 57%. Also, the facilities provide 33% compliance with the sub-techniques of “collecting and reusing uncontaminated rainwater and leachate recirculation”. While there is 30% full compliance with the BAT of “controlling the bottom height of the leachate at the floor of the cell”, the composition and depth of leachate is monitored

at a rate of 46%. These BATs are very important to prevent emissions to groundwater and facilities should pay more attention to this issue. Moreover, for the BAT of “developing procedures to ensure that the top cover system is not damaged, a comprehensive monitoring and repair program”; 55% of the landfills are with full compliance and 18% are with partial compliance. The last sub-technique in which the full compliance status of the facilities is moderate is about the regular monitoring of leachate, wastewater, and topsoil condition. Landfills comply with this sub-technique at a rate of 50%. According to this BAT, monitoring studies should be carried out at least every 3 years. It is thought that the reason why the percentage of fully compliant landfills is not high may be that the facilities do not comply with the monitoring frequency. In addition, the reason why the compliance on leachate and wastewater control is moderate or low in general can be that the facilities that do not generate leachate have also responded to these BATs.

Also, while there is one sub-technique with 64% moderate compliance among odor management-related BATs that is a restriction of waste disposal activities in adverse weather conditions, low compliance is observed in four sub-techniques on the management of cell staging and size effectively, Odor Management Plan preparation and implementation, pretreating odor-producing wastes and monitoring of closed areas regularly for fugitive volatile organic carbon emissions at a rate between 0% and 43%. The reason for the moderate and low compliance of the facilities to the BATs related to odor control can be that they do not store the wastes that will cause odor and gas formation.

In addition, there is a one sub-technique that is only applicable only to new facilities. According to the third sub-technique of BAT 35, a 750 m buffer distance from the landfill footprint to any sensitive receptor for a new landfill facility accepting a significant part of the potentially odorous waste should be provided. Ensuring this distance is an issue that should be taken into account when deciding on the location of the landfill facility. Therefore, it would not be possible to apply this technique to existing facilities. According to the information received from the facility authorities, the rate of meeting the requirement of this BAT is 71%. As a result, while

the rate of full compliance with the BATs from “The BAT Guidance Note on BATs for the Waste Sector: Landfill Activities” by the EPA is high and moderate, the rate of partial compliance and non-compliance is low in general. The total compliance of landfill facilities within the scope of the IED in Türkiye with these 17 BATs is 70%.



Table 4.4 Compliance Status of Landfills in Türkiye with the BATs from the BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by Ireland EPA

BAT No	BATs	Number of responding facilities	Facilities implementing BAT Number (%)	Facilities partially implementing BAT Number (%)	Facilities not implementing BAT Number (%)
19	<i>Conducting a risk assessment for known and unknown obligations to understand and manage environmental risk</i>	16	15 (94)	0 (0)	1 (6)
20	<i>The preparation to ensure that the following pollution control systems are maintained and effective after the waste storage process is completely finished:</i>				
	Gas control system	7	3 (43)	1 (14)	3 (43)
	Leachate collection, treatment, and discharge system	14	11 (79)	3 (21)	0 (0)
	Landfill top layer	16	15 (94)	0 (0)	1 (6)
	Groundwater monitoring	15	15 (100)	0 (0)	0 (0)
	Slope stability	15	14 (93)	0 (0)	1 (7)
	All above-ground components, such as gas well covers, leachate pumping manholes, and monitoring boreholes	15	11 (73)	3 (20)	1 (7)
21	<i>Having financial provision for environmental obligations (known and unknown) after restoration and waste storage process is completed</i>	11	5 (45)	0 (0)	6 (55)

Table 4.4 (cont'd)

BAT No	BATs	Number of responding facilities	Facilities implementing BAT Number (%)	Facilities partially implementing BAT Number (%)	Facilities not implementing BAT Number (%)
22	<i>Controlling surface water flow within the landfill, including collection and monitoring activities</i>	14	13 (93)	0 (0)	1 (7)
23	<i>Quality control of the artificial impermeability layer used in the landfill</i>	16	13 (81)	1 (6)	2 (13)
24	<i>Ensuring that all wastes generated in the landfill are properly stored and transported</i>	15	15 (100)	0 (0)	0 (0)
25	<i>Treatment of wastewater before discharge to the receiving environment</i>	7	6 (86)	0 (0)	1 (14)
26	<i>Having an infrastructure regarding the monitoring of discharges to the receiving environment</i>	7	4 (57)	1 (14)	2 (29)
27	<i>Treatment to meet the relevant discharge standards, if discharged to sewers</i>	5	1 (20)	0 (0)	4 (80)
28	<i>Groundwater monitoring to identify any groundwater contamination from the landfill as soon as possible and to set alarm levels and upper limits</i>	15	15 (100)	0 (0)	0 (0)

Table 4.4 (cont'd)

BAT No	BATs	Number of responding facilities	Facilities implementing BAT Number (%)	Facilities partially implementing BAT Number (%)	Facilities not implementing BAT Number (%)
29	Implementation of the following management techniques to prevent emissions to groundwater				
	Waste storage by controlling the impermeability layer	13	11 (84)	1 (8)	1 (8)
	Regular monitoring of the topsoil condition (at least 1 in 3 years)	10	5 (50)	1 (10)	4 (40)
	Checking the bottom height of the leachate at the floor of the cell (at least 0.5 m)	10	3 (30)	1 (10)	6 (60)
	Deciding and determining alarm levels for groundwater quality for all landfills, based on the specific hydrogeological conditions of the area, considering the direction and slope of groundwater flow	14	10 (72)	1 (7)	3 (21)
	Ensuring the safety of groundwater monitoring wells	16	15 (94)	0 (0)	1 (6)
30	Application of the following management techniques to minimize leachate emissions				
	Keeping the active fill area as small as possible with a maximum of 25m*25 m and 1:3 slope, unless specifically agreed	11	8 (73)	3 (27)	0 (0)

Table 4.4 (cont'd)

BAT No	BATs	Number of responding facilities	Facilities implementing BAT Number (%)	Facilities partially implementing BAT Number (%)	Facilities not implementing BAT Number (%)
	Usage of daily and intermediate cover and proper compaction to decrease the amount and quality of leachate and water infiltration level	11	9 (82)	1 (9)	1 (9)
	Procedures to ensure that the containment system is not damaged by the placement of soil remediation layers or the environmental control systems	9	7 (78)	1 (11)	1 (11)
	Leachate recirculation	9	3 (33)	1 (11)	5 (56)
	Developing procedures to ensure that the top cover system is not damaged, comprehensive monitoring and repair program	11	6 (55)	2 (18)	3 (27)
	Applying waste acceptance procedures regularly	14	14 (100)	0 (0)	0 (0)
31	<i>Application of the following control techniques to minimize leachate emissions</i>				
	Reducing rain seepage into accumulated waste by using soil, recycled/recovered materials, or artificial cover materials	11	10 (91)	0 (0)	1 (9)

Table 4.4 (cont'd)

BAT No	BATs	Number of responding facilities	Facilities implementing BAT Number (%)	Facilities partially implementing BAT Number (%)	Facilities not implementing BAT Number (%)
	Composition and depth of leachate monitoring	11	5 (46)	4 (36)	2 (18)
	Covering and restoration of the filled parts of the landfill as soon as possible	13	12 (92)	0 (0)	1 (8)
	Collecting and reusing uncontaminated rainwater	12	4 (33)	0 (0)	8 (67)
32	Implementation of the following gas management systems to prevent uncontrolled gas escape from the landfill				
	Pretreating the waste before it is accepted for the landfill for minimization of gas generation potential of landfill	5	3 (60)	1 (20)	1 (20)
	Avoiding landfill gas from passing to the ground in both dissolved and gas states	5	3 (60)	1 (20)	1 (20)
	Avoiding methane emission to the atmosphere	5	3 (60)	0 (0)	2 (40)
	Management of odor risks	5	3 (60)	2 (40)	0 (0)
	Avoiding condensation in the gas collection network	5	4 (80)	0 (0)	1 (20)
	Implementation of horizontal and vertical gas collection piping	5	5 (100)	0 (0)	0 (0)

Table 4.4 (cont'd)

BAT No	BATs	Number of responding facilities	Facilities implementing BAT Number (%)	Facilities partially implementing BAT Number (%)	Facilities not implementing BAT Number (%)
	Balancing of gas wells regularly	4	3 (75)	1 (25)	0 (0)
	Monitoring and balancing of gas extraction wells regularly	5	5 (100)	0 (0)	0 (0)
	Using the automatic warning system for fault detection.	4	2 (50)	0 (0)	2 (50)
	Managing condensation to prevent emissions	5	3 (60)	1 (20)	1 (20)
33	<i>Application of the following techniques for process gas emissions</i>				
	Pretreating waste for biodegradable removal or reduction	5	3 (60)	1 (20)	1 (20)
	Choosing appropriate cell sizes	6	2 (33)	1 (17)	3 (50)
34	<i>Implementation of the following management techniques to minimize the risk of odor in the landfill facility</i>				
	Pretreating odor-producing wastes	7	1 (14)	0 (0)	6 (86)
	Application of proper waste acceptance procedures	8	8 (100)	0 (0)	0 (0)
	Odor Management Plan preparation and implementation	7	3 (43)	1 (14)	3 (43)

Table 4.4 (cont'd)

BAT No	BATs	Number of responding facilities	Facilities implementing BAT Number (%)	Facilities partially implementing BAT Number (%)	Facilities not implementing BAT Number (%)
	Review of gas management and measurement protocols regularly	6	5 (83)	0 (0)	1 (17)
	Management of cell staging and size effectively	6	2 (33)	0 (0)	4 (67)
	Monitoring of closed areas regularly for fugitive volatile organic carbon emissions	6	0 (0)	1 (17)	5 (83)
35	<i>Application of the following techniques for the control of odors in the landfill facility</i>				
	Open tipping area minimization	7	6 (86)	1 (14)	0 (0)
	Storage, compaction, and covering of waste quickly	7	6 (86)	1 (14)	0 (0)
	Providing a 750 m buffer distance from the landfill footprint to any sensitive receptor for a new landfill facility accepting a significant part of the potentially odorous waste	7	5 (71)	0 (0)	2 (29)
	Restriction of especially odorous waste loads and burial of them immediately	7	7 (100)	0 (0)	0 (0)
	Restriction of waste disposal activities in adverse weather conditions	11	7 (64)	0 (0)	4 (36)

To summarize the compliance status of landfills in Türkiye with the BATs from the BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by EPA, a BAT compliance rate above 70% is defined as "high compliance", between 50-70% as "moderate compliance", and less than 50% as "low compliance" and the evaluations presented in Table 4.5 were obtained.

Table 4.5 Summary of Compliance Status of Landfills in Türkiye with the BATs from the BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by EPA

BAT #	BAT	Level of Compliance
19	Conducting a risk assessment for known and unknown obligations to understand and manage environmental risk	High
20	The preparation to ensure that pollution control systems are maintained and effective after the waste storage process is completely finished	High
21	Having financial provision for environmental obligations (known and unknown) after restoration and waste storage process is completed	Low
22	Controlling surface water flow within the landfill, including collection and monitoring activities	High
23	Quality control of the artificial impermeability layer used in the landfill	High
24	Ensuring that all wastes generated in the landfill are properly stored and transported	High
25	Treatment of wastewater before discharge to the receiving environment	High
26	Having an infrastructure regarding the monitoring of discharges to the receiving environment	Moderate
27	Treatment to meet the relevant discharge standards, if discharged to sewers	Low
28	Groundwater monitoring to identify any groundwater contamination from the landfill as soon as possible and to set alarm levels and upper limits	High
29	Implementation of the management techniques to prevent emissions to groundwater	Moderate
30	Application of the management techniques to minimize leachate emissions	High

Table 4.5 (cont'd)

BAT #	BAT	Level of Compliance
31	Application of the control techniques to minimize leachate emissions	Moderate
32	Implementation of the gas management systems to prevent uncontrolled gas escape from the landfill	Moderate
33	Application of the techniques for process gas emissions	Low
34	Implementation of the management techniques to minimize the risk of odor in the landfill facility	Low
35	Application of the techniques for the control of odors in the landfill facility	High

The distribution of BATs by compliance rate is given in Table 4.6. As shown, the compliance rate is over 90% for 23% of the provisions of the BAT Guidance Note on BATs for the Waste Sector: Landfill Activities and 75 to 90% for 15% of the provisions. Looking at findings in general, quite a high compliance of the landfills in Türkiye with the provisions of the BATs is observed.

Table 4.6 Distribution of BATs by Compliance Rate

BAT Compliance Rate	# of BAT	% Distribution of BATs by compliance rate
<%25	27	6
%25-49	21, 33, 34	18
%50-74	20, 26, 29, 30, 31, 32	35
%75-90	23, 25, 35	18
>%90	19, 22, 24, 28	23

4.1.3 Compliance Status of Landfills in Türkiye with the RoLW

As mentioned earlier, the techniques defined in the LD and the BATs defined in “the BAT Guidance Note on BATs for the Waste Sector: Landfill Activities”, cover already the some of the provisions of the RoLW. Appendix E shows the provisions

of the RoLW that overlap with the BATs and techniques, as well as which provision overlaps with which BAT or technique. In this part of the study, the RoLW compliance status of the landfills in Türkiye (excluding inert waste landfills) based on the compliance with the BATs and techniques is presented.

4.1.3.1 Compliance for the Provisions Overlapping with the Landfill Directive

When the 18 techniques from the LD in the BAT Checklist are compared with the RoLW, it is seen that 15 of these techniques are also included in the RoLW (see Appendix E). Therefore, the compliance data for those 15 techniques, form the compliance data for the corresponding operational requirements of the RoLW.

The first of these 15 techniques is about waste acceptance. This technique requires a three-stage waste acceptance procedure stated in Article 18 of the RoLW. As mentioned in Table 4.1, the compliance status of the landfills with Technique 1 is 82%, which is the average of all sub-techniques.

Regarding the techniques related to environmental obligations in the BAT Checklist, Technique 2 and Technique 3 are discussed in Article 6 of the RoLW, together with all sub-techniques taking measures to prevent negative environmental effects and pollution formation. Also, Technique 13, the usage of excavated soil as a top cover after the closure phase of a landfill to protect the soil, groundwater, and surface water, is mentioned in Article 17 of the same regulation. Similarly, Technique 6, regarding stability is discussed in Article 6 of the RoLW. According to the regulation, the wastes accepted to the landfill facility during the operation phase are stored at a security level that will not damage the structural strength of the site and will not cause slips and collapses on interior and exterior slopes. The compliance status of the facilities with these four provisions is high at a rate of 77%, 100%, 81% and 100%, respectively.

On the other hand, Technique 8 and Technique 9, which are related to the control of possible pollution in nearby surface water control, are addressed in the section on

water control and leachate management for the protection of soils and waters in the RoLW. Article 7 Item 2 of the RoLW, corresponds in these two techniques. The compliance status of the facilities with both Technique 8 and Technique 9 is high at a rate of 94%.

Similarly, according to Article 7 of the RoLW, collecting and treating contaminated water and leachate is an important technique for the control of water pollution. These issues in the RoLW correspond to Technique 10 and Technique 11 in the BAT Checklist. The compliance status of the facilities is 94% with Technique 10 and 90% with Technique 11 which indicates a high compliance with the relevant measures.

Article 16 of the RoLW states that an impermeability layer should be formed on the bottom and side surfaces of the landfill facility in a way to prevent the leachate from mixing with the groundwater. In this article, there is information about the geological impermeability layer that should be applied in sanitary landfills, the properties of the artificial impermeability layer, and the drainage layer. This article of the regulation complies with Technique 12 and three sub-techniques of Technique 14. The compliance of the facilities with these two techniques is 80% and 66%, respectively.

Another important issue in landfill facilities is landfill gas management. Issues regarding the gas management in Technique 15, Technique 16, Technique 17, and Technique 18 are addressed in Article 8 of the RoLW. The compliance status of the facilities with these four techniques is 83%, 50%, 67% and 20%, respectively. As indicated in Section 4.1.1, the landfill gas management seems to be a major weakness of the landfills in Türkiye.

A summary of the compliance status of the landfills with the provisions of the RoLW overlapping with the LD is given in Table 4.7. As presented, landfill facilities generally have high compliance with the techniques covered by RoLW. Among 15 techniques, three of them have moderate compliance and one of them has low compliance.

Table 4.7 A Summary of the Compliance Status of Techniques for RoLW

Compliance Status	Technique # (Compliance Rate, %)
High (>70%)	1 (82), 2 (77), 3 (100), 6 (100), 8 (94), 9 (94), 10 (94), 11 (90), 12 (80), 13 (81), 15 (83)
Moderate (50%-70%)	14 (66), 16 (50), 17 (67)
Low (<50%)	18 (20)

As a result, while the total compliance status of the landfill facilities within the scope of the IED in Türkiye with 18 techniques from the LD is 82% as determined in Section 4.1.1, the compliance status with 15 techniques that have legal obligations among these BATs is 79%.

4.1.3.2 Compliance for the Provisions Overlapping with the BATs

When the 17 BATs from the BAT Guidance Note on BATs for the Waste Sector: Landfill Activities in the BAT Checklist are compared with the Turkish legislation, it is seen that 8 of these BATs are also included in the Turkish legislation.

According to Article 23 of the RoLW, the function of the landfill gas and leachate management system built in the landfill facility should continue even after the waste storage process is completely completed. In addition, according to Article 17 of the same regulation, before starting the closure process, it should be determined that the stored waste mass is adequately seated against the risk of slipping and collapsing, and then a top cover should be formed. According to Article 24 of the regulation, alarm levels are regularly monitored in case of a change in groundwater quality after the facility is closed. These issues in Turkish legislation correspond to BAT 20 in the BAT Checklist. As mentioned in Table 4.4, the compliance status of facilities with BAT 20 is high at a rate of 80%.

BAT 21 states that a facility must have financial provisions for environmental obligations after the restoration and waste storage process is completed. In Turkish legislation, financial provisions given for the landfill facility are determined

according to the Waste Management Regulation published in the Official Gazette dated 02/04/2015 and numbered 29314. This is stated in Article 29 of the RoLW. The compliance status of facilities with BAT 21 is low at a rate of 45%.

In Turkish legislation, sampling, analysis frequency and parameters to be considered in the analysis regarding the monitoring of the quality of surface waters are determined and applied according to the provisions of the RoLW. Also, according to the regulation, the contact of surface waters with stored waste should be prevented. These issues correspond to BAT 22 in BAT Checklist. The compliance status of facilities with BAT 22 is high at a rate of 93%.

Article 6 in the same regulation, attention should be paid to slope stability during waste storage. In addition, according to Article 18, vehicles that bring waste to the landfill facility must be registered by the Ministry or have a transport license, in accordance with the Waste Management Regulation. Similarly, BAT 24 states to ensure that all wastes generated in the landfill are properly stored and transported. BAT 24 is applied by all facilities so the percentage of compliance for this BAT is 100%.

As mentioned in the previous section of this thesis, the contaminated water and leachate collected in the landfill must be treated in order to comply with the discharge standards in line with the Water Pollution Control Regulation published in the Official Gazette dated 31/12/2004 and numbered 25687. This is stated in Article 7 of RoLW and corresponds to BAT 25 in the BAT Checklist. The compliance status of facilities with BAT 25 is high at a rate of 86%.

To protect the groundwater quality for all landfills, BAT 28 and sub-technique 4 of BAT 29 include deciding on alarm levels. According to Article 24 of the RoLW, an alarm level must be determined in order to prevent a significant change in groundwater quality. As can be seen, BATs on this subject are also included in Turkish legislation. The compliance status of facilities for these two BATs is 100% and 72%, respectively.

According to Article 7 of RoLW, leachate is collected in the drainage system and equalization tanks and transferred back to the storage area for a period to be determined by the Ministry. In the BAT-Checklist, this is mentioned as leachate recirculation in the fourth sub-technique of BAT 30. Lastly, the sixth sub-technique of the same BAT, adherence to three-stage waste acceptance procedures, is discussed in Article 18 of the RoLW. The average compliance status of facilities with these two sub-techniques of BAT 30 is 67%.

A summary of the compliance status of the landfills with the provisions of the RoLW overlapping with the BAT Guidance Note on BATs for the Waste Sector: Landfill Activities is given in Table 4.8. As presented, landfill facilities generally have high compliance with the BATs covered by RoLW. Among 8 BATs, one of them has moderate compliance and one of them has low compliance.

Table 4.8 A Summary of the Compliance Status of BATs for RoLW

Compliance Status	BAT # (Compliance Rate, %)
High (>70%)	20 (80), 22 (93), 24 (100), 25 (86), 28 (100), 29 (72)
Moderate (50%-70%)	30(67)
Low (<50%)	21 (45)

As a result, while the total compliance status of the landfill facilities within the scope of the IED in Türkiye with 18 BATs from the BAT Guidance Note on BATs for the Waste Sector: Landfill Activities is 70% as determined in Section 4.1.2, the compliance status with 8 BATs that have legal obligations among these BATs is 80%.

4.2 Applicability of BATs and Techniques

In order to determine the applicability of BATs, 16 facilities were interviewed. In these interviews, the BAT-Checklist used for the compliance assessment was used. In this section of this thesis, the applicability of techniques from LD and “BAT

Guidance Note on BATs for the Waste Sector: Landfill Activities” by the Ireland EPA are presented under separate sub-headings.

4.2.1 Applicability of the Techniques from the Council Directive on the Landfill of Waste

In order to determine the applicability of 18 techniques taken from the LD in conditions of Türkiye, 16 facilities were interviewed over the prepared BAT-Checklist, and respondents were asked about how applicable they find the techniques listed to be. Appendix F provides the responses of the facilities interviewed and Table 4.9 presents the overall responses of the landfill sector. As shown, landfill operators find most the techniques listed by the LD “applicable”. The lowest rate is for the adaptation of “taking measures for the control of aerosol formation in the landfill”. Only 33 % of the respondents find this technique applicable. The second lowest rate is for the measures regarding the control of birds, insects, and other animals reproduce in the area and carry pathogens to the environment. Almost half of the respondents find this measure applicable.

Facilities found the techniques regarding waste acceptance, surface water control, safety, stability and quality control, leachate and wastewater management to be highly applicable.

According to applicability results, there is moderate applicability for the two sub-techniques for preventing leachate. While the facilities consider the gas drainage layer application is 57% applicable, a geological impermeable layer is 79% applicable.

In addition, the techniques related to gas management are moderately applicable based on the facility responses. Facilities consider sub-techniques of taking appropriate measures to control the gas generated, collection and treatment of the gas generated, and using the collected gas to generate energy are 63% applicable. On the other hand, the applicability rate for flaring the gas if the collected gas is not used to generate energy is 50%. The reason why facilities do not find techniques on gas

management highly applicable is that there are landfills that do not cause gas generation among responding facilities.

Moreover, the sub-techniques related to taking mitigation measures for the spread of wastes with the effect of the wind, and the possibility of fire, which are among the general obligations of facilities to prevent adverse environmental effects, are found 64% and 67% applicable by facilities, respectively.



Table 4.9 Applicability of Techniques from the Council Directive on the Landfill of Waste

Technique No	Techniques	Number of Responding Facilities	Number of "Applicable" Answers	Number of "Partially Applicable" Answers	Number of "Not Applicable" Answers	Applicability Rate, %
1	<i>Using a three-level hierarchy that includes characterization and testing of waste for their acceptance</i>					
	Level 1: The process of defining and characterizing the main characteristics of the waste	12	11	0	1	92
	Level 2: Compliance tests to meet the waste acceptance criteria given for landfill classes	12	11	0	1	92
	Level 3: Verification tests carried out at the facility to confirm that the wastes transferred to the facility are the same as the declared wastes with basic characterization and compliance tests.	11	9	1	1	82
2	<i>Taking measures on the following issues to minimize the adverse environmental effects and hazards arising from the landfill</i>					
	Odor and dust emissions to the environment	16	13	3	0	81
	Spread of wastes with the effect of the wind	14	9	1	4	64
	Noise and traffic density	14	11	2	1	79

Table 4.9 (cont'd)

Technique No	Techniques	Number of Responding Facilities	Number of "Applicable" Answers	Number of "Partially Applicable" Answers	Number of "Not Applicable" Answers	Applicability Rate, %
	Birds, insects, and other animals reproduce in the area and carry pathogens to the environment.	13	6	3	4	46
	Aerosol formation	12	4	2	6	33
	Possibility of fire	12	8	1	3	67
3	<i>Taking measures to control environmental pollution originating from the landfill</i>	14	14	0	0	100
4	<i>Taking security measures to prevent free access to the landfill</i>	14	14	0	0	100
5	<i>Having a control and access system for the facility, including a program of action to detect and deter illegal dumping at the facility</i>	13	13	0	0	100
6	<i>The placement of waste on the landfill in a way providing the stability of the waste mass and associated structures, especially to prevent slippage</i>	14	14	0	0	100

Table 4.9 (cont'd)

Technique No	Techniques	Number of Responding Facilities	Number of "Applicable" Answers	Number of "Partially Applicable" Answers	Number of "Not Applicable" Answers	Applicability Rate, %
7	<i>If an artificial layer is used, ensuring that the geological substratum is stable enough not to damage the artificial impermeability layer taking into account the morphology of the landfill</i>	12	12	0	0	100
8	<i>Controlling the water coming from precipitations to the landfill</i>	14	13	1	0	93
9	<i>Preventing surface water and/or groundwater from entering landfill waste</i>	13	12	1	0	92
10	<i>Collection of wastewater and leachate</i>	15	15	0	0	100
11	<i>Treatment of wastewater and leachate collected from the landfill according to the appropriate standards required for their discharge</i>	14	13	0	1	93
12	<i>Completion of a geological impermeable layer artificially if necessary to protect soil, groundwater, and surface water</i>	14	14	0	0	100

Table 4.9 (cont'd)

Technique No	Techniques	Number of Responding Facilities	Number of "Applicable" Answers	Number of "Partially Applicable" Answers	Number of "Not Applicable" Answers	Applicability Rate, %
13	<i>Preserving the excavated soil to use as a top cover after the closure phase of a landfill to protect the soil, groundwater, and surface water</i>	12	12	0	0	100
14	<i>In order to prevent leachate, in addition to the geological barrier, the application of the following recommendations for surface sealing</i>					
	Gas drainage layer	14	8	0	6	57
	Artificial sealing liner	11	11	0	0	100
	Geological impermeable layer	14	11	0	3	79
	Drainage layer > 0.5 m	12	11	0	1	92
	Topsoil cover > 1 m	12	12	0	0	100
15	<i>Taking appropriate measures to control the gas generated</i>	8	5	0	3	63
16	<i>Collection and treatment of the gas generated</i>	8	5	0	3	63
17	<i>Using the collected gas to generate energy</i>	8	5	0	3	63
18	<i>Flaring the gas if the collected gas is not used to generate energy</i>	8	4	0	4	50

A summary of the applicability of the techniques from the LD is given in Table 4.10. In this table, the techniques with an applicability rate above 70% are classified as "high applicable", between 50-70% as "moderate applicable", and less than 50 % as "low applicable". As shown, the techniques are found to be generally highly applicable. Of the 18 techniques, facilities rated only consider five techniques with seven sub-techniques “moderately applicable”, and only two sub-techniques as “low applicable” (see Appendix F).

Table 4.10 A Summary of Applicability of Techniques from the LD

Technique #	Technique	Applicability Rate
1	Using a three-level hierarchy that includes characterization and testing of waste for their acceptance	High
2	Taking measures to minimize the adverse environmental effects and hazards arising from the landfill	Moderate
3	Taking measures to control environmental pollution originating from the landfill	High
4	Taking security measures to prevent free access to the landfill	High
5	Having a control and access system for the facility, including a program of action to detect and deter illegal dumping at the facility	High
6	The placement of waste on the landfill in a way providing the stability of the waste mass and associated structures, especially to prevent slippage	High
7	If an artificial layer is used, ensuring that the geological substratum is stable enough not to damage the artificial impermeability layer taking into account the morphology of the landfill	High
8	Controlling the water coming from precipitations to the landfill	High
9	Preventing surface water and/or groundwater from entering landfill waste	High
10	Collection of wastewater and leachate	High

Table 4.10 (cont'd)

Technique #	Technique	Applicability Rate
11	Treatment of wastewater and leachate collected from the landfill according to the appropriate standards required for their discharge	High
12	Completion of a geological impermeable layer artificially if necessary to protect soil, groundwater, and surface water	High
13	Preserving the excavated soil to use as a top cover after the closure phase of a landfill to protect the soil, groundwater, and surface water	High
14	In order to prevent leachate, in addition to the geological barrier, the application of the following recommendations for surface sealing	High
15	Taking appropriate measures to control the gas generated	Moderate
16	Collection and treatment of the gas generated	Moderate
17	Using the collected gas to generate energy	Moderate
18	Flaring the gas if the collected gas is not used to generate energy	Moderate

The distribution of techniques by applicability rate is given in Table 4.11. As shown, the applicability rate is over 90% for 83% of the provisions of the LD and 75 to 90% for 11% of the provisions. All these findings indicate that landfill facilities in Türkiye consider the provisions of the LD highly applicable.

Table 4.11 Distribution of Techniques by Applicability Rate

Applicability Rate	# of Technique	% Distribution of Techniques by applicability rate
<%25	-	0
%25-49	-	0
%50-74	18	6
%75-90	1, 14	11
>%90	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13	83

4.2.2 Applicability of BATs Taken from BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by the Ireland EPA

Similarly, in order to determine the applicability of 17 BATs taken from BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by the Ireland EPA in conditions of Türkiye, 16 facilities were interviewed over the prepared BAT-Checklist, and respondents were asked about how applicable they find the BATs listed to be. Appendix G provides the responses of the facilities interviewed and Table 4.12 presents the overall responses of the landfill sector.

When the applicability of BATs from the BAT Guidance Note on BATs for the Waste Sector: Landfill Activities” by the EPA is evaluated, it is seen that the number of BATs with high applicability is higher than those with moderate and low applicability. As can be seen from Table 4.12, of the 17 BATs and their 43 sub-techniques, facilities thought low applicability is shown for four BATs with 10 sub-techniques. On the other hand, 11 sub-techniques are moderately applicable according to facility responses.

The facilities consider the BATs regarding environmental obligations, surface water control, stability, and quality control are highly applicable. On the other hand, according to facility responses, there are moderate and low applicable BATs as well as highly applicable BATs for leachate and wastewater control. For example, facilities find BAT of treatment to meet the relevant discharge standards, if discharged to sewers applicable with a rate of 38%. This is because facilities that respond to the BAT-Checklist include those that do not currently discharge into sewers. Another low applicable BAT is the composition and depth of leachate monitoring. This monitoring activity was found to be applicable at a rate of 36% by the facilities. In addition, "checking the bottom height of the leachate at the floor of the cell (at least 0.5 m)", and "deciding and determining alarm levels for groundwater quality for all landfills, based on the specific hydrogeological conditions of the area,

considering the direction and slope of groundwater flow" sub-techniques are among the management techniques to prevent emissions to groundwater and have an applicability of 56% and 69%, respectively. Similarly, leachate recirculation, which is among the management techniques to minimize leachate emissions, is a sub-technique that is considered difficult to implement by the facilities with a 33% applicability rate.

Moreover, the implementation of the following gas management systems to prevent uncontrolled gas escape from the landfill BAT, together with its sub-techniques, are found to be low-applicable by facilities. Landfills that do not cause gas formation are reluctant to take measures in this regard and do not consider these BATs to be applicable. Similarly, in relation to gas management BATs, odor management BATs are also techniques where low applicability is observed according to information taken from facilities. Regarding odor management, BATs with moderate applicability have a rate of between 50% and 67%, while BATs with low applicability have a rate of between 10% and 36%.

Table 4.12 Applicability of BATs from BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by the Ireland EPA

BAT No	BATs	Number of Responding Facilities	Number of "Applicable" Answers	Number of "Partially Applicable" Answers	Number of "Not Applicable" Answers	Applicability Rate, %
19	<i>Conducting a risk assessment for known and unknown obligations to understand and manage environmental risk</i>	13	13	0	0	100
20	<i>The preparation to ensure that the following pollution control systems are maintained and effective after the waste storage process is completely finished:</i>					
	Gas control system	8	7	0	1	88
	Leachate collection, treatment, and discharge system	9	8	1	0	89
	Landfill top layer	12	12	0	0	100
	Groundwater monitoring	10	10	0	0	100
	Slope stability	10	10	0	0	100
	All above-ground components, such as gas well covers, leachate pumping manholes, and monitoring boreholes	12	11	0	1	92
21	<i>Having financial provision for environmental obligations (known and unknown) after restoration and waste storage process is completed</i>	11	9	2	0	82

Table 4.12 (cont'd)

BAT No	BATs	Number of Responding Facilities	Number of "Applicable" Answers	Number of "Partially Applicable" Answers	Number of "Not Applicable" Answers	Applicability Rate, %
22	<i>Controlling surface water flow within the landfill, including collection and monitoring activities</i>	13	11	0	2	85
23	<i>Quality control of the artificial impermeability layer used in the landfill</i>	15	15	0	0	100
24	<i>Ensuring that all wastes generated in the landfill are properly stored and transported</i>	14	13	0	1	93
25	<i>Treatment of wastewater before discharge to the receiving environment</i>	8	7	0	1	88
26	<i>Having an infrastructure regarding the monitoring of discharges to the receiving environment</i>	9	8	0	1	89
27	<i>Treatment to meet the relevant discharge standards, if discharged to sewers</i>	8	3	0	5	38

Table 4.12 (cont'd)

BAT No	BATs	Number of Responding Facilities	Number of "Applicable" Answers	Number of "Partially Applicable" Answers	Number of "Not Applicable" Answers	Applicability Rate, %
28	<i>Groundwater monitoring to identify any groundwater contamination from the landfill as soon as possible and to set alarm levels and upper limits</i>	12	11	0	1	92
29	<i>Implementation of the following management techniques to prevent emissions to groundwater</i>					
	Waste storage by controlling the impermeability layer	12	9	2	1	75
	Regular monitoring of the topsoil condition (at least 1 in 3 years)	11	8	0	3	73
	Checking the bottom height of the leachate at the floor of the cell (at least 0.5 m)	9	5	1	3	56
	Deciding and determining alarm levels for groundwater quality for all landfills, based on the specific hydrogeological conditions of the area, considering the direction and slope of groundwater flow	13	9	1	3	69

Table 4.12 (cont'd)

BAT No	BATs	Number of Responding Facilities	Number of "Applicable" Answers	Number of "Partially Applicable" Answers	Number of "Not Applicable" Answers	Applicability Rate, %
	Ensuring the safety of groundwater monitoring wells	15	15	0	0	100
30	<i>Application of the following management techniques to minimize leachate emissions</i>					
	Keeping the active fill area as small as possible with a maximum of 25m*25 m and 1:3 slope, unless specifically agreed	12	9	2	1	75
	Usage of daily and intermediate cover and proper compaction to decrease the amount and quality of leachate and water infiltration level	12	10	0	2	83
	Procedures to ensure that the containment system is not damaged by the placement of soil remediation layers or the environmental control systems	10	7	1	2	70
	Leachate recirculation	9	3	1	5	33

Table 4.12 (cont'd)

BAT No	BATs	Number of Responding Facilities	Number of "Applicable" Answers	Number of "Partially Applicable" Answers	Number of "Not Applicable" Answers	Applicability Rate, %
	Developing procedures to ensure that the top cover system is not damaged, comprehensive monitoring and repair program	12	9	2	1	75
	Applying waste acceptance procedures regularly	11	11	0	0	100
31	<i>Application of the following control techniques to minimize leachate emissions</i>					
	Reducing rain seepage into accumulated waste by using soil, recycled/recovered materials, or artificial cover materials	12	12	0	0	100
	Composition and depth of leachate monitoring	11	4	4	3	36
	Covering and restoration of the filled parts of the landfill as soon as possible	12	12	0	0	100
	Collecting and reusing uncontaminated rainwater	9	8	0	1	89
32	<i>Implementation of the following gas management systems to prevent uncontrolled gas escape from the landfill</i>					

Table 4.12 (cont'd)

BAT No	BATs	Number of Responding Facilities	Number of "Applicable" Answers	Number of "Partially Applicable" Answers	Number of "Not Applicable" Answers	Applicability Rate, %
	Pretreating the waste before it is accepted for the landfill for minimization of gas generation potential of landfill	8	5	0	3	63
	Avoiding landfill gas from passing to the ground in both dissolved and gas states	7	3	1	3	43
	Avoiding methane emission to the atmosphere	8	5	0	3	63
	Management of odor risks	8	4	1	3	50
	Avoiding condensation in the gas collection network	7	4	0	3	57
	Implementation of horizontal and vertical gas collection piping	7	4	0	3	57
	Balancing of gas wells regularly	6	2	1	3	33
	Monitoring and balancing of gas extraction wells regularly	6	3	0	3	50
	Using the automatic warning system for fault detection.	6	1	2	3	17

Table 4.12 (cont'd)

BAT No	BATs	Number of Responding Facilities	Number of "Applicable" Answers	Number of "Partially Applicable" Answers	Number of "Not Applicable" Answers	Applicability Rate, %
	Managing condensation to prevent emissions	7	3	1	3	43
33	<i>Application of the following techniques for process gas emissions</i>					
	Pretreating waste for biodegradable removal or reduction	7	3	0	4	43
	Choosing appropriate cell sizes	9	5	0	4	56
34	<i>Implementation of the following management techniques to minimize the risk of odor in the landfill facility</i>					
	Pretreating odor-producing wastes	10	2	1	7	20
	Application of proper waste acceptance procedures	10	7	0	3	70
	Odor Management Plan preparation and implementation	11	4	1	6	36
	Review of gas management and measurement protocols regularly	10	5	0	5	50
	Management of cell staging and size effectively	10	3	1	6	30
	Monitoring of closed areas regularly for fugitive volatile organic carbon emissions	10	1	1	8	10

Table 4.12 (cont'd)

BAT No	BATs	Number of Responding Facilities	Number of "Applicable" Answers	Number of "Partially Applicable" Answers	Number of "Not Applicable" Answers	Applicability Rate, %
35	<i>Application of the following techniques for the control of odors in the landfill facility</i>					
	Open tipping area minimization	8	7	0	1	88
	Storage, compaction, and covering of waste quickly	8	7	0	1	88
	Providing a 750 m buffer distance from the landfill footprint to any sensitive receptor for a new landfill facility accepting a significant part of the potentially odorous waste	6	4	2	0	67
	Restriction of especially odorous waste loads and burial of them immediately	7	6	0	1	86
	Restriction of waste disposal activities in adverse weather conditions	8	5	0	3	63

A summary of the applicability of BATs from the BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by EPA is given in Table 4.14. In this table, the techniques with an applicability rate above 70% are classified as "high applicable", between 50-70% as "moderate applicable", and less than 50 % as "low applicable". As shown, the techniques are found to be generally highly applicable. Of the 18 techniques, facilities rated consider eleven sub-techniques “moderately applicable”, and four techniques with ten sub-techniques as “low applicable” (see Appendix G).

Table 4.13 A Summary of Applicability of BATs from the BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by EPA

BAT #	BAT	Applicability Rate
19	Conducting a risk assessment for known and unknown obligations to understand and manage environmental risk	High
20	The preparation to ensure that pollution control systems are maintained and effective after the waste storage process is completely finished	High
21	Having financial provision for environmental obligations (known and unknown) after restoration and waste storage process is completed	High
22	Controlling surface water flow within the landfill, including collection and monitoring activities	High
23	Quality control of the artificial impermeability layer used in the landfill	High
24	Ensuring that all wastes generated in the landfill are properly stored and transported	High
25	Treatment of wastewater before discharge to the receiving environment	High
26	Having an infrastructure regarding the monitoring of discharges to the receiving environment	High
27	Treatment to meet the relevant discharge standards, if discharged to sewers	Low

Table 4.13 (cont'd)

BAT #	BAT	Applicability Rate
28	Groundwater monitoring to identify any groundwater contamination from the landfill as soon as possible and to set alarm levels and upper limits	High
29	Implementation of the management techniques to prevent emissions to groundwater	High
30	Application of the management techniques to minimize leachate emissions	High
31	Application of the control techniques to minimize leachate emissions	High
32	Implementation of the gas management systems to prevent uncontrolled gas escape from the landfill	Low
33	Application of the techniques for process gas emissions	Low
34	Implementation of the management techniques to minimize the risk of odor in the landfill facility	Low
35	Application of the techniques for the control of odors in the landfill facility	High

The distribution of BATs by applicability rate is given in Table 4.14. As shown, the applicability rate is over 90% for 29% of the provisions of the BATs and 75 to 90% for 41% of the provisions. All these findings indicate that landfill facilities in Türkiye consider the provisions of the BATs highly applicable.

Table 4.14 Distribution of BATs by Applicability Rate

Applicability Rate	# of BAT	% Distribution of BATs by applicability rate
<%25	-	0
%25-49	27, 32, 34	18
%50-74	30, 33	12
%75-90	21, 22, 25, 26, 29, 31, 35	41
>%90	19, 20, 23, 24, 28	29

4.3 Cost of Compliance with the Techniques and BATs

In this section, a compliance cost assessment is provided for the full compliance of the landfills in Türkiye with the techniques listed in the LD and BATs listed by the Ireland EPA as well as the provisions of the RoLW. While calculating the compliance cost, besides the investment cost of each BAT/technique, the non-compliance ratio of the facilities to each BAT/technique is also considered, since the investment for compliance is to be made by the landfill facilities that do not comply with the BATs/techniques. Along with the investment cost for each BAT/technique, the sectoral cost for full compliance with all the BATs/techniques is presented in this section.

An example compliance cost calculation is presented below for Technique 1. Table 4.15 presents the cost of compliance of a landfill with the waste acceptance-related Technique 1. As compliance with this technique requires compliance with all three sub-techniques, the compliance cost for this technique should be equal to the total cost of compliance with the three sub-techniques.

Table 4.15 Cost of Compliance with Technique 1

BAT/Tech nique No	BAT/Technique	Investment needed for BAT/LD Compliance in a landfill, €	Non- Compliance Level	Sectoral Investment Needed for BAT/LD Compliance in Landfills, €
Technique 1	<i>Using a three-level hierarchy that includes characterization and testing of waste for their acceptance</i>			
	Level 1: The process of defining and characterizing the main characteristics of the waste	0	0.07	0
	Level 2: Compliance tests to meet the waste acceptance criteria given for landfill classes	20,000	0.28	134,400

Table 4.15 (cont'd)

BAT/Technique No	BAT/Technique	Investment needed for BAT/LD Compliance in a landfill, €	Non-Compliance Level	Sectoral Investment Needed for BAT/LD Compliance in Landfills, €
	Level 3: Verification tests carried out at the facility to confirm that the wastes transferred to the facility are the same as the declared wastes with basic characterization and compliance tests.	10,000	0.2	48,000

As can be seen from Table 4.15, no investment is required for compliance with the first sub-technique of Technique 1. On the other hand, an investment of 20,000 and 10,000 Euros is necessary for compliance of a landfill facility with the second and third sub-techniques, respectively. Therefore, the cost of the cost of complying with Technique 1 for a landfill is 30.000 €.

4.3.1 Sectoral Cost of Compliance with BATs and Techniques

The sectoral cost of complying with the second sub-technique of Technique 1 is calculated as follows;

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{\text{Technique 1-Subtechnique 2}} = 20,000 \text{ Euros}$$

$$Compliance\ Level_{\text{Technique 1-Subtechnique 2}} = 0.72$$

$$\begin{aligned} \text{Sectoral total investment cost} &= 24 \times 20,000 \times (1 - 0.72) \\ &= \mathbf{134,400 \text{ Euros}} \end{aligned}$$

Similarly, for the third sub-technique of Technique 1;

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{BAT1-Subtechnique\ 3} = 10,000 \text{ Euros}$$

$$Compliance\ Level_{BAT1-Subtechnique\ 3} = 0.8$$

$$\begin{aligned} \text{Sectoral investment cost} &= 24 \times 10,000 \times (1 - 0.8) \\ &= \mathbf{48,000 \text{ Euros}} \end{aligned}$$

Then, the total sectoral cost for Technique 1 is 182,400 Euros, which is the sum of the sectoral investments of the second and third sub-techniques of Technique 1.

This calculation was made for all BAT/techniques and sub-techniques, and the sectoral compliance costs presented in Table 4.16 to Table 4.22 were obtained. (The details of the calculations are given in Appendix H). As the cost of compliance with some BATs/techniques already covers the cost of other relevant BAT/technique or sub-technique, for some of the BATs/techniques, no additional costs were considered. In the cost columns of Table 4.16 to Table 4.22, for these BATs/techniques, no cost figures are presented.

Table 4.16 Cost of Compliance with the Environmental Obligations Related BATs/Techniques

BAT/Technique No	BATs/Techniques	Investment needed for BAT/LD Compliance in a landfill, €	Non-Compliance Level	Sectoral Investment Needed for the BAT/LD Compliance in Landfills, €
Technique 2	<i>Taking measures on the following issues to minimize the adverse environmental effects and hazards arising from the landfill</i>			
	Odor and dust emissions to the environment	650,000	0.29	2,964,000
	Spread of wastes with the effect of the wind	Included in 1 st sub-technique of Technique 2.	0.11	Included in 1 st sub-technique of Technique 2.
	Noise and traffic density	*	0.08	*
	Birds, insects, and other animals reproduce in the area and carry pathogens to the environment.	*	0.25	*
	Aerosol formation	*	0.63	*
Technique 3	Possibility of fire	175,000	0.14	588,000
	<i>Taking measures to control environmental pollution originating from the landfill</i>	*	0	*
Technique 13	<i>Preserving the excavated soil to use as a top cover after the closure phase of a landfill to protect the soil, groundwater, and surface water</i>	35,000	0.19	159,600
BAT 19	<i>Conducting a risk assessment for known and unknown obligations to understand and manage environmental risk</i>	40,000	0.06	57,600

Table 4.16 (cont'd)

BAT/Technique No	BATs/Techniques	Investment needed for BAT/LD Compliance in a landfill, €	Non-Compliance Level	Sectoral Investment Needed for the BAT/LD Compliance in Landfills, €
BAT 20	<i>The preparation to ensure that the following pollution control systems are maintained and effective after the waste storage process is completely finished:</i>			
	Gas control system	100,000	0.57	1,368,000
	Leachate collection, treatment, and discharge system	3,150,000	0.93	15,876,000
	Landfill top layer	Included in 1 st sub-technique of Technique 2.	0.06	Included in 1 st sub-technique of Technique 2.
	Groundwater monitoring	*	0	*
	Slope stability	*	0.07	*
	All above-ground components, such as gas well covers, leachate pumping manholes, and monitoring boreholes	1,200,000	0.27	7,776,000
BAT 21	<i>Having financial provision for environmental obligations (known and unknown) after restoration and waste storage process is completed</i>	*	0.55	*

Table 4.17 Cost of Surface Water Control Related BATs/Techniques

BAT/Technique No	BATs/Techniques	Investment needed for the BAT/LD Compliance in a landfill, €	Non-Compliance Level	Sectoral Investment Needed for the BAT/LD Compliance in Landfills, €
Technique 8	<i>Controlling the water coming from precipitations to the landfill</i>	Included in Technique 22.	0.06	Included in Technique 22.
Technique 9	<i>Preventing surface water and/or groundwater from entering landfill waste</i>	22,700	0.06	32,688
BAT 22	<i>Controlling surface water flow within the landfill, including collection and monitoring activities</i>	30,000	0.07	50,400

Table 4.18 Cost of Stability and Quality Control Related BATs/Techniques

BAT/Technique No	BATs/Techniques	Investment needed for the BAT/LD Compliance in a landfill, €	Non-Compliance Level	Sectoral Investment Needed for the BAT/LD Compliance in Landfills, €
Technique 6	<i>The placement of waste on the landfill in a way providing the stability of the waste mass and associated structures, especially to prevent slippage</i>	0	0	0

Table 4.18 (cont'd)

BAT/Technique No	BATs/Techniques	Investment needed for the BAT/LD Compliance in a landfill, €	Non-Compliance Level	Sectoral Investment Needed for the BAT/LD Compliance in Landfills, €
Technique 7	<i>If an artificial layer is used, ensuring that the geological substratum is stable enough not to damage the artificial impermeability layer taking into account the morphology of the landfill</i>	72,500	0	0
BAT 23	<i>Quality control of the artificial impermeability layer used in the landfill</i>	20,000	0.19	91,200
BAT 24	<i>Ensuring that all wastes generated in the landfill are properly stored and transported</i>	0	0	0

Table 4.19 Cost of Security-Related BATs/Techniques

BAT/Technique No	BATs/Techniques	Investment needed for the BAT/LD Compliance in a landfill, €	Non-Compliance Level	Sectoral Investment Needed for the BAT/LD Compliance in Landfills, €
Technique 4	<i>Taking security measures to prevent free access to the landfill</i>	5500	0	0
Technique 5	<i>Having a control and access system for the facility, including a program of action to detect and deter illegal dumping at the facility</i>	25,000	0	0

Table 4.20 Cost of Leachate and Wastewater Management-Related BATs/Techniques

BAT/Technique No	BATs/Techniques	Investment needed for the BAT/LD Compliance in a landfill, €	Non-Compliance Level	Sectoral Investment Needed for the BAT/LD Compliance in Landfills, €
Technique 10	<i>Collection of wastewater and leachate</i>	Included in 2 nd sub technique of Technique 20.	0.06	Included in 2 nd sub technique of Technique 20.
Technique 11	<i>Treatment of wastewater and leachate collected from the landfill according to the appropriate standards required for their discharge</i>	Included in 2 nd sub technique of Technique 20.	0.1	Included in 2 nd sub technique of Technique 20.
Technique 12	<i>Completion of a geological impermeable layer artificially if necessary to protect soil, groundwater, and surface water</i>	450,000	0.2	2,160,000
Technique 14	<i>In order to prevent leachate, in addition to the geological barrier, the application of the following recommendations for surface sealing</i>			
	Gas drainage layer	500,000	0.58	6,960,000
	Artificial sealing liner	450,000	0.14	1,512,000
	Geological impermeable layer	100,000	0.29	696,000
	Drainage layer > 0.5 m	112,500	0.2	540,000
	Topsoil cover > 1 m	35,000	0.43	361,200
BAT 25	<i>Treatment of wastewater before discharge to the receiving environment</i>	Included in 2 nd sub technique of Technique 20.	0.14	Included in 2 nd sub technique of Technique 20.

Table 4.20 (cont'd)

BAT/Technique No	BATs/Techniques	Investment needed for the BAT/LD Compliance in a landfill, €	Non-Compliance Level	Sectoral Investment Needed for the BAT/LD Compliance in Landfills, €
BAT 26	<i>Having an infrastructure regarding the monitoring of discharges to the receiving environment</i>	*	0.43	*
BAT 27	<i>Treatment to meet the relevant discharge standards, if discharged to sewers</i>	Included in 2 nd sub technique of Technique 20.	0.8	Included in 2 nd sub technique of Technique 20.
BAT 28	<i>Groundwater monitoring to identify any groundwater contamination from the landfill as soon as possible and to set alarm levels and upper limits</i>	*	0	*
BAT 29	<i>Implementation of the following management techniques to prevent emissions to groundwater</i>			
	Waste storage by controlling the impermeability layer	0	0.16	0
	Regular monitoring of the topsoil condition (at least 1 in 3 years)	0	0.5	0
	Checking the bottom height of the leachate at the floor of the cell (at least 0.5 m)	0	0.7	0

Table 4.20 (cont'd)

BAT/Technique No	BATs/Techniques	Investment needed for the BAT/LD Compliance in a landfill, €	Non-Compliance Level	Sectoral Investment Needed for the BAT/LD Compliance in Landfills, €
	Deciding and determining alarm levels for groundwater quality for all landfills, based on the specific hydrogeological conditions of the area, considering the direction and slope of groundwater flow Ensuring the safety of groundwater monitoring wells	150,000 40,000	0.28 0.06	1,044,000 57,600
BAT 30	<i>Application of the following management techniques to minimize leachate emissions</i>			
	Keeping the active fill area as small as possible with a maximum of 25m*25 m and 1:3 slope, unless specifically agreed	0	0.27	0
	Usage of daily and intermediate cover and proper compaction to decrease the amount and quality of leachate and water infiltration level	0	0.18	0
	Procedures to ensure that the containment system is not damaged by the placement of soil remediation layers or the environmental control systems	20,000	0.22	105,600

Table 4.20 (cont'd)

BAT/Technique No	BATs/Techniques	Investment needed for the BAT/LD Compliance in a landfill, €	Non-Compliance Level	Sectoral Investment Needed for the BAT/LD Compliance in Landfills, €
	Leachate recirculation	60,000	0.67	964,800
	Developing procedures to ensure that the top cover system is not damaged, comprehensive monitoring and repair program	0	0.45	0
	Applying waste acceptance procedures regularly	0	0	0
BAT 31	<i>Application of the following control techniques to minimize leachate emissions</i>			
	Reducing rain seepage into accumulated waste by using soil, recycled/recovered materials, or artificial cover materials	65,000	0.09	140,400
	Composition and depth of leachate monitoring	40,000	0.54	528,000
	Covering and restoration of the filled parts of the landfill as soon as possible	0	0.08	0
	Collecting and reusing uncontaminated rainwater	0	0.67	0

Table 4.21 Cost of Gas Management-Related BATs/Techniques

BAT/Technique No	BATs/Techniques	Investment needed for the BAT/LD Compliance in a landfill, €	Non-Compliance Level	Sectoral Investment Needed for the BAT/LD Compliance in Landfills, €
Technique 15	<i>Taking appropriate measures to control the gas generated</i>	1,000,000	0.17	4,080,000
Technique 16	<i>Collection and treatment of the gas generated</i>	90,000	0.5	1,080,000
Technique 17	<i>Using the collected gas to generate energy</i>	Included in Technique 15.	0.33	Included in Technique 15.
Technique 18	<i>Flaring the gas if the collected gas is not used to generate energy</i>	Included in Technique 15.	0.8	Included in Technique 15.
BAT 32	<i>Implementation of the following gas management systems to prevent uncontrolled gas escape from the landfill</i>			
	Pretreating the waste before it is accepted for the landfill for minimization of gas generation potential of landfill	15,000,000	0.4	144,000,000
	Avoiding landfill gas from passing to the ground in both dissolved and gas states	Included in Technique 15.	0.4	Included in Technique 15.
	Avoiding methane emission to the atmosphere	Included in Technique 15.	0.4	Included in Technique 15.
	Management of odor risks	Included in Technique 15.	0.4	Included in Technique 15.

Table 4.21 (cont'd)

BAT/Technique No	BATs/Techniques	Investment needed for the BAT/LD Compliance in a landfill, €	Non-Compliance Level	Sectoral Investment Needed for the BAT/LD Compliance in Landfills, €
	Avoiding condensation in the gas collection network	Included in Technique 15.	0.2	Included in Technique 15.
	Implementation of horizontal and vertical gas collection piping	Included in Technique 15.	0	Included in Technique 15.
	Balancing of gas wells regularly	Included in Technique 15.	0.25	Included in Technique 15.
	Monitoring and balancing of gas extraction wells regularly	Included in Technique 15.	0	Included in Technique 15.
	Using the automatic warning system for fault detection.	Included in Technique 15.	0.5	Included in Technique 15.
	Managing condensation to prevent emissions	Included in Technique 15.	0.4	Included in Technique 15.
BAT 33	<i>Application of the following techniques for process gas emissions</i>			
	Pretreating waste for biodegradable removal or reduction	Included in 1 st sub technique of Technique 32.	0.4	Included in 1 st sub technique of Technique 32.
	Choosing appropriate cell sizes	0	0.67	0

Table 4.22 Cost of Odor Management-Related BATs/Techniques

BAT/Technique No	BAT/Technique	Investment needed for the BAT Compliance in a landfill, €	Non-Compliance Level	Sectoral Investment Needed for the BAT Compliance in Landfills, €
BAT 34	Implementation of the following management techniques to minimize the risk of odor in the landfill facility			
	Pretreating odor-producing wastes	Included in 1 st sub technique of Technique 32.	0.86	Included in 1 st sub technique of Technique 32.
	Application of proper waste acceptance procedures	0	0	0
	Odor Management Plan preparation and implementation	0	0.57	0
	Review of gas management and measurement protocols regularly	0	0.17	0
	Management of cell staging and size effectively	0	0.67	0
BAT 35	Monitoring of closed areas regularly for fugitive volatile organic carbon emissions	Included in Technique 15.	1	Included in Technique 15.
	Application of the following techniques for the control of odors in the landfill facility			
	Open tipping area minimization	0	0.14	0
	Storage, compaction, and covering of waste quickly	0	0.14	0
	Providing a 750 m buffer distance from the landfill footprint to any sensitive receptor for a new landfill facility accepting a significant part of the potentially odorous waste	0	0.29	0

Table 4.22 (cont'd)

BAT/Technique No	BAT/Technique	Investment needed for the BAT Compliance in a landfill, €	Non-Compliance Level	Sectoral Investment Needed for the BAT Compliance in Landfills, €
	Restriction of especially odorous waste loads and burial of them immediately	0	0	0
	Restriction of waste disposal activities in adverse weather conditions	0	0.36	0

The graph representing the total sectoral costs determined as a result of the cost calculations for BAT/technique subjects is given in Figure 4.1.

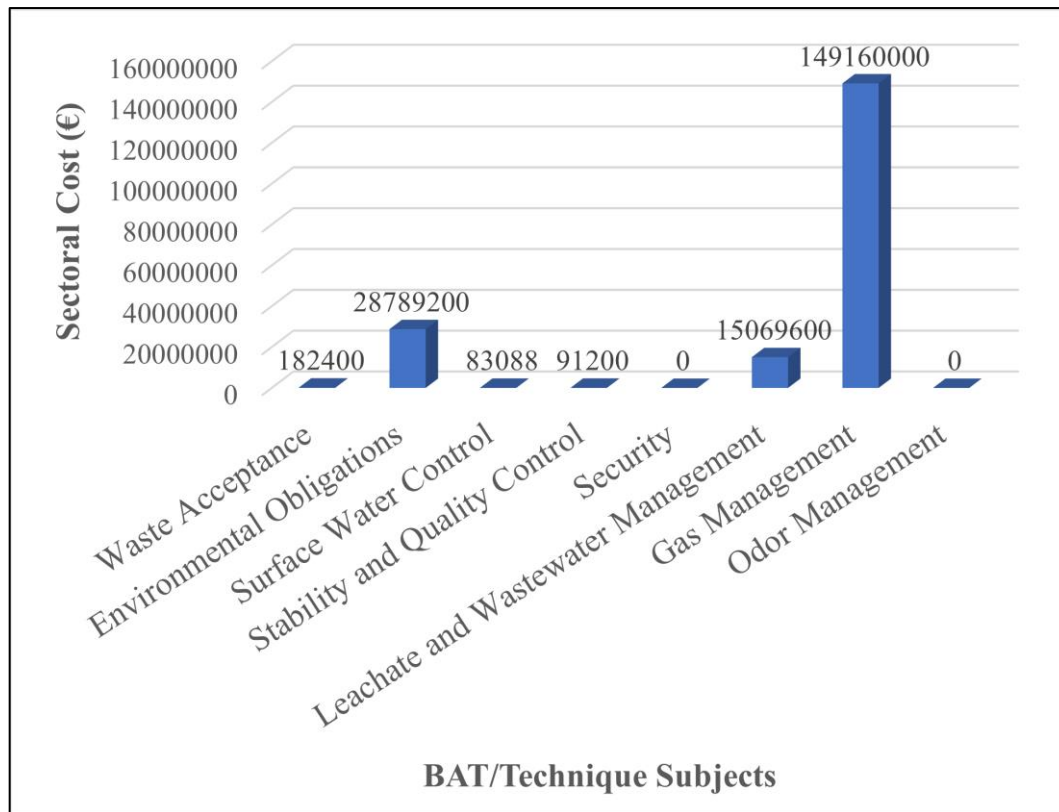


Figure 4.1 Sectoral Costs by BAT/Technique Subjects

According to cost analysis results, the costliest BATs/techniques are related to gas management. The sectoral compliance cost for these BATs/techniques was calculated as 149,160,000 Euros as given in Figure 4.1. Among the gas management-related BATs/techniques, “pretreating the waste before it is accepted for the landfill to minimize the gas generation potential of the landfill” is the one with the highest compliance cost of 144,000,000 as shown in Table 4.21.

After the BATs/techniques related to gas management, the BATs/techniques that require the highest cost are related to the environmental obligations of landfills. Sub-technique of “maintaining pollution control systems that are all above-ground components, such as gas well covers, leachate pumping manholes, and monitoring boreholes after the waste storage process is completely finished” require high cost.

The costliest sub-technique of this group is the leachate collection, treatment, and discharge system with 15,876,000 Euros as can be seen in Table 4.16.

The third most costly BATs/techniques are about leachate and wastewater management. Among the BATs/techniques grouped under this subject, the technique that causes the most cost is the sub-technique about the installation of gas drainage layer with a sectoral cost of 6,960,000 Euros as mentioned in Table 4.20.

Waste acceptance-related techniques, which rank fourth in cost with 182,400 Euros as given in Figure 4.1, generally include analyzes and verifications made during the waste acceptance process.

Among the BATs/techniques under the subject of stability and quality control, all BATs/techniques have 100% compatibility except one BAT. Therefore, sectoral cost is determined only for this BAT. The BAT of quality control of the artificial impermeability layer used in the landfill with a cost of 91,200 Euro, constitutes the sectoral cost requirement of this group as presented in

Table 4.18 and this group ranks fifth in sectoral cost requirement.

While surface water control-related BATs/techniques ranked sixth, as the facilities fully comply with security-related ones, this group does not need sectoral costs. In addition, since the BATs/techniques that require cost among the BATs/techniques related to odor management are evaluated in the gas management group and this group generally consists of cost-free BATs/techniques, there is no need for any sectoral cost for the odor management group.

In summary, the BATs/techniques that require the most sectoral cost are the gas management-related BATs/techniques with 149,600,000 Euros as presented in Figure 4.1. This group is followed by the subjects of environmental obligations, leachate and wastewater management, waste acceptance, stability, and quality control, and surface water control, respectively. Since there is no need for any sectoral costs, security, and odor management-related BATs/techniques are in the last place.

As a results of the cost analysis findings, average cost of complying with BATs and techniques for a landfill and total sectoral cost of complying with BATs and techniques are given in Table 4.23.

Table 4.23. A Summary of Cost Analysis for Compliance with BATs and Techniques

# of landfills falling under the LD	Average Cost of complying with BATs and Techniques for a landfill	Sectoral cost of complying with BATs and Techniques
24	8,057,312	193,375,488

4.3.2 Sectoral Cost of Compliance with the RoLW

In addition to the sectoral costs determined for compliance with BATs and techniques, the cost of complying with the RoLW was also evaluated. This evaluation can help to establish a priority for the implementation of BATs/techniques in Türkiye. Table 4.24 presents the sectoral compliance costs for each of the provisions of the RoLW and also the overall sectoral full compliance cost with the RoLW.

Table 4.24. Sectoral Compliance Costs for RoLW

BAT/ Technique #	Definition	Sectoral cost of compliance, €
Technique 1	Using a three-level hierarchy that includes characterization and testing of waste for their acceptance	182,400
Technique 2	Taking measures to minimize the adverse environmental effects and hazards arising from the landfill	3,552,200
Technique 3	Taking measures to control environmental pollution originating from the landfill	*
Technique 6	The placement of waste on the landfill in a way providing the stability of the waste mass and associated structures, especially to prevent slippage	0
Technique 8	Controlling the water coming from precipitations to the landfill	Included in Technique 22.
Technique 9	Preventing surface water and/or groundwater from entering landfill waste	32,688
Technique 10	Collection of wastewater and leachate	Included in 2 nd sub-technique of Technique 20.
Technique 11	Treatment of wastewater and leachate collected from the landfill according to the appropriate standards required for their discharge	Included in 2 nd sub-technique of Technique 20.
Technique 12	Completion of a geological impermeable layer artificially if necessary to protect soil, groundwater, and surface water	2,160,000
Technique 13	Preserving the excavated soil to use as a top cover after the closure phase of a landfill to protect the soil, groundwater, and surface water	159,600
Technique 14	In order to prevent leachate, in addition to the geological barrier, the application of the following recommendations for surface sealing (Sub-technique no 1, 2, 3)	9,168,000
Technique 15	Taking appropriate measures to control the gas generated	4,080,000
Technique 16	Collection and treatment of the gas generated	1,080,000

Table 4.24 (cont'd)

BAT/ Technique #	Definition	Sectoral cost of compliance, €
Technique 17	Using the collected gas to generate energy	Included in Technique 15.
Technique 18	Flaring the gas if the collected gas is not used to generate energy	Included in Technique 15.
BAT 20	The preparation to ensure that pollution control systems are maintained and effective after the waste storage process is completely finished	20,020,000
BAT 21	Having financial provision for environmental obligations (known and unknown) after restoration and waste storage process is completed	*
BAT 22	Controlling surface water flow within the landfill, including collection and monitoring activities	50,400
BAT 24	Ensuring that all wastes generated in the landfill are properly stored and transported	0
BAT 25	Treatment of wastewater before discharge to the receiving environment	Included in 2 nd sub-technique of Technique 20.
BAT 28	Groundwater monitoring to identify any groundwater contamination from the landfill as soon as possible and to set alarm levels and upper limits	*
BAT 29	Implementation of the management techniques to prevent emissions to groundwater (Sub-technique no 4)	1,044,000
BAT 30	Application of the management techniques to minimize leachate emissions (Sub-technique no 4, 6)	964,800
TOTAL		42,493,888

The total sectoral costs found by classifying the BATs and techniques in Turkish legislation according to their subjects are given in Table 4.25.

Table 4.25 Sectoral Compliance Costs for RoLW by BATs/Techniques Subjects

BATs/Techniques Subjects	BATs/Techniques #	Sectoral cost of compliance, €
Waste Acceptance	1	182,400
Environmental Obligations	2, 3, 13, 21	28,731,600
Surface Water Control	22	83,088
Stability and Quality Control	6, 24	0
Leachate and Wastewater Management	10, 11, 12, 14 (sub-technique no 1, 2, 3), 25, 28, 29 (sub-technique 4), 30 (sub-technique no 4, 6)	13,336,800
Gas Management	15, 16, 17, 18	5,160,000

In addition, the cost analysis prepared for only BATs/techniques with legal obligations and determined according to the subjects of the techniques are presented in Figure 4.2. As can be seen from Figure 4.2, the BAT/technique subject that requires the most cost with legal obligation is environmental obligations, which includes more general techniques, measures to prevent pollution to water, soil and air and to reduce negative environmental impacts. These BATs/techniques are followed by the BATs/techniques related to leachate and wastewater management, gas management, waste acceptance and surface water control, respectively. BATs/techniques related to stability and quality control, security and odor management do not require any cost.

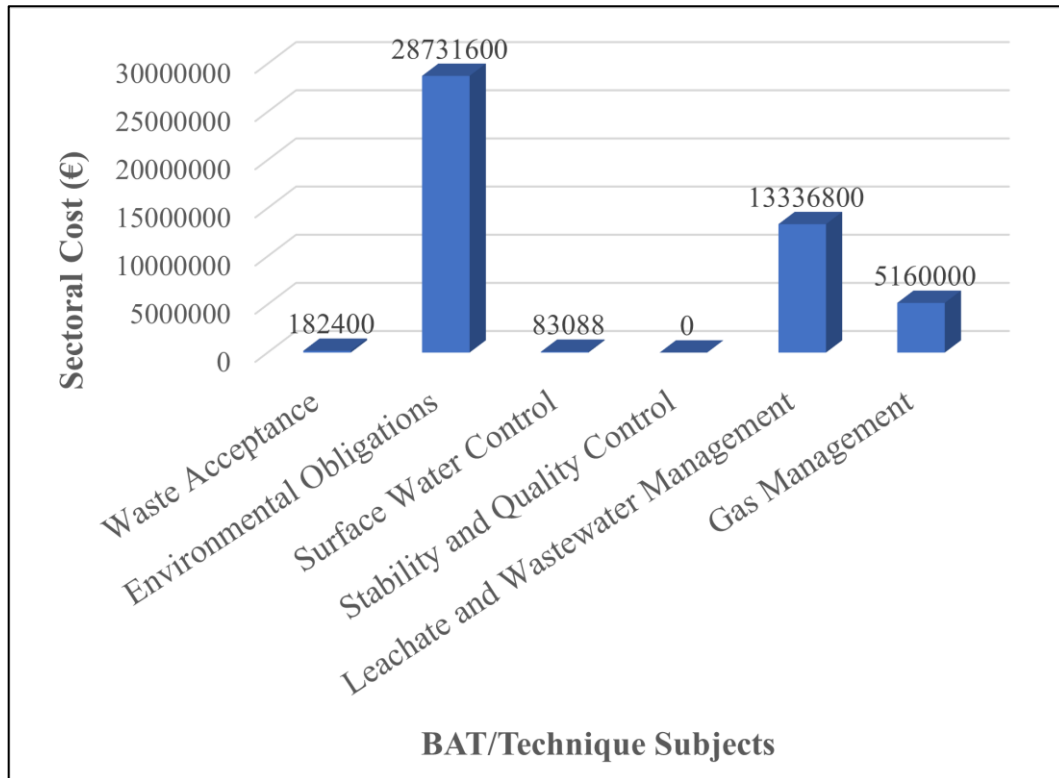


Figure 4.2 Sectoral Cost of Compliance with the RoLW by BATS/Techniques Subjects

Technique 1 which is about waste acceptance procedures is, should be applied by all facilities as it is also mandatory and of great importance in Turkish legislation. On the other hand, BATs/techniques, which are evaluated under the heading of environmental obligations and related to both the operation and after the closure of the facility, have legal obligations as mentioned in the previous sections of this thesis. The only exception here is the BAT of conducting a risk assessment for known and unknown obligations to understand and manage environmental risk, discussed in BAT 19.

Surface water control is another important issue in landfill facilities and all BATs/techniques determined in this regard are also mandatory by Turkish legislation. The techniques determined under the security heading are not included in the regulations in force in Türkiye, but the facilities attach importance to preventing free access and detecting illegal dumping. Therefore, all facilities apply these techniques, and the sectoral cost is zero for these techniques.

Looking at the BATs/techniques in the stability and quality control group, it is seen that half of these BATs/techniques are legally required. It is seen that one of the techniques that is not legally obligatory is applied by all facilities. However, since quality control of the artificial impermeability layer used in the landfill is applied by 81% of facilities in Türkiye, this BAT requires cost.

Among the BATs/techniques determined for leachate and wastewater management, it was determined that four BATs/techniques and their 10 sub-techniques are not legally required. As seen in Figure 4.2, BATs/techniques related to leachate and wastewater management, which have legal obligations, have a sectoral cost of 13,336,800 Euros.

The most general and important technique related to gas management is Technique 15, taking appropriate measures to control the gas generated. Many BATs and techniques that are not included in the Turkish legislation and are sub-techniques of BAT 32 have been evaluated under Technique 15 and included in its cost. However, the first sub-technique of BAT 32, pretreating the waste before it is accepted for the landfill for minimization of gas generation potential of the landfill, is a sub-technique that has a high investment cost of 144 million Euros (see Table 4.21) and is not included in the Turkish legislation. The pretreating odor-producing wastes technique, which is among the BATs related to odor management, is also included in this cost. On the other hand, BATs related to odor management generally do not require cost, even if they are not included in Turkish legislation.

The total required cost of all BATs and techniques taken from both the LD and the BAT Guidance Note on BATs for the Waste Sector: Landfill Activities is 193,375,488 Euros. However, BATs/techniques, which are not included in the Turkish legislation and thus do not have legal obligations, constitute 75% of the total sectoral cost. Thus, the BATs and techniques covered by Turkish legislation require 42,493,888 Euros in total as presented in Table 4.25. During the implementation of BATs and techniques, BATs/techniques with legal obligations will take precedence over those that do not.

All the BATs/techniques in the BAT Checklist provide benefits in avoiding or reducing negative environmental impacts if they occur. While prioritizing BATs/techniques, it is necessary to look at the environmental benefits and their costs, apart from distinguishing whether the BATs/techniques have legal obligations or not.

Since the BATs related to odor management do not require any cost, they can be applied more easily, although they do not have legal obligations. On the other hand, the BAT of pretreatment of wastes, which is included in the gas management techniques but is also effective in reducing the odor potential, will be more difficult to implement as it will cause a cost of 144 million Euros.

The quality control process of the artificial impermeable layer, which is under the heading of stability and quality control and causes a cost of 91200 Euros, is a very important BAT. Since the impermeable layer will prevent the leachate from mixing with soil and groundwater, it is necessary to ensure regular quality control, although it is not required by the regulation.

In addition, among the BATs/techniques that do not have legal obligations for leachate and wastewater management, there are BATs/techniques and sub-techniques that do not require cost and can thus be easily applied.

Finally, the BAT of conducting a risk assessment for known and unknown obligations to understand and manage environmental risks, which is included under environmental obligations, is an important BAT that does not have a legal obligation. The sectoral cost for this BAT is 57600 Euros. Risk assessment is among the BATs/techniques that should be prioritized even if it is not in Turkish legislation, as it will help to raise awareness about possible hazards and prevent negative effects.

As a results of the cost analysis findings, average cost of complying with RoLW for a landfill and total sectoral cost of complying with RoLW are given in Table 4.26.

Table 4.26. A Summary of Cost Analysis for Compliance with RoLW

# of landfills falling under the LD	Average Cost of complying with RoLW for a landfill	Sectoral cost of complying with RoLW
24	1,770,589	42,493,888



CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

The purpose of the IED is to approach pollution control in an integrated way and to prevent emissions to air, water, and soil. According to the directive, in cases where emissions cannot be reduced, it is aimed to minimize them as much as possible, thus creating a minimum environmental impact via the application of BATs. The IED is the general framework for the integrated prevention and control of pollution from many industrial activities, including waste management activity, and for achieving sustainable development.

In this thesis, the BAT and LD compliance status of landfills, one of the activities falling under the waste management sector, was studied. The Council Directive on the Landfill of Waste (1999/31/EC) and the BAT Guidance Note on BATs for the Waste Sector: Landfill Activities prepared by the Ireland EPA were used as references in preparing the BAT Checklist that includes a total 35 BATs/techniques. Based on the responses from the field study visits made to four landfills and online surveys conducted with 12 landfills, the BAT and LD compliance status of landfills, the applicability of BATs/techniques and also the investment needed for full compliance with LD and BATs were determined. The following conclusions were drawn:

- The landfills covered by the IED in Türkiye are highly compatible with BATs/techniques. While the total average compliance level with the 18 techniques from the Council Directive on the Landfill of Waste is as high as 82%, the compliance with the BATs listed by the Ireland EPA is 70%.
- The overall BAT and LD compliance level of landfill facilities covered by the IED was calculated as over 75%.

- Among the techniques taken from the Council Directive on the Landfill of Waste, the compliance of the facilities only with the ones included in the Turkish legislation is 79%.
- Among the BATs taken from the BAT Guidance Note on BATs for the Waste Sector: Landfill Activities prepared by the Ireland EPA, the compliance of the facilities only with the ones included in the Turkish legislation is 80%.
- The applicability rate is over 90% for 83% of the provisions of the LD and 75 to 90% for 11% of the provisions of LD.
- The applicability rate is over 90% for 29% of the provisions of the BATs and 75 to 90% for 41% of the provisions of BATs.
- The total BAT and LD compliance cost of the landfill sector in Türkiye is 193,375,488 Euros, and the average investment needed per landfill facility was estimated as 8,057,312 Euros. The BATs/techniques that require the highest investment are the gas management related ones with 149,600,000 Euros. A large part of this cost is the sub-technique of pretreating the waste before it is accepted for the landfill for minimization of gas generation potential of landfill with a sectoral cost of 144,000,000 Euros.
- BATs/techniques related to gas management are followed by the subjects of environmental obligations, leachate and wastewater management, waste acceptance, stability, and quality control, and surface water control in terms of cost, respectively.

With this thesis, it is revealed what actions the facilities should take in order to become compatible with BATs/techniques. Gas management, which is an important issue for landfills, should not be neglected and landfill facilities must be operated in compliance with the BATs and techniques defined for the management of landfill gas. The landfills need to ensure the gas is collected and used to generate energy or flared. In relation to gas management, facilities should also take measures to address the odor problem. In this context, facilities should apply techniques for pretreating odor-producing wastes. In addition, necessary measures should be taken regarding the leachate, which is another important issue. Leachate management must be done

properly to protect soil and water resources. Facilities should not neglect to control the leachate level in the waste storage cells. Moreover, alternative uses of leachate and surface water such as leachate recirculation and reusing uncontaminated rainwater should be given a chance in order to use water efficiently and to reduce the resulting pollution.

The results of the study are expected to be a reference point for decision makers who will develop policy options that can promote sectoral alignment with the IED. In addition, landfill operators who aim to minimize possible negative effects by addressing environmental problems in an integrated manner can benefit from the BATs evaluated in this thesis. In this context, besides revealing the compliance of BATs, the determination of applicability of BATs in conditions of Türkiye and cost analysis will be a beneficial factor for the authorities in their decision-making process.



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APPENDICES

A. ANNEX I of the IED - Categories of activities COVERED BY THE IED

1. Energy industries

1.1. Combustion of fuels in installations with a total rated thermal input of 50 MW or more

1.2. Refining of mineral oil and gas

1.3. Production of coke

1.4. Gasification or liquefaction of:

(a) coal;

(b) other fuels in installations with a total rated thermal input of 20 MW or more.

2. Production and processing of metals

2.1. Metal ore (including sulphide ore) roasting or sintering

2.2. Production of pig iron or steel (primary or secondary fusion) including continuous casting, with a capacity exceeding 2,5 tonnes per hour

2.3. Processing of ferrous metals:

(a) operation of hot-rolling mills with a capacity exceeding 20 tonnes of crude steel per hour;

(b) operation of smitheries with hammers the energy of which exceeds 50 kilojoule per hammer, where the calorific power used exceeds 20 MW;

(c) application of protective fused metal coats with an input exceeding 2 tonnes of crude steel per hour.

2.4. Operation of ferrous metal foundries with a production capacity exceeding 20 tonnes per day

2.5. Processing of non-ferrous metals:

- (a) production of non-ferrous crude metals from ore, concentrates or secondary raw materials by metallurgical, chemical or electrolytic processes;
- (b) melting, including the alloyage, of non-ferrous metals, including recovered products and operation of non-ferrous metal foundries, with a melting capacity exceeding 4 tonnes per day for lead and cadmium or 20 tonnes per day for all other metals.

2.6. Surface treatment of metals or plastic materials using an electrolytic or chemical process where the volume of the treatment vats exceeds 30 m³

3. Mineral industry

3.1. Production of cement, lime and magnesium oxide:

- (a) production of cement clinker in rotary kilns with a production capacity exceeding 500 tonnes per day or in other kilns with a production capacity exceeding 50 tonnes per day;
- (b) production of lime in kilns with a production capacity exceeding 50 tonnes per day;
- (c) production of magnesium oxide in kilns with a production capacity exceeding 50 tonnes per day.

3.2. Production of asbestos or the manufacture of asbestos-based products

3.3. Manufacture of glass including glass fibre with a melting capacity exceeding 20 tonnes per day

3.4. Melting mineral substances including the production of mineral fibres with a melting capacity exceeding 20 tonnes per day

3.5. Manufacture of ceramic products by firing, in particular roofing tiles, bricks, refractory bricks, tiles, stoneware or porcelain with a production capacity

exceeding 75 tonnes per day and/or with a kiln capacity exceeding 4 m³ and with a setting density per kiln exceeding 300 kg/m³

4. Chemical industry

For the purpose of this section, production within the meaning of the categories of activities contained in this section means the production on an industrial scale by chemical or biological processing of substances or groups of substances listed in points 4.1 to 4.6

4.1. Production of organic chemicals, such as:

- (a) simple hydrocarbons (linear or cyclic, saturated or unsaturated, aliphatic or aromatic);
- (b) oxygen-containing hydrocarbons such as alcohols, aldehydes, ketones, carboxylic acids, esters and mixtures of esters, acetates, ethers, peroxides and epoxy resins;
- (c) sulphurous hydrocarbons;
- (d) nitrogenous hydrocarbons such as amines, amides, nitrous compounds, nitro compounds or nitrate compounds, nitriles, cyanates, isocyanates;
- (e) phosphorus-containing hydrocarbons;
- (f) halogenic hydrocarbons;
- (g) organometallic compounds;
- (h) plastic materials (polymers, synthetic fibres and cellulose-based fibres);
- (i) synthetic rubbers;
- (j) dyes and pigments;
- (k) surface-active agents and surfactants.

4.2. Production of inorganic chemicals, such as:

(a) gases, such as ammonia, chlorine or hydrogen chloride, fluorine or hydrogen fluoride, carbon oxides, sulphur compounds, nitrogen oxides, hydrogen, sulphur dioxide, carbonyl chloride;

(b) acids, such as chromic acid, hydrofluoric acid, phosphoric acid, nitric acid, hydrochloric acid, sulphuric acid, oleum, sulphurous acids;

(c) bases, such as ammonium hydroxide, potassium hydroxide, sodium hydroxide;

(d) salts, such as ammonium chloride, potassium chlorate, potassium carbonate, sodium carbonate, perborate, silver nitrate;

(e) non-metals, metal oxides or other inorganic compounds such as calcium carbide, silicon, silicon carbide.

4.3. Production of phosphorous-, nitrogen- or potassium-based fertilisers (simple or compound fertilisers)

4.4. Production of plant protection products or of biocides

4.5. Production of pharmaceutical products including intermediates

4.6. Production of explosives

5. Waste management

5.1. Disposal or recovery of hazardous waste with a capacity exceeding 10 tonnes per day involving one or more of the following activities:

(a) biological treatment;

(b) physico-chemical treatment;

(c) blending or mixing prior to submission to any of the other activities listed in points 5.1 and 5.2;

(d) repackaging prior to submission to any of the other activities listed in points 5.1 and 5.2;

- (e) solvent reclamation/regeneration;
- (f) recycling/reclamation of inorganic materials other than metals or metal compounds;
- (g) regeneration of acids or bases;
- (h) recovery of components used for pollution abatement;
- (i) recovery of components from catalysts;
- (j) oil re-refining or other reuses of oil;
- (k) surface impoundment.

5.2. Disposal or recovery of waste in waste incineration plants or in waste coincineration plants:

- (a) for non-hazardous waste with a capacity exceeding 3 tonnes per hour;
- (b) for hazardous waste with a capacity exceeding 10 tonnes per day.

5.3. (a) Disposal of non-hazardous waste with a capacity exceeding 50 tonnes per day involving one or more of the following activities, and excluding activities covered by Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment⁷:

- (i) biological treatment;
- (ii) physico-chemical treatment;
- (iii) pre-treatment of waste for incineration or co-incineration;
- (iv) treatment of slags and ashes;

⁷ OJ L 135, 30.5.1991, p. 40.

(v) treatment in shredders of metal waste, including waste electrical and electronic equipment and end-of-life vehicles and their components.

(b) Recovery, or a mix of recovery and disposal, of non-hazardous waste with a capacity exceeding 75 tonnes per day involving one or more of the following activities, and excluding activities covered by Directive 91/271/EEC:

(i) biological treatment;

(ii) pre-treatment of waste for incineration or co-incineration;

(iii) treatment of slags and ashes;

(iv) treatment in shredders of metal waste, including waste electrical and electronic equipment and end-of-life vehicles and their components.

When the only waste treatment activity carried out is anaerobic digestion, the capacity threshold for this activity shall be 100 tonnes per day.

5.4. Landfills, as defined in Article 2(g) of Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste⁸, receiving more than 10 tonnes of waste per day or with a total capacity exceeding 25 000 tonnes, excluding landfills of inert waste

5.5. Temporary storage of hazardous waste not covered under point 5.4 pending any of the activities listed in points 5.1, 5.2, 5.4 and 5.6 with a total capacity exceeding 50 tonnes, excluding temporary storage, pending collection, on the site where the waste is generated

5.6. Underground storage of hazardous waste with a total capacity exceeding 50 tonnes

6. Other activities

6.1. Production in industrial installations of:

⁸ OJ L 182, 16.7.1999, p. 1.

- (a) pulp from timber or other fibrous materials;
- (b) paper or card board with a production capacity exceeding 20 tonnes per day;
- (c) one or more of the following wood-based panels: oriented strand board, particleboard or fibreboard with a production capacity exceeding 600 m³ per day.

6.2. Pre-treatment (operations such as washing, bleaching, mercerisation) or dyeing of textile fibres or textiles where the treatment capacity exceeds 10 tonnes per day

6.3. Tanning of hides and skins where the treatment capacity exceeds 12 tonnes of finished products per day

6.4. (a) Operating slaughterhouses with a carcass production capacity greater than 50 tonnes per day

(b) Treatment and processing, other than exclusively packaging, of the following raw materials, whether previously processed or unprocessed, intended for the production of food or feed from:

(i) only animal raw materials (other than exclusively milk) with a finished product production capacity greater than 75 tonnes per day;

(ii) only vegetable raw materials with a finished product production capacity greater than 300 tonnes per day or 600 tonnes per day where the installation operates for a period of no more than 90 consecutive days in any year;

(iii) animal and vegetable raw materials, both in combined and separate products, with a finished product production capacity in tonnes per day greater than:

- 75 if A is equal to 10 or more; or,
- $[300 - (22,5 \times A)]$ in any other case,

where 'A' is the portion of animal material (in percent of weight) of the finished product production capacity.

Packaging shall not be included in the final weight of the product.

This subsection shall not apply where the raw material is milk only.

(c) Treatment and processing of milk only, the quantity of milk received being greater than 200 tonnes per day (average value on an annual basis).

6.5. Disposal or recycling of animal carcasses or animal waste with a treatment capacity exceeding 10 tonnes per day

6.6. Intensive rearing of poultry or pigs:

(a) with more than 40 000 places for poultry;

(b) with more than 2 000 places for production pigs (over 30 kg), or

(c) with more than 750 places for sows.

6.7. Surface treatment of substances, objects or products using organic solvents, in particular for dressing, printing, coating, degreasing, waterproofing, sizing, painting, cleaning or impregnating, with an organic solvent consumption capacity of more than 150 kg per hour or more than 200 tonnes per year

6.8. Production of carbon (hard-burnt coal) or electrographite by means of incineration or graphitisation

6.9. Capture of CO₂ streams from installations covered by this Directive for the purposes of geological storage pursuant to Directive 2009/31/EC

6.10. Preservation of wood and wood products with chemicals with a production capacity exceeding 75 m³ per day other than exclusively treating against sapstain

6.11. Independently operated treatment of waste water not covered by Directive 91/271/EEC and discharged by an installation covered by Chapter II.

B. BAT Checklist

Anketin yapıldığı tarih :/...../2022

AÇIKLAMALAR

- Bu anket formu, "Entegre Kirlilik Önleme ve Kontrolü (EKÖK) Kapsamında Atık İşleme Tesislerinin Değerlendirilmesi, Uyum Durumlarının Araştırılması ve Uyum Gereksinim Modellerinin Geliştirilmesi Projesi" kapsamında Çevre, Şehircilik ve İklim Değişikliği Bakanlığı (Çevre Yönetimi Genel Müdürlüğü) adına hazırlanmıştır.
- Bu anket formu proje kapsamındaki: (i) atık işleme sektörlerinin mevcut durumunun ortaya konması, (ii) söz konusu sektörlerde Mevcut En İyi Teknik'lerin (MET'lerin) uygulanabilirliğinin belirlenmesi, (iii) MET'leri içeren prosesler ve/veya tesisler için yatırım maliyetlerinin tespit edilmesi, (iv) MET'leri içeren proseslerin uygulanması için ihtiyaç duyulan zamanın belirlenmesi, (v) MET Sonuç Dokümanlarında belirtilmiş olan zorunlu MET'lerin söz konusu sektörler tarafından karşılanma durumunun ortaya konması amacıyla kullanılacaktır. Verilecek bilgi ve belgeler bu amaç dışında herhangi bir yerde kullanılmayacak ve üçüncü şahıs veya kurumlarla paylaşılmayacaktır.
- Anketler, atık işleme sektörlerinde faaliyet gösteren tesislerde uygulanacaktır.
- Birden fazla atık işleme alt sektöründe (örneğin, düzenli depolama, anaerobik işleme vb) faaliyet gösteren tesislerin her bir alt sektör faaliyeti için ilgili anketleri doldurmaları beklenmektedir. (Örneğin **İşbu anket "Düzenli Atık Depolama Sahaları Anketi"**). Ancak, "Genel MET uygulamaları" anketinin her tesis için sadece bir kez doldurulması yeterlidir.
- Bu anket formunda istenilen bilgiler asgari bilgiler olup belirtilen hususları destekleyici her türlü ayrıntılı tablo, rapor, belge, doküman vb. ankete eklenmesi (mesaj eki olarak ya da, uygunsa, bu excel dokümanında ek bir segme olarak) rica olunur.
- Anket formunda cevap için ayrılan alanın yetersiz kaldığı durumlarda yazım alanı gerektiği kadar genişletilebilir.
- Anketi doldurduktan sonra lütfen doküman isminin sonuna tesis ismini ekleyerek kaydediniz (örn: Düzenli Atık Depolama Sahaları (Düzenli Atık Depolama Sahaları Anketi_tesis adı)
- Sorularınız için iletişim bilgisi: Prof. Dr. Ulku Yetiş (e-posta: uyetis@metu.edu.tr) veya Reyvan Karahan (e-posta: reyvan.karahan@metu.edu.tr)

2010/75/EU Direktifi EK.1 Kapsam Değerlendirmesi	
5.4. Günde 10 tondan fazla atık alan veya toplam kapasitesi 25.000 tonu aşan katı atık depolama alanları (inert atıkların düzenli depolama sahaları hariç)	
* Lütfen ankete başlamadan önce aşağıda istenen bilgileri doldurunuz.	
1.	Firma/Tesis Adı: _____ Şehir: _____ Kabul edilen atık: ton/gün Toplam depolama kapasitesi: ton Katılımcının Adı: _____ Görevi: _____ Telefon No: _____ Cep Tel. : ____ / ____ - ____ E-Posta: _____ @ _____
2.	
3.	Tesisinizde işlenen atık türünü işaretleyiniz: ☐ Tehlikeli Atık ☐ Tehlikesiz Atık
4.	☐ Organize Sanayi Bölgesi ☐ İş Kumesi ☐ Teknoloji Geliştirme Bölgesi (TeknoPark) ☐ Serbest Bölge ☐ Münferit/Tekil ☐ Diğer
5.	Tesisinizin kuruluş yılı: _____ Tesisinizin toplam çalışan sayısı: _____ kişi
6.	Düzenli atık depolama saha sınıfı ☐ 1. Sınıf ☐ 2. Sınıf ☐ 3. Sınıf
7.	Tesisinizde işlenen atıkların kodlarını belirtiniz (ya da bir doküman olarak paylaşınız).
8.	Tesisinizde uygulanan düzenli atık depolama prosesi ile doğrudan teknik bağlantısı olan diğer faaliyetler (geçici depolama, ön işlem, üretilen atığın işlenmesi vb.) varsa lütfen yazınız. Bu faaliyetlerin her biri için kapasite bilgisini yazınız. Faaliyet 1 : ton atık/gün Faaliyet 2 : ton atık/gün Faaliyet 3 : ton atık/gün Faaliyet 4 : ton atık/gün Faaliyet 5 : ton atık/gün Faaliyet 6 : ton atık/gün Faaliyet 7 : ton atık/gün

BREF Bölüm No/MET No/Teknik No*	Kaynak/Sayfa No	MET	MET Uygulamasına ilişkin Görüşler (Bu kolonda, E, F, G, H, I ve J kolonlarında verdiğiniz yanıtlara ilişkin açıklama, kabuller ve diğer belirtmek istediğiniz hususları yazınız)	Uygulama Durumu	Uygunabilirlik	Yatırım Maliyeti (Euro)	İşletme, Bakım Maliyeti (Euro)	MET Uyumu için Gerektiği Süre	MET Uygulamasının Sağladığı Tasarruflar (m3 su, kg/sa elektrik, TL/yıl vb.)
Teknik 1	Konsey Direktifi 1999/31/EC / S.15	Atığın genel karakterizasyonu ve testi için aşağıdaki üç aşamalı kontrol yöntemini kullanıyor musunuz?	Aşama 1. Atıkların Düzenli Depolanmasına Dair Yönetmelik Madde 19'a göre atığın temel özelliklerinin tanımlanması ve nitelendirilmesi işlemi (Bu aşama, atığın depolama tesisi'ne kabulünden önce; tesise gönderilmesi planlanan atığın ürettiği kaynakta yapısını ve tüm özelliklerini gösteren bilgiler toplanarak atığın temel özelliklerinin tanımlanması ve nitelendirilmesini içerir.) Aşama 2. Atıkların Düzenli Depolanmasına Dair Yönetmelik Madde 21'ye göre uygunluk testi uygulaması (Bu aşama, en azından temel özelliklerinin tanımlanması ve nitelendirilmesi için yapılan testlerden oluşur.) Aşama 3. Atıkların Düzenli Depolanmasına Dair Yönetmelik Madde 22'ye göre testin doğrulama işlemi uygulaması (Bu aşama, tesise sevk edilen atıkların uygunluk ve temel nitelendirilme testleri ile beyan edilen atıklar ile aynı olduğunun teyidi için tesiste yapılan doğrulama testlerini içerir.) *Aşama 3 testi zorunludur ve Seviye 1 ve Seviye 2 mümkün olduğu ölçüde uygulanır. Bu ön aşamada, belirli bir depolama sahası sınıfa kabul edilecek atık, ya sınırlayıcı ulusal ya da sahaya özgü bu depolama sahası sınıfı listesinde yer almalı ya da	☐ Evet ☐ Hayır ☐ Kamen	☐ Uygulanabilir ☐ Uygulanamaz ☐ Kamen Uygulanabilir			☐ <1 yıl ☐ 1-3 yıl ☐ 3-5 yıl ☐ >5 yıl	
				☐ Evet ☐ Hayır ☐ Kamen	☐ Uygulanabilir ☐ Uygulanamaz ☐ Kamen Uygulanabilir			☐ <1 yıl ☐ 1-3 yıl ☐ 3-5 yıl ☐ >5 yıl	
				☐ Evet ☐ Hayır ☐ Kamen	☐ Uygulanabilir ☐ Uygulanamaz ☐ Kamen Uygulanabilir			☐ <1 yıl ☐ 1-3 yıl ☐ 3-5 yıl ☐ >5 yıl	

Meteorolojik Veriler			Yer Altı Suyunu Korumaya Yönelik İzleme		
Parametre	İşletme Aşaması İzleme Sıklığı	Kapatma Sonrası Aşama İzleme Sıklığı	Parametre	İşletme Aşaması İzleme Sıklığı	Kapatma Sonrası Aşama İzleme Sıklığı
Yağış hacmi (mm/gün, mm/ay)			Yer altı suyu seviyesi	(1)	(1)
Sıcaklık, en düşük, en yüksek ve ortalama 14-00'de (°C)			Yer altı suyu kompozisyonu	(2) (3)	(2) (3)
Rüzgârın yönü ve hızı (m/s)		-	(1) Değişiklen yeraltı suyu seviyeleri varsa, frekans artırılmalıdır.		
Buharlaşma (mm/gün, mm/ay)			(2) Sıklık, iki örnek arasında bir tetkikleme seviyesine ulaşıldığında, yönlendirici eylemler olasılığına dayanmalıdır, yani frekans, bilgi birikimi ve yeraltı suyu akış		
Bağıl nem		-	(3) Bir tetkikleme seviyesine ulaşıldığında örneklemeyle tekrarlanarak doğrulama		
Kaynak: Atıkların düzenli depolanmasına dair yönetmelik, Ek-4			Kaynak: Konsey Direktifi 1999/31/EC / S.18		
Depo Gazı ve Sızıntı Suyunun Kontrolü ve İzlenmesi			Düzenli Depolama Alanı Gövdesine İlişkin Veriler		
Parametre	İşletme Aşaması İzleme Sıklığı (2)	Kapatma Sonrası Bakım Aşaması İzleme Sıklığı (2)	Parametre	İşletme Aşaması İzleme Sıklığı	Kapatma Sonrası Aşama İzleme Sıklığı
Sızıntı suyu hacmi (6)			Düzenli depolama gövdesinin yapısı ve bileşimi (1)		
Sızıntı suyunun kompozisyonu (1) (6)			Düzenli depolama gövdesi seviyesinin çökme davranışı		
CH ₄ , CO ₂ , H ₂ S, O ₂ ve H ₂ emisyonları (3)	(4)	(5)	(1) İlgili düzenli depolama sahasının durum planı için veriler: atığın kapladığı yüzey, atık hacmi ve bileşimi, biriktirme yöntemleri, biriktirme zamanı ve süresi, düzenli depolama sahasında hala mevcut olan kalan kapasitenin hesaplanması.		
(1) Ölçülmesi gereken parametreler depolanmış atığın kompozisyonuna bağlı olarak değişkenlik gösterir.			Kaynak: Konsey Direktifi 1999/31/EC / S.19		
(2) Bakım için uygun görmesi halinde analiz sıklığı, tesis bazında azaltılabilir. Ancak sızıntı sularında iletkenlik yılda en az bir kez ölçülür.					
(3) Gaz ölçümleri depolanan atığın organik madde içeriğine bağlıdır.					
(4) CH ₄ , CO ₂ , O ₂ gazları tablodaki verilen sıklıkta, diğer gazlar depolanan atığın kompozisyonuna bağlı olarak belirlenir ve uygun görülen sıklıkta ölçülür.					
(5) Gaztoplama sisteminin kapatma sonrasındaki verimliliği düzenli olarak kontrol edilir.					
(6) Sızıntı suyu hacmi ve kompozisyonu sadece sızıntı suyu toplama sistemi bulunan tesislerde tespit edilir.					
Kaynak: Atıkların düzenli depolanmasına dair yönetmelik, Ek-5					

Yüzey Suyu Emisyonları İçin Emisyon Seviyesi Değerleri *			Kaçak Hava Emisyonları		
Parametre (Not 1)	MET-İES	Yüzdelik azalma	Parametre	Konsantrasyon/Alarm Level	
pH		-	Metan	%..... hacim/hacim ya da %..... Lower Explosive Limit (Not 1)	
Toksiste (Not 2)	 TU	-		 ppmv sınırlı alan üzerinden ortalama	
BOD5	 mg/L	%..... (Not 4)	Uçucu organik karbon (yüzey emisyonu)	Depolama sahası ayak izi içindeki açık yüzeylerde ppmv anlık okuma Tanımlanan tüm özellikler etrafında ppmv	
Aşıda katı madde	 mg/L	-	Karbon dioksit	%..... hacim/hacim	
Toplam amonyak (N olarak)	 mg/L	-	Toplam toz atılımı	 mg/m ² /day	
Toplam nitrojen (N olarak) (Not 3&5)	 mg/L	%..... (Not 4)			
Toplam fosfor (P olarak) (Not 5)	 mg/L	%..... (Not 4)	Not 1: Herhangi bir sondaj değinde, binada veya bitişğinde bulunan bir tesiste, servis kanalı veya menhol üzerinde ölçülmüştür.		
Metaller	(Not 6)	-			
Öncelikli Maddeler (Suya göre Çerçeve Direktifi)	(Not 6)	-			
Diğer	(Not 6&7)	-			
*Bütün değerler aksi belirtilmedikçe günlük ortalama 24 saat akış oranlı kompozit numuneye ve sürekli değeri ifade eden pH'dır. Seviyeler, kirlenmiş akarsularla seyreltilmeden önceki atık su için geçerlidir, öm. Yağmur suyu, soğutma suyu, vb.			Depo Gazı Yakma ve Kullanım Tesisleri İçin Emisyon Seviyesi Değerleri (Not 1)		
Değer			Parametre	Alevlenme (kapalı)	Kullanım Tesisi
Not 1: Bir EPA lisansında pH, TOC ve iletkenlik gibi parametreler için çökeltilme havuzlarından yüzey suyu deşarjına testleme seviyeleri konulabilir.			NOx	 mg/m ³	 mg/m ³
Not 2: Toksik birim sayısı (TU) = 100 / X saat EC / LC50 (hacim / hacim yüzdezi olarak), böylece daha yüksek TU değerleri daha yüksek toksite seviyelerini yansıtır. Tüm ölçümlerin kolayca tespit edilemediği test rejimleri için, hareketleştirme ölümüyle eşdeğer kabul edilir.			Not 1: Isı gradının, büyük yakma tesislerinden havaya belirli kirlenmelerin emisyonlarının sınırlandırılmasına ilişkin 2001/80 / EC sayılı Direktif 50MW'yi aşması durumunda geçerli olacaktır.		
Not 3: Toplam Azot, Kükürlü Azot, Nitrat N ve Nitröz N'nin toplamı anlamına gelir.			Kaynak: EPA - Atık Sektörü İçin Mevcut En İyi Teknikler hakkında Nihai Taslak BAT Kılavuz		
Not 4: Griş yükü ile ilgili azalma.			Notu: Düzelti Depolama Faaliyetleri/S.35, Tablo 6.3		
Not 5: Sınırlar, alıcı su kütlesinin hassasiyetine bağlı olacaktır.					
Not 6: BAT ile ilgili emisyon seviyeleri büyük ölçüde üretim sürecine, atık su matrisine ve arıtmaya bağlıdır. Bu parametreler, emisyon sınır değerleri belirlenirken sahaya özgü bir temelde dikkate alınacaktır.					
Not 7: 2004 tarihli S.1. No. 394 Çözgezinde belirtilen ilgili kirlenici maddeler: EPA (Lisanslama) (Değişiklik) Yönetmelikleri, 2004					
Kaynak: EPA - Atık Sektörü İçin Mevcut En İyi Teknikler hakkında Nihai Taslak BAT Kılavuz Notu: Düzelti Depolama Faaliyetleri/S.34, Tablo 6.1					

C. Facility Responses for the Compliance Status of BATs from the Council Directive on the Landfill of Waste (Y: Yes, N: No, P: Partially, NN: Not Necessary)

Technique No	Description	Landfill Facilities															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Technique 1	Using a three-level hierarchy that includes characterization and testing of waste for their acceptance																
	Level 1: The process of defining and characterizing the main characteristics of the waste	Y	N	Y	NN	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	-	Y
	Level 2: Compliance tests to meet the waste acceptance criteria given for landfill classes	Y	N	Y	NN	P	Y	Y	Y	P	-	P	Y	Y	Y	Y	Y
	Level 3: Verification tests carried out at the facility to confirm that the wastes transferred to the facility are the same as the declared wastes with basic characterization and compliance tests.	Y	N	Y	NN	Y	Y	NN	N	NN	NN	NN	Y	Y	Y	-	Y
Technique 2	Taking measures on the following issues to minimize the adverse environmental effects and hazards arising from the landfill																

Technique No	Description	Landfill Facilities															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
	Odor and dust emissions to the environment	Y	N	Y	P	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	P	Y
	Spread of wastes with the effect of the wind	Y	P	Y	NN	Y	Y	NN	NN	NN	NN	Y	Y	Y	Y	NN	Y
	Noise and traffic density	Y	N	Y	NN	Y	Y	NN	Y	Y	Y	Y	Y	Y	Y	NN	-
	Birds, insects, and other animals reproduce in the area and carry pathogens to the environment.	Y	P	P	NN	Y	Y	NN	NN	NN	NN	Y	Y	Y	Y	NN	-
	Aerosol formation	N	N	P	NN	N	N	NN	NN	NN	NN	Y	Y	Y	Y	NN	-
	Possibility of fire	Y	Y	P	NN	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	-
Technique 3	Taking measures to control environmental pollution originating from the landfill	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Technique 4	Taking security measures to prevent free access to the landfill	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Technique 5	Having a control and access system for the facility, including a program of action to detect and deter illegal dumping at the facility	Y	Y	Y	NN	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Technique No	Description	Landfill Facilities															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Technique 6	The placement of waste on the landfill in a way providing the stability of the waste mass and associated structures, especially to prevent slippage	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Technique 7	If an artificial layer is used, ensuring that the geological substratum is stable enough not to damage the artificial impermeability layer taking into account the morphology of the landfill	Y	Y	Y	Y	Y	Y	NN	Y	Y	Y	Y	Y	Y	-	Y	-
Technique 8	Controlling the water coming from precipitations to the landfill	Y	Y	P	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Technique 9	Preventing surface water and/or groundwater from entering landfill waste	Y	Y	P	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Technique 10	Collection of wastewater and leachate	Y	Y	Y	P	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Technique No	Description	Landfill Facilities															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Technique 11	Treatment of wastewater and leachate collected from the landfill according to the appropriate standards required for their discharge	NN	NN	Y	P	Y	NN	NN	NN	Y	Y	Y	Y	Y	Y	NN	Y
Technique 12	Completion of a geological impermeable layer artificially if necessary to protect soil, groundwater, and surface water	Y	Y	Y	P	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	-	N
Technique 13	Preserving the excavated soil to use as a top cover after the closure phase of a landfill to protect the soil, groundwater, and surface water	Y	Y	P	N	P	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Technique 14	In order to prevent leachate, in addition to the geological barrier, the application of the following recommendations for surface sealing																
	Gas drainage layer	Y	Y	Y	N	N	N	NN	NN	N	N	N	Y	Y	N	NN	-
	Artificial sealing liner	Y	Y	Y	P	Y	Y	NN	NN	Y	Y	Y	Y	Y	N	Y	-

Technique No	Description	Landfill Facilities															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
	Geological impermeable layer	Y	Y	Y	Y	Y	Y	NN	NN	N	N	N	Y	Y	N	Y	-
	Drainage layer > 0.5 m	Y	Y	Y	N	N	Y	NN	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Topsoil cover > 1 m	Y	Y	P	N	N	Y	NN	N	N	N	N	Y	Y	Y	Y	-
	Taking appropriate measures to control the gas generated	Y	Y	Y	NN	Y	NN	NN	NN	NN	NN	NN	NN	Y	NN	N	NN
Technique 16	Collection and treatment of the gas generated	Y	N	P	NN	Y	NN	NN	NN	NN	NN	NN	Y	NN	N	NN	NN
Technique 17	Using the collected gas to generate energy	Y	N	Y	NN	Y	NN	NN	NN	NN	NN	NN	Y	NN	N	NN	NN
Technique 18	Flaring the gas, if the collected gas is not used to generate energy	N	N	N	NN	Y	NN	NN	NN	NN	NN	NN	NN	NN	N	NN	NN

D. Facility Responses for the Compliance Status of BATs from the BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by the Ireland EPA (Y: Yes, N: No, P: Partially, NN: Not Necessary)

BAT No	Description	Facilities															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
BAT 19	Conducting a risk assessment for known and unknown obligations to understand and manage environmental risk	Y	Y	Y	Y	Y	Y	N	Y		Y	Y	Y	Y	Y	Y	Y
BAT 20	The preparation to ensure that the following pollution control systems are maintained and effective after the waste storage process is completely finished:																
	Gas control system	Y	Y	Y	NN	P	N	NN	NN	NN	NN	NN	N	N	NN	NN	NN
	Leachate collection, treatment, and discharge system	P	Y	Y	P	Y	P	Y	Y	Y	-	Y	Y	Y	Y	Y	-
	Landfill top layer	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Groundwater monitoring	Y	Y	Y	Y	Y	Y	NN	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Slope stability	Y	Y	Y	N	Y	Y	Y	NN	Y	Y	Y	Y	Y	Y	Y	Y
	All above-ground components, such as gas well covers, leachate pumping manholes, and monitoring boreholes	Y	Y	Y	N	Y	Y	Y	P	P	P	P	Y	Y	Y	NN	Y
	Having financial provision for environmental obligations (known and unknown) after restoration and waste storage process is completed	N	N	Y	N	N	N	Y	NN	-	-	N	Y	Y	NN	Y	-
BAT 21																	

BAT No	Description	Facilities															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
BAT 22	Controlling surface water flow within the landfill, including collection and monitoring activities	Y	Y	Y	N	Y	Y	Y	NN	Y	Y	Y	Y	Y	Y	NN	Y
BAT 23	Quality control of the artificial impermeability layer used in the landfill	Y	Y	Y	P	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	N
BAT 24	Ensuring that all wastes generated in the landfill are properly stored and transported	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	NN	Y
BAT 25	Treatment of wastewater before discharge to the receiving environment	-	NN	Y	NN	Y	NN	NN	NN	NN	NN	NN	Y	Y	Y	N	Y
BAT 26	Having an infrastructure regarding the monitoring of discharges to the receiving environment	-	Y	-	NN	P	NN	NN	NN	NN	NN	NN	N	Y	Y	N	Y
BAT 27	Treatment to meet the relevant discharge standards, if discharged to sewers	N	NN	Y	NN	NN	NN	NN	NN	NN	NN	NN	N	N	-	N	-
BAT 28	Groundwater monitoring to identify any groundwater contamination from the landfill as soon as possible and to set alarm levels and upper limits	Y	Y	Y	Y	Y	Y	NN	Y	Y	Y	Y	Y	Y	Y	Y	Y
BAT 29	Implementation of the following management techniques to prevent emissions to groundwater																

BAT No	Description	Facilities															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
	Waste storage by controlling the impermeability layer	Y	Y	Y	N	Y	Y	NN	Y	P	Y	Y	Y	Y	-	Y	-
	Regular monitoring of the topsoil condition (at least 1 in 3 years)	Y	Y	Y	N	P	Y	NN	NN	-	-	N	N	N	-	Y	-
	Checking the bottom height of the leachate at the floor of the cell (at least 0.5 m)	Y	N	N	NN	P	Y	NN	NN	N	-	N	N	N	-	Y	-
	Deciding and determining alarm levels for groundwater quality for all landfills, based on the specific hydrogeological conditions of the area, considering the direction and slope of groundwater flow	Y	P	Y	Y	Y	Y	NN	NN	Y	Y	Y	N	N	Y	N	Y
BAT 30	Ensuring the safety of groundwater monitoring wells	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Application of the following management techniques to minimize leachate emissions																
	Keeping the active fill area as small as possible with a maximum of 25m*25 m and 1:3 slope, unless specifically agreed	Y	Y	P	NN	P	Y	Y	NN	-	-	P	Y	Y	Y	NN	Y
	Usage of daily and intermediate cover and proper compaction to decrease the	Y	P	Y	NN	Y	Y	Y	NN	-	-	N	Y	Y	Y	NN	Y

BAT No	Description	Facilities															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
	amount and quality of leachate and water infiltration level																
	Procedures to ensure that the containment system is not damaged by the placement of soil remediation layers or the environmental control systems	Y	Y	Y	NN	P	Y	Y	NN	-	-	N	Y	Y	-	NN	-
	Leachate recirculation	N	Y	Y	NN	P	N	N	NN	-	-	Y	N	N	-	NN	-
	Developing procedures to ensure that the top cover system is not damaged, comprehensive monitoring and repair program	N	P	Y	NN	P	N	Y	NN	-	-	N	Y	Y	Y	NN	Y
	Applying waste acceptance procedures regularly	Y	Y	Y	NN	Y	Y	NN	Y	Y	Y	Y	Y	Y	Y	Y	Y
BAT 31	Application of the following control techniques to minimize leachate emissions																
	Reducing rain seepage into accumulated waste by using soil, recycled/recovered materials, or artificial cover materials	Y	Y	-	NN	Y	Y	NN	NN	Y	Y	N	Y	Y	Y	NN	Y
	Composition and depth of leachate monitoring	Y	P	Y	NN	P	Y	NN	NN	P	P	Y	N	N	Y	NN	-
	Covering and restoration of the filled parts of the landfill as soon as possible	Y	Y	Y	NN	N	Y	Y	NN	Y	Y	Y	Y	Y	Y	-	Y

BAT No	Description	Facilities															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
	Collecting and reusing uncontaminated rainwater	N	N	N	NN	N	N	NN	Y	N	N	Y	Y	Y	-	N	-
BAT 32	Implementation of the following gas management systems to prevent uncontrolled gas escape from the landfill																
	Pretreating the waste before it is accepted for the landfill for minimization of gas generation potential of landfill	Y	N	Y	NN	Y	NN	NN	NN	NN	NN	NN	NN	P	NN	NN	NN
	Avoiding landfill gas from passing to the ground in both dissolved and gas states	Y	N	Y	NN	P	NN	NN	NN	NN	NN	NN	NN	Y	NN	NN	NN
	Avoiding methane emission to the atmosphere	Y	N	N	NN	Y	NN	NN	NN	NN	NN	NN	NN	Y	NN	NN	NN
	Management of odor risks	Y	P	P	NN	Y	NN	NN	NN	NN	NN	NN	NN	Y	NN	NN	NN
	Avoiding condensation in the gas collection network	Y	N	Y	NN	Y	NN	NN	NN	NN	NN	NN	NN	Y	NN	NN	NN
	Implementation of horizontal and vertical gas collection piping	Y	Y	Y	NN	Y	NN	NN	NN	NN	NN	NN	NN	Y	NN	NN	NN
	Balancing of gas wells regularly	-	Y	Y	NN	P	NN	NN	NN	NN	NN	NN	NN	Y	NN	NN	NN
	Monitoring and balancing of gas extraction wells regularly	Y	Y	Y	NN	Y	NN	NN	NN	NN	NN	NN	NN	Y	NN	NN	NN
	Using the automatic warning system for fault detection.	-	N	Y	NN	N	NN	NN	NN	NN	NN	NN	NN	Y	NN	NN	NN

BAT No	Description	Facilities															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
	Managing condensation to prevent emissions	Y	N	Y	NN	P	NN	NN	NN	NN	NN	NN	NN	Y	NN	NN	NN
BAT 33	Application of the following techniques for process gas emissions																
	Pretreating waste for biodegradable removal or reduction	Y	Y	Y	NN	N	NN	NN	NN	NN	NN	NN	NN	P	NN	NN	NN
	Choosing appropriate cell sizes	N	N	P	NN	N	NN	NN	NN	NN	NN	NN	Y	Y	NN	NN	NN
BAT 34	Implementation of the following management techniques to minimize the risk of odor in the landfill facility																
	Pretreating odor-producing wastes	Y	N	N	NN	N	N	NN	NN	NN	NN	NN	N	N	NN	NN	NN
	Application of proper waste acceptance procedures	Y	Y	Y	NN	Y	Y	NN	NN	NN	NN	NN	Y	Y	NN	Y	NN
	Odor Management Plan preparation and implementation	Y	N	Y	NN	P	Y	NN	NN	NN	NN	NN	N	N	NN	NN	NN
	Review of gas management and measurement protocols regularly	Y	Y	Y	NN	Y	NN	NN	NN	NN	NN	NN	N	Y	NN	NN	NN
	Management of cell staging and size effectively	N	N	-	NN	N	N	NN	NN	NN	NN	NN	Y	Y	NN	NN	NN
	Monitoring of closed areas regularly for fugitive volatile organic carbon emissions	N	N	-	NN	P	N	NN	NN	NN	NN	NN	N	N	NN	NN	NN
	Application of the following techniques for the control of odors in the landfill facility																
BAT 35	Open tipping area minimization	Y	Y	P	NN	Y	Y	NN	NN	NN	NN	NN	Y	Y	NN	NN	NN

BAT No	Description	Facilities															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
	Storage, compaction, and covering of waste quickly	Y	Y	P	NN	Y	Y	NN	NN	NN	NN	NN	Y	Y	NN	NN	NN
	Providing a 750 m buffer distance from the landfill footprint to any sensitive receptor for a new landfill facility accepting a significant part of the potentially odorous waste	Y	N	Y	NN	N	Y	NN	NN	NN	NN	NN	Y	Y	NN	NN	NN
	Restriction of especially odorous waste loads and burial of them immediately	Y	Y	Y	NN	Y	Y	NN	NN	NN	NN	NN	Y	Y	NN	NN	NN
	Restriction of waste disposal activities in adverse weather conditions	N	Y	N	NN	Y	Y	NN	NN	Y	Y	Y	N	N	NN	Y	NN

E. BATs and Techniques listed in the BAT Checklist with Their Place in the RoLW

BAT/ Technique #	Definition	Origin	Presence in the RoLW
1	Using a three-level hierarchy that includes characterization and testing of waste for their acceptance	LD	Article 18
2	Taking measures to minimize the adverse environmental effects and hazards arising from the landfill	LD	Article 6
3	Taking measures to control environmental pollution originating from the landfill	LD	Article 6
4	Taking security measures to prevent free access to the landfill	LD	-
5	Having a control and access system for the facility, including a program of action to detect and deter illegal dumping at the facility	LD	-
6	The placement of waste on the landfill in a way providing the stability of the waste mass and associated structures, especially to prevent slippage	LD	Article 6
7	If an artificial layer is used, ensuring that the geological substratum is stable enough not to damage the artificial impermeability layer taking into account the morphology of the landfill	LD	-
8	Controlling the water coming from precipitations to the landfill	LD	Article 7
9	Preventing surface water and/or groundwater from entering landfill waste	LD	Article 7
10	Collection of wastewater and leachate	LD	Article 7

BAT/ Technique #	Definition	Origin	Presence in the RoLW
11	Treatment of wastewater and leachate collected from the landfill according to the appropriate standards required for their discharge	LD	Article 7
12	Completion of a geological impermeable layer artificially if necessary to protect soil, groundwater, and surface water	LD	Article 16
13	Preserving the excavated soil to use as a top cover after the closure phase of a landfill to protect the soil, groundwater, and surface water	LD	Article 17
14	In order to prevent leachate, in addition to the geological barrier, the application of the following recommendations for surface sealing	LD	Article 16
15	Taking appropriate measures to control the gas generated	LD	Article 8
16	Collection and treatment of the gas generated	LD	Article 8
17	Using the collected gas to generate energy	LD	Article 8
18	Flaring the gas if the collected gas is not used to generate energy	LD	Article 8
19	Conducting a risk assessment for known and unknown obligations to understand and manage environmental risk	BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by EPA	-
20	The preparation to ensure that pollution control systems are maintained and effective after the waste storage process is completely finished	BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by EPA	Article 17, Article 23, Article 24
21	Having financial provision for environmental obligations (known and unknown) after restoration and waste storage process is completed	BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by EPA	Article 29

BAT/ Technique #	Definition	Origin	Presence in the RoLW
22	Controlling surface water flow within the landfill, including collection and monitoring activities	BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by EPA	Article 25
23	Quality control of the artificial impermeability layer used in the landfill	BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by EPA	-
24	Ensuring that all wastes generated in the landfill are properly stored and transported	BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by EPA	Article 6, Article 18
25	Treatment of wastewater before discharge to the receiving environment	BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by EPA	Article 7
26	Having an infrastructure regarding the monitoring of discharges to the receiving environment	BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by EPA	-
27	Treatment to meet the relevant discharge standards, if discharged to sewers	BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by EPA	-
28	Groundwater monitoring to identify any groundwater contamination from the landfill as soon as possible and to set alarm levels and upper limits	BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by EPA	Article 24

BAT/ Technique #	Definition	Origin	Presence in the RoLW
29	Implementation of the management techniques to prevent emissions to groundwater	BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by EPA	Article 24
30	Application of the management techniques to minimize leachate emissions	BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by EPA	Article 7, Article 18
31	Application of the control techniques to minimize leachate emissions	BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by EPA	-
32	Implementation of the gas management systems to prevent uncontrolled gas escape from the landfill	BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by EPA	-
33	Application of the techniques for process gas emissions	BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by EPA	-
34	Implementation of the management techniques to minimize the risk of odor in the landfill facility	BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by EPA	-
35	Application of the techniques for the control of odors in the landfill facility	BAT Guidance Note on BATs for the Waste Sector: Landfill Activities by EPA	-

F. Facility Responses for the Applicability of BATs from the Council Directive on the Landfill of Waste (A: applicable, NA: not applicable, PA: partially applicable)

Technique No	Description	Facilities Responses																
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	
Technique 1	Using a three-level hierarchy that includes characterization and testing of waste for their acceptance																	
	Level 1: The process of defining and characterizing the main characteristics of the waste	A	NA	A	-	A	A	A	A	A	-	-	A	A	A	-	A	
	Level 2: Compliance tests to meet the waste acceptance criteria given for landfill classes	A	NA	A	-	A	A	A	A	-	-	-	A	A	A	A	A	
	Level 3: Verification tests carried out at the facility to confirm that the wastes transferred to the facility are the same as the declared wastes with basic characterization and compliance tests.	A	NA	A	-	A	A	A	PA	-	-	-	A	A	A	-	A	
	Taking measures on the following issues to minimize the adverse environmental effects and hazards arising from the landfill																	
Technique 2	Odor and dust emissions to the environment	A	PA	A	PA	A	A	A	A	A	A	A	A	A	A	PA	A	
	Spread of wastes with the effect of the wind	A	A	A	-	A	A	PA	-	NA	NA	NA	A	A	A	NA	A	

Technique No	Description	Facilities Responses															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
	Noise and traffic density	A	PA	A	-	A	A	PA	A	A	A	A	A	A	A	NA	-
	Birds, insects, and other animals reproduce in the area and carry pathogens to the environment.	A	PA	PA	-	A	A	PA	-	NA	NA	NA	A	A	A	NA	-
	Aerosol formation	A	NA	PA	-	A	NA	PA	-	NA	NA	NA	A	A	-	NA	-
	Possibility of fire	A	A	PA	-	A	A	A	A	NA	NA	-	A	A	-	NA	-
	Taking measures to control environmental pollution originating from the landfill	A	A	A	A	A	A	A	A	A	A	-	A	A	-	A	A
Technique 4	Taking security measures to prevent free access to the landfill	A	A	A	A	A	A	A	A	A	A	-	A	A	-	A	A
Technique 5	Having a control and access system for the facility, including a program of action to detect and deter illegal dumping at the facility	A	A	A	-	A	A	A	A	A	A	-	A	A	A	-	A
Technique 6	The placement of waste on the landfill in a way providing the stability of the waste mass and associated structures, especially to prevent slippage	A	A	A	A	A	A	A	A	A	A	-	A	A	-	A	A
Technique 7	If an artificial layer is used, ensuring that the geological substratum is stable enough not to damage the artificial	A	A	A	A	A	A	A	-	A	A	-	A	A	-	A	-

Technique No	Description	Facilities Responses															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
	impermeability layer taking into account the morphology of the landfill																
Technique 8	Controlling the water coming from precipitations to the landfill	A	A	PA	A	A	A	A	A	A	A	-	A	A	-	A	A
Technique 9	Preventing surface water and/or groundwater from entering landfill waste	A	A	PA	-	A	A	A	A	A	A	-	A	A	-	A	A
Technique 10	Collection of wastewater and leachate	A	A	A	A	A	A	A	A	A	A	-	A	A	A	A	A
Technique 11	Treatment of wastewater and leachate collected from the landfill according to the appropriate standards required for their discharge	A	A	A	A	A	A	A	-	A	A	-	A	A	A	NA	A
Technique 12	Completion of a geological impermeable layer artificially if necessary to protect soil, groundwater, and surface water	A	A	A	A	A	A	A	A	A	A	-	A	A	A	-	A
Technique 13	Preserving the excavated soil to use as a top cover after the closure phase of a landfill to protect the soil, groundwater, and surface water	A	A	A	A	A	A	A	A	-	A	-	A	A	-	A	-

Technique No	Description	Facilities Responses															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Technique 14	<i>In order to prevent leachate, in addition to the geological barrier, the application of the following recommendations for surface sealing</i>																
	Gas drainage layer	A	A	A	NA	A	NA	A	-	NA	NA	NA	A	A	A	NA	-
	Artificial sealing liner	A	A	A	A	A	A	A	-	-	-	-	A	A	A	A	-
	Geological impermeable layer	A	A	A	A	A	A	A	-	NA	NA	NA	A	A	A	A	-
	Drainage layer > 0.5 m	A	A	A	A	A	A	NA	-	-	-	-	A	A	A	A	A
	Topsoil cover > 1 m	A	A	A	A	A	A	A	-	-	-	A	A	A	A	A	-
Technique 15	<i>Taking appropriate measures to control the gas generated</i>	A	A	A	-	A	-	-	-	-	-	NA	NA	A	-	NA	-
Technique 16	<i>Collection and treatment of the gas generated</i>	A	A	A	-	A	-	-	-	-	-	NA	NA	A	-	NA	-
Technique 17	<i>Using the collected gas to generate energy</i>	A	A	A	-	A	-	-	-	-	-	NA	NA	A	-	NA	-
Technique 18	<i>Flaring the gas, if the collected gas is not used to generate energy</i>	A	A	A	-	A	-	-	-	-	-	NA	NA	NA	-	NA	-

G. Facility Responses for the Applicability of BATs from the BAT Guidance Note on BATs for the Waste Sector: Landfill
Activities by the Ireland EPA ((A: applicable, NA: not applicable, PA: partially applicable))

Technique No	Description	Facilities Responses															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
BAT 19	Conducting a risk assessment for known and unknown obligations to understand and manage environmental risk	A	A	A	A	A	A	A	A	-	-	-	A	A	A	A	A
BAT 20	The preparation to ensure that the following pollution control systems are maintained and effective after the waste storage process is completely finished:																
	Gas control system	A	A	A	A	-	A	A	-	-	-	-	-	-	A	NA	A
	Leachate collection, treatment, and discharge system	-	A	A	-	A	PA	A	A	-	-	-	A	A	-	A	-
	Landfill top layer	A	A	A	-	A	A	A	A	-	-	-	A	A	A	A	A
	Groundwater monitoring	A	A	A	-	A	A	-	A	-	-	-	A	A	-	A	A
	Slope stability	A	A	A	-	A	A	A	-	-	-	-	A	A	-	A	A
	All above-ground components, such as gas well covers, leachate pumping manholes, and monitoring boreholes																
		A	A	A	-	A	A	A	A	-	-	-	A	A	A	NA	A
BAT 21	Having financial provision for environmental obligations (known and unknown) after	A	PA	A	A	A	A	A	-	-	-	PA	A	A	-	A	-

Technique No	Description	Facilities Responses															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
	restoration and waste storage process is completed																
BAT 22	Controlling surface water flow within the landfill, including collection and monitoring activities	A	A	A	NA	A	A	A	-	A	A	-	A	A	-	NA	A
BAT 23	Quality control of the artificial impermeability layer used in the landfill	A	A	A	A	A	A	A	A	A	A	-	A	A	A	A	A
BAT 24	Ensuring that all wastes generated in the landfill are properly stored and transported	A	A	A	A	A	A	A	A	A	A	-	A	A	-	NA	A
BAT 25	Treatment of wastewater before discharge to the receiving environment	-	A	A	-	A	-	-	-	A	A	-	A	A	-	NA	-
BAT 26	Having an infrastructure regarding the monitoring of discharges to the receiving environment	-	A	-	-	A	-	-	-	A	A	-	A	A	A	NA	A
BAT 27	Treatment to meet the relevant discharge standards, if discharged to sewers	A	A	A	NA	NA	-	-	-	-	-	-	NA	NA	-	NA	-
BAT 28	Groundwater monitoring to identify any groundwater	A	A	A	A	A	A	-	A	-	-	-	NA	A	A	A	A

Technique No	Description	Facilities Responses															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
BAT 29	contamination from the landfill as soon as possible and to set alarm levels and upper limits																
	Implementation of the following management techniques to prevent emissions to groundwater																
	Waste storage by controlling the impermeability layer	A	A	-	NA	A	A	A	A	PA	PA	-	A	A	-	A	-
	Regular monitoring of the topsoil condition (at least 1 in 3 years)	A	A	A	NA	A	A	A	-	-	-	A	NA	NA	-	A	-
	Checking the bottom height of the leachate at the floor of the cell (at least 0.5 m)	A	A	PA	-	A	A	A	-	-	-	NA	NA	NA	-	-	-
BAT 30	Deciding and determining alarm levels for groundwater quality for all landfills, based on the specific hydrogeological conditions of the area, considering the direction and slope of groundwater flow																
	Ensuring the safety of groundwater monitoring wells	A	A	A	A	A	A	A	A	A	-	A	A	A	A	A	A
	Application of the following management techniques to minimize leachate emissions																
	Keeping the active fill area as small as possible with a maximum of 25m*25 m and 1:3 slope, unless specifically agreed	A	A	A	-	PA	A	A	-	-	-	PA	A	A	A	NA	A

Technique No	Description	Facilities Responses															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
BAT 31	Usage of daily and intermediate cover and proper compaction to decrease the amount and quality of leachate and water infiltration level	A	A	A	-	A	A	A	-	-	-	NA	A	A	A	NA	A
	Procedures to ensure that the containment system is not damaged by the placement of soil remediation layers or the environmental control systems	A	A	A	-	PA	A	A	-	-	-	NA	A	A	-	NA	-
	Leachate recirculation	A	A	A	-	PA	NA	NA	-	-	-	-	NA	NA	-	NA	-
	Developing procedures to ensure that the top cover system is not damaged, comprehensive monitoring and repair program	A	PA	A	-	PA	A	A	-	-	-	A	A	A	A	NA	A
	Applying waste acceptance procedures regularly	A	A	A	-	A	A	A	-	-	-	-	A	A	A	A	A
	Application of the following control techniques to minimize leachate emissions																
	Reducing rain seepage into accumulated waste by using soil, recycled/recovered materials, or artificial cover materials	A	A	-	-	A	A	-	-	A	A	A	A	A	A	A	A
	Composition and depth of leachate monitoring	A	PA	A	-	PA	A	-	-	PA	PA	-	NA	NA	A	NA	-

Technique No	Description	Facilities Responses															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
BAT 32	Covering and restoration of the filled parts of the landfill as soon as possible	A	A	A	-	A	A	A	-	A	A	-	A	A	A	-	A
	Collecting and reusing uncontaminated rainwater	A	A	A	-	A	A	-	A	-	-	-	A	A	-	NA	-
	Implementation of the following gas management systems to prevent uncontrolled gas escape from the landfill																
	Pretreating the waste before it is accepted for the landfill for minimization of gas generation potential of landfill	A	A	A	-	A	-	-	-	-	-	-	NA	NA	A	-	NA
	Avoiding landfill gas from passing to the ground in both dissolved and gas states	A	A	-	-	PA	-	-	-	-	-	-	NA	NA	A	-	NA
	Avoiding methane emission to the atmosphere	A	A	A	-	A	-	-	-	-	-	-	NA	NA	A	-	NA
	Management of odor risks	A	PA	A	-	A	-	-	-	-	-	-	NA	NA	A	-	NA
	Avoiding condensation in the gas collection network	A	A	-	-	A	-	-	-	-	-	-	NA	NA	A	-	NA
	Implementation of horizontal and vertical gas collection piping	A	A	-	-	A	-	-	-	-	-	-	NA	NA	A	-	NA
	Balancing of gas wells regularly	-	A	-	-	PA	-	-	-	-	-	-	NA	NA	A	-	NA
Monitoring and balancing of gas extraction wells regularly		A	-	-	A	-	-	-	-	-	-	NA	NA	A	-	NA	

Technique No	Description	Facilities Responses															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
BAT 33	Using the automatic warning system for fault detection.	-	PA	-	-	PA	-	-	-	-	-	NA	NA	A	-	NA	-
	Managing condensation to prevent emissions	A	A	-	-	PA	-	-	-	-	-	NA	NA	A	-	NA	-
	Application of the following techniques for process gas emissions																
BAT 34	Pretreating waste for biodegradable removal or reduction	-	A	-	-	A	-	-	-	NA	NA	NA	-	A	-	NA	-
	Choosing appropriate cell sizes	A	A	-	-	A	-	-	-	NA	NA	NA	A	A	-	NA	-
	Implementation of the following management techniques to minimize the risk of odor in the landfill facility																
BAT 35	Pretreating odor-producing wastes	A	PA	A	-	NA	-	-	-	NA	NA	NA	NA	NA	-	NA	-
	Application of proper waste acceptance procedures	A	A	-	-	A	A	-	-	NA	NA	NA	A	A	-	A	-
	Odor Management Plan preparation and implementation	A	PA	A	-	A	A	-	-	NA	NA	NA	NA	NA	-	NA	-
	Review of gas management and measurement protocols regularly	A	A	A	-	A	-	-	-	NA	NA	NA	NA	A	-	NA	-
	Management of cell staging and size effectively	NA	A	-	-	PA	NA	-	-	NA	NA	NA	A	A	-	NA	-
BAT 35	Monitoring of closed areas regularly for fugitive volatile organic carbon emissions	NA	A	-	-	PA	NA	-	-	NA	NA	NA	NA	NA	-	NA	-
BAT 35	Application of the following techniques for the control of odors in the landfill facility																

Technique No	Description	Facilities Responses															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
	Open tipping area minimization	A	A	A	-	A	A	-	-	-	-	-	A	A	-	NA	-
	Storage, compaction, and covering of waste quickly	A	A	A	-	A	A	-	-	-	-	-	A	A	-	NA	-
	Providing a 750 m buffer distance from the landfill footprint to any sensitive receptor for a new landfill facility accepting a significant part of the potentially odorous waste	A	PA	-	-	PA	A	-	-	-	-	-	A	A	-	-	-
	Restriction of especially odorous waste loads and burial of them immediately	A	A	-	-	A	A	-	-	-	-	-	A	A	-	NA	-
	Restriction of waste disposal activities in adverse weather conditions	NA	A	A	-	A	A	-	-	-	-	-	NA	NA	-	A	-

H. Sectoral Cost Calculations

Sectoral total investment cost

$$= \sum_{n=1}^n \# \text{ of landfills covered by the IED} \times CAPEX_{BAT/Technique\ n} \times (1 - Compliance\ Level_{BAT/Technique\ n})$$

For the first sub-technique of Technique 2:

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{Technique2-Subtechnique\ 1} = 650,000 \text{ Euros}$$

$$Compliance\ Level_{Technique2-Subtechnique\ 1} = 0.81$$

$$\begin{aligned} \text{Sectoral total investment cost} &= 24 \times 650,000 \times (1 - 0.81) \\ &= \mathbf{2,964,000 \text{ Euros}} \end{aligned}$$

For the sixth sub-technique of Technique 2:

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{Technique2-Subtechnique\ 6} = 175,000 \text{ Euros}$$

$$Compliance\ Level_{Technique2-Subtechnique\ 6} = 0.86$$

$$\begin{aligned} \text{Sectoral total investment cost} &= 24 \times 175,000 \times (1 - 0.86) \\ &= \mathbf{588,000 \text{ Euros}} \end{aligned}$$

For the Technique 4:

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{Technique4} = 5,500 \text{ Euros}$$

$$Compliance\ Level_{Technique4} = 1$$

$$\text{Sectoral total investment cost} = 24 \times 5,500 \times (1 - 1) = \mathbf{0 \text{ Euros}}$$

For the Technique 5:

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{\text{Technique5}} = 25,000 \text{ Euros}$$

$$\text{Compliance Level}_{\text{Technique5}} = 1$$

$$\text{Sectoral total investment cost} = 24 \times 25,000 \times (1 - 1) = \mathbf{0 \text{ Euros}}$$

For the Technique 7:

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{\text{Technique7}} = 72,500 \text{ Euros}$$

$$\text{Compliance Level}_{\text{Technique7}} = 1$$

$$\text{Sectoral total investment cost} = 24 \times 72,500 \times (1 - 1) = \mathbf{0 \text{ Euros}}$$

For the Technique 9:

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{\text{Technique9}} = 22,700 \text{ Euros}$$

$$\text{Compliance Level}_{\text{Technique9}} = 0.94$$

$$\begin{aligned} \text{Sectoral total investment cost} &= 24 \times 22,700 \times (1 - 0.94) \\ &= \mathbf{32,688 \text{ Euros}} \end{aligned}$$

For the Technique 12:

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{\text{Technique12}} = 450,000 \text{ Euros}$$

$$\text{Compliance Level}_{\text{Technique12}} = 0.8$$

$$\begin{aligned} \text{Sectoral total investment cost} &= 24 \times 450,000 \times (1 - 0.8) \\ &= \mathbf{160,000 \text{ Euros}} \end{aligned}$$

For the Technique 13:

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{\text{Technique13}} = 35,000 \text{ Euros}$$

$$\text{Compliance Level}_{\text{Technique13}} = 0.81$$

$$\begin{aligned} \text{Sectoral total investment cost} &= 24 \times 35,000 \times (1 - 0.81) \\ &= \mathbf{159,600 \text{ Euros}} \end{aligned}$$

For the first sub-technique of Technique 14:

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{\text{Technique14-Subtechnique 1}} = 500,000 \text{ Euros}$$

$$\text{Compliance Level}_{\text{Technique14-Subtechnique 1}} = 0.42$$

$$\begin{aligned} \text{Sectoral total investment cost} &= 24 \times 500,000 \times (1 - 0.42) \\ &= \mathbf{6,960,000 \text{ Euros}} \end{aligned}$$

For the second sub-technique of Technique 14:

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{\text{Technique14-Subtechnique 2}} = 450,000 \text{ Euros}$$

$$\text{Compliance Level}_{\text{Technique14-Subtechnique 2}} = 0.86$$

$$\begin{aligned} \text{Sectoral total investment cost} &= 24 \times 450,000 \times (1 - 0.86) \\ &= \mathbf{1,512,000 \text{ Euros}} \end{aligned}$$

For the third sub-technique of Technique 14:

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{\text{Technique14-Subtechnique 3}} = 100,000 \text{ Euros}$$

$$\text{Compliance Level}_{\text{Technique14-Subtechnique 3}} = 0.71$$

$$\begin{aligned} \text{Sectoral total investment cost} &= 24 \times 100,000 \times (1 - 0.71) \\ &= \mathbf{696,000 \text{ Euros}} \end{aligned}$$

For the fourth sub-technique of Technique 14:

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{\text{Technique14-Subtechnique 4}} = 112,500 \text{ Euros}$$

$$\text{Compliance Level}_{\text{Technique14-Subtechnique 4}} = 0.8$$

$$\begin{aligned} \text{Sectoral total investment cost} &= 24 \times 112,500 \times (1 - 0.8) \\ &= \mathbf{540,000 \text{ Euros}} \end{aligned}$$

For the fifth sub-technique of Technique 14:

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{\text{Technique14-Subtechnique 5}} = 35,000 \text{ Euros}$$

$$\text{Compliance Level}_{\text{Technique14-Subtechnique 5}} = 0.57$$

$$\begin{aligned} \text{Sectoral total investment cost} &= 24 \times 35,000 \times (1 - 0.57) \\ &= \mathbf{361,200 \text{ Euros}} \end{aligned}$$

For the Technique 15:

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{\text{Technique15}} = 1,000,000 \text{ Euros}$$

$$\text{Compliance Level}_{\text{Technique15}} = 0.83$$

$$\begin{aligned} \text{Sectoral total investment cost} &= 24 \times 1,000,000 \times (1 - 0.83) \\ &= \mathbf{4,080,000 \text{ Euros}} \end{aligned}$$

For the Technique 16:

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{\text{Technique16}} = 90,000 \text{ Euros}$$

$$\text{Compliance Level}_{\text{Technique16}} = 0.5$$

$$\begin{aligned} \text{Sectoral total investment cost} &= 24 \times 90,000 \times (1 - 0.5) \\ &= \mathbf{1,080,000 \text{ Euros}} \end{aligned}$$

For the BAT 19:

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{BAT19} = 40,000 \text{ Euros}$$

$$Compliance Level_{BAT19} = 0.94$$

$$\begin{aligned} \text{Sectoral total investment cost} &= 24 \times 40,000 \times (1 - 0.94) \\ &= \mathbf{57,600 \text{ Euros}} \end{aligned}$$

For the first sub-technique of BAT 20:

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{BAT20-Subtechnique 1} = 100,000 \text{ Euros}$$

$$Compliance Level_{BAT20-Subtechnique 1} = 0.43$$

$$\begin{aligned} \text{Sectoral total investment cost} &= 24 \times 100,000 \times (1 - 0.43) \\ &= \mathbf{1,368,000 \text{ Euros}} \end{aligned}$$

For the second sub-technique of BAT 20:

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{BAT20-Subtechnique 2} = 3,150,000 \text{ Euros}$$

$$Compliance Level_{BAT20-Subtechnique 2} = 0.79$$

$$\begin{aligned} \text{Sectoral total investment cost} &= 24 \times 3,150,000 \times (1 - 0.79) \\ &= \mathbf{15,876,000 \text{ Euros}} \end{aligned}$$

For the sixth sub-technique of BAT 20:

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{BAT20-Subtechnique 6} = 1,200,000 \text{ Euros}$$

$$Compliance Level_{BAT20-Subtechnique 6} = 0.73$$

$$\begin{aligned} \text{Sectoral total investment cost} &= 24 \times 1,200,000 \times (1 - 0.73) \\ &= \mathbf{7,776,000 \text{ Euros}} \end{aligned}$$

For the BAT 22:

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{BAT22} = 30,000 \text{ Euros}$$

$$Compliance Level_{BAT22} = 0.93$$

$$\begin{aligned} \text{Sectoral total investment cost} &= 24 \times 30,000 \times (1 - 0.93) \\ &= \mathbf{50,400 \text{ Euros}} \end{aligned}$$

For the BAT 23:

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{BAT23} = 20,000 \text{ Euros}$$

$$Compliance Level_{BAT23} = 0.81$$

$$\begin{aligned} \text{Sectoral total investment cost} &= 24 \times 20,000 \times (1 - 0.81) \\ &= \mathbf{91,200 \text{ Euros}} \end{aligned}$$

For the fourth sub-technique of BAT 29:

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{BAT29\text{--}Subtechnique\ 4} = 150,000 \text{ Euros}$$

$$Compliance Level_{BAT29\text{--}Subtechnique\ 4} = 0.72$$

$$\begin{aligned} \text{Sectoral total investment cost} &= 24 \times 150,000 \times (1 - 0.72) \\ &= \mathbf{1,044,000 \text{ Euros}} \end{aligned}$$

For the fifth sub-technique of BAT 29:

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{BAT29\text{--}Subtechnique\ 5} = 40,000 \text{ Euros}$$

$$Compliance Level_{BAT29\text{--}Subtechnique\ 5} = 0.94$$

$$\begin{aligned} \text{Sectoral total investment cost} &= 24 \times 40,000 \times (1 - 0.94) \\ &= \mathbf{57,600 \text{ Euros}} \end{aligned}$$

For the third sub-technique of BAT 30:

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{BAT30-Subtechnique\ 3} = 20,000 \text{ Euros}$$

$$Compliance\ Level_{BAT30-Subtechnique\ 3} = 0.78$$

$$\begin{aligned} \text{Sectoral total investment cost} &= 24 \times 20,000 \times (1 - 0.78) \\ &= \mathbf{105,600 \text{ Euros}} \end{aligned}$$

For the fourth sub-technique of BAT 30:

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{BAT30-Subtechnique\ 4} = 60,000 \text{ Euros}$$

$$Compliance\ Level_{BAT30-Subtechnique\ 4} = 0.33$$

$$\begin{aligned} \text{Sectoral total investment cost} &= 24 \times 60,000 \times (1 - 0.33) \\ &= \mathbf{964,800 \text{ Euros}} \end{aligned}$$

For the first sub-technique of BAT 31:

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{BAT31-Subtechnique\ 1} = 65,000 \text{ Euros}$$

$$Compliance\ Level_{BAT31-Subtechnique\ 1} = 0.91$$

$$\begin{aligned} \text{Sectoral total investment cost} &= 24 \times 65,000 \times (1 - 0.91) \\ &= \mathbf{144,400 \text{ Euros}} \end{aligned}$$

For the second sub-technique of BAT 31:

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$CAPEX_{BAT31-Subtechnique\ 2} = 40,000 \text{ Euros}$$

$$Compliance\ Level_{BAT31-Subtechnique\ 2} = 0.46$$

$$\begin{aligned}\text{Sectoral total investment cost} &= 24 \times 40,000 \times (1 - 0.46) \\ &= \mathbf{528,000 \text{ Euros}}\end{aligned}$$

For the first sub-technique of BAT 32:

$$\sum_{n=1}^n \# \text{ of landfills covered by the IED} = 24$$

$$\text{CAPEX}_{\text{BAT32-Subtechnique 1}} = 15,000,000 \text{ Euros}$$

$$\text{Compliance Level}_{\text{BAT32-Subtechnique 1}} = 0.6$$

$$\begin{aligned}\text{Sectoral total investment cost} &= 24 \times 15,000,000 \times (1 - 0.6) \\ &= \mathbf{144,000,000 \text{ Euros}}\end{aligned}$$

