ENVIRONMENTAL SUSTAINABILITY FOR SELECTED PACKAGING WASTES

by

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ABSTRACT

ENVIRONMENTAL SUSTAINABILITY FOR SELECTED PACKAGING WASTES

Rapid production and consumption have led to increase in the waste generation in the past several decades. According to the Eurostat (2018) 19% of total municipal solid waste is comprised of packaging waste. To alleviate the environmental impacts associated with packaging waste in both production and disposal phases, recycling is a key solution. The aim of this study is to evaluate selected plastic and glass beverage packaging wastes in Turkey according to the national recycling targets using a Life Cycle Assessment (LCA) methodology and provide science-based recommendations for development of roadmap for achieving sustainable consumption and production goals. For this purpose, the current years (2017 and 2018) and the future (2025) national and EU recycling targets were assessed by LCA on an annual basis. The data for both production and recycling processes were obtained from packaging factories and recycling facilities. The energy processes used in the study were calculated according to the primary energy sources of the relevant year. With this study, the contribution of recycling to the environmental impacts of glass and PET packaging during the life cycle was analyzed.

ÖZET

SEÇİLİ AMBALAJ ATIKLARI İÇİN ÇEVRESEL SÜRDÜRÜLEBİLİRLİK

Hızlı üretim ve tüketim, son yıllarda atık üretiminde artışa neden olmuştur. Eurostat'a göre (2018) belediye katı atıklarının %19'u ambalaj atıklarından oluşmaktadır. Ambalaj atıkları ile ilgili çevresel etkileri hem üretim hem de bertaraf safhalarında azaltmak için geri dönüşüm kilit bir çözümdür. Bu çalışmanın amacı, Türkiye'de seçilen plastik ve cam içecek paketleme atıklarını, bir Yaşam Döngüsü Değerlendirmesi (YDD) metodolojisi kullanarak ulusal geri dönüşüm hedeflerine göre değerlendirmek ve sürdürülebilir tüketim ve üretim hedeflerine ulaşmak için yol haritasının geliştirilmesi için bilime dayalı öneriler sunmaktır. Bu amaçla, mevcut yıllar (2017 ve 2018) ve gelecek (2025) ulusal ve AB geri dönüşüm hedefleri yıllık bazda YDD ile değerlendirilmiştir. Hem üretim hem de geri dönüşüm işlemlerinin verileri paketleme fabrikalarından ve geri dönüşüm tesislerinden elde edilmiştir. Çalışmada kullanılan enerji süreçleri, ilgili yılın birincil enerji kaynaklarına göre hesaplanmıştır. Çalışma ile geri dönüşümün cam ve PET ambalajların yaşam döngüsü boyunca çevresel etkilerine olan katkısı analiz edilmiştir.

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LIST OF SYMBOLS/ABBREVIATIONS

Symbol	Explanation	Unit
Al	Aluminum	
C_2H_4	Ethene or Ethylene	
CO_2	Carbon dioxide	
gr	Gram	
Km	Kilometer	
kW	Kilo watt	
MJ	Megajoule	
PO_4	Phosphate	
R11	Trichloromonofluoromethane	
SO_2	Sulphur dioxide	
^oC	Centigrade degree	

Abbreviation	Explanation	
AP	Acidification Potential	kg SO_2 Equivalent
CEN	Committee European de Normalization	
EP	Eutrophication Potential	kg PO_4 Equivalent
EU	European Union	
HDPE	High Density Polyethylene	
GWP	Global Warming Potential	kg CO_2 Equivalent
ISO	International Organization for Standardization	
LCA	Life Cycle Assessment	
LDPE	Low Density Polyethylene	
ODP	Ozone Layer Depletion Potential	kg R11 Equivalent
O.G	Official Gazette	
PET	Polyethylene terephthalate	
PP	Polypropylene	
PS	Polystyrene	
PVC	Polyvinyl Chloride	
POCP	Photochemical Ozone Layer Creation Potential	kg Ethene Equivalent

SDG	Sustainable Development Goal
TSE	Turkish Standards Institution
TS EN	Turkish Standard European Norm

1. INTRODUCTION

Packaging wastes constitute 19% of total municipal solid waste and play an important role in environmental damage caused by human activities both in terms of production and disposal. According to the Eurostat (2018), 167 kg packaging wastes was generated per person in the EU member countries in 2015. On December 2, 2015, a package was prepared by the European Commission to support the Circular Economy Strategy. It is anticipated that products and materials can be used as long as possible in the approach of circular economy. Accordingly, it is proposed to reduce waste and resource use and reuse a product to produce another value when it comes to end of life. It is aimed to recycle 70% of packaging waste by 2030 according to the Circular Economic Strategy.

Technological developments and rapid consumption contribute to increase of greenhouse gases causing climate change. To slow down this trend as much as possible and to minimize damage caused by humans, various policies and targets have been developed and implemented. For this purpose, 17 goals and 169 targets has been identified in the United Nations (UN) Sustainable Development Conference held in New York in 2015, in order to ensure sustainability.

The UN Sustainable Development Goal 12 (SDG 12), Sustainable Consumption and Production, aims at “doing more and better with less,” increasing net welfare gains from economic activities by reducing resource use, degradation and pollution along the whole lifecycle, while increasing quality of life. One of the targets for achieving SDG12 is substantially reducing waste generation through prevention, reduction, recycling and reuse by 2030. The national recycling rate is the indicator to determine the adaptation to this target (Sustainable Development Knowledge Platform, 2018).

In terms of reducing waste and its environmental consequences, increasing packaging recycling is a crucial development. One of the strategic environmental decision-making tools used in this direction is the Life Cycle Assessment (LCA), which evaluates sustainable production-friendly alternatives by calculating potential environmental impacts of selected products, including production, consumption and disposal processes, from cradle-to-cradle, and proposing solutions to improve processes.

The aim of this study is to evaluate the environmental consequences of current and future plastic and glass packaging waste recycling in Turkey in light of current practices and future national and EU targets using LCA methodology. Obtained results were interpreted in terms of Turkey's waste recycling goals and EU targets provide useful science-based technical data for development of the roadmap for achievement those goals.

2. LITERATURE REVIEW

Life cycle analysis (LCA) is a method to measure the environmental burden originated by a product or a process. LCA is an important way to determine the environmental impacts of a product during its life cycle, to make improvements for the necessary conditions and to evaluate the recovery, recycle and reuse opportunities. In the various LCA studies carried out in the world, different life cycle scenarios are being created while environmental effects of the products are determined, and the changes that these differences cause on the environment are calculated. Accordingly, different options such as recycling scenarios, landfilling, incineration facilities, and waste generation are compared while the end-of-life scenarios are established in the life cycle of products. As a holistic approach, LCA not only evaluates the recycling process and its direct consequences but, also other changes along product's value chain due to recycling (Department of Environment, Climate Change and Water NSW, 2010). The process of recycling can find a place itself in the economic world when the output product outweighs the process costs. In environmental aspect, the process of recycling can be logical option when environmental credits from the output product outweigh the environmental loads of the process. So, to quantify plus and minuses of recycling process using LCA, is not easy because of the ambiguous structure of the recycling process. The character of recycling process based on two steps as follows, waste management and production of new material. Due to that, recycling process classified as multi-functional process in LCA (van der Harst et al., 2016).

Recycling of plastics is one of the most significant concepts for reduction of the environmental burdens of waste. Plastics are invented in 1900s and they are synthetic organic polymers in the simplest terms. Usage and number of plastics increased incredibly since its invention. Nowadays waste management of plastics one of biggest concerns in the world. The main generators of plastics are China (23%), Europe (21%) and North America (20%). Recycling of plastics will decrease the dependence on fossil fuels. But still, compared to glass, metals, and paper, recycling rates of plastics are typically low due to various character. Figure 2.1 shows the distribution of plastics usage areas. There are various kinds of plastics. Local fraction of usage and plastic kinds may vary, based on specific circumstances due to some of them mainly used in specific applications. In the purpose of packaging, PET, PS and the polyolefins dominate (Shen et al., 2014).

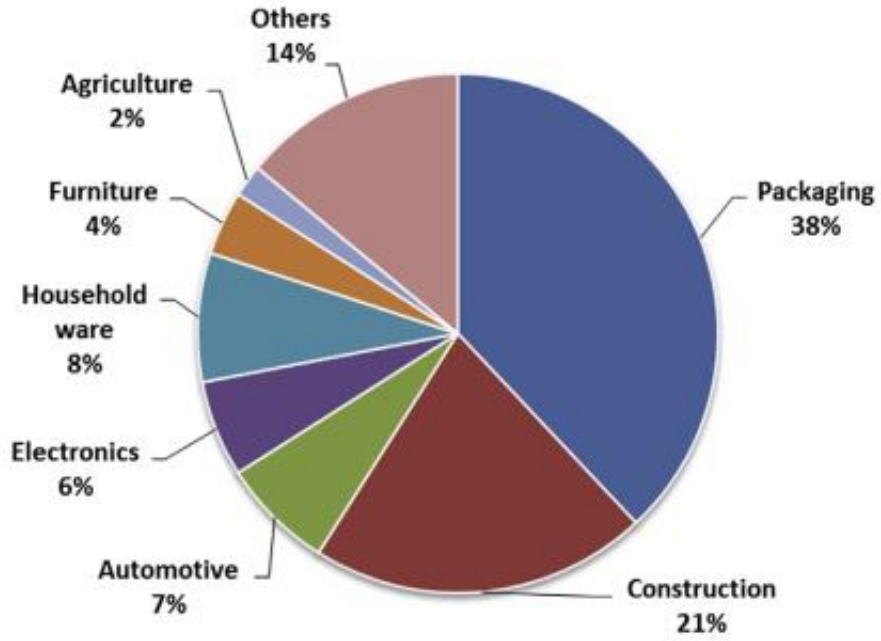


Figure 2.1. Key applications of plastics. Distribution is based on data from the EU-15 member states (Shen et al., 2014).

Moreover, Polyethylene terephthalate (PET) is a plastic type which is used globally and mainly for the generation of synthetic fibers. Approximately 30% of the PET, used in the purpose of food packaging. General usage applications of PET bottles are bottled water, cosmetics, pharmaceuticals and soft drinks due to its inert structure (Marathe et al., 2019).

2.1. Evaluation of Recycling of Packaging Wastes with LCA Methodology

Packaging has very significant place in the food industry as well as European economy. Collection of packaging materials increase the consumption of energy and capacity of waste. In order to reduce the rate of energy consumption and volume of waste, reusable packaging materials started to use 40% in Europe for the transportation of fruits and vegetables. Reusable packaging system is a closed loop but, reverse flows from the consumer to supplier increase the difficulty of logistics in consideration one-way system. Moreover, packaging system should be characterized by geography of the network but still, it is not the only consideration (Baruffaldi et al., 2019). Specifically, to reduce the environmental impacts of food packaging, 4 steps as follows can be solution, reduction, reuse, recycling and redesign focusing on circular economy. Reduction, reuse, and recycling, but also redesign support the aims of the circular economy. For understanding the role of food packaging in

the circular economy, it must be known that recycling is just one of the solutions for providing environmentally friendly and safe food packaging (Geueke et al., 2018).

Toniolo et al. (2013), studied on two different packaging products which one is made by recyclable material while the other is non-recyclable. For the recyclable material, incineration, landfilling and recycling was applied together while only incineration and landfilling were applied for non-recyclable packaging product. As a result of this study, it is determined that using a recyclable material for the packaging and recycling are more environmental and therefore more preferable since the non-recyclable material has 96% higher in most impact categories except for terrestrial ecotoxicity and natural land transformation. Similarly, Xie et al. (2011), compared the potential environmental impacts of two different milk packaging by LCA tool. The packaging materials are; i) composite packaging which is consist of paper, aluminum and polyethylene, and ii) plastic packaging which is consist of polyethylene. According to the study, since polyethylene and aluminum cannot be separated, it is not possible to recycle the composite packaging and therefore the environmental impacts of the composite are more than the plastic one.

Some of the LCA studies on packaging analyze the environmental impacts of the different stages of the packaging in their life cycle. Humbert et al. (2009), researched the LCA of baby food packaging alternatives; plastic pots and glass jars and determined their environmental impacts. The transportation of the product was included in the study. When the distance between the factory and market assumed same for both plastic and glass packaging, it was found that plastic pot is more environmentally friendly than glass jars since it is lighter, and it affects the transportation of the product positively.

By LCA, it is possible to determine the effects of the innovations which are made in order to decrease the environmental impacts of the packaging. For example, in the study of Manfredi et al. (2015a), an antimicrobial coating was added to the traditional Tetra Top® used for milk and compared with the environmental influences with the non-coated one by using LCA tool. As a result of the study, even though the inputs of the product such as raw material, energy etc. increases, it extends the shelf life of the milk product and decrease %50 of product which turns into waste and reduce environmental impacts in all categories. Therefore, it can be said that extension of the shelf life of a product decreases the environmental impacts.

Researches about the packaging are not limited with comparing the production of different kind of packaging materials. There are also studies about the impacts of the different filling systems of the

packaging material. One of these researches, Manfredi et al. (2015), assessed the sustainability and the environmental performance of hot filling systems and aseptic packaging systems for 0.5-liter plastic beverage bottle. At the end of the determination, it is found that both processes have nearly the same environmental impacts. However, since the hot filling system requires high temperature endurances, which can be obtained by a heavier PET packaging material, aseptic packaging was found more environmentally friendly with a reduction of 20% in all impact categories.

Another study that consist the recycling of the packaging material was studied by Ferreira et al. (2014). In the study, Portugal's packaging waste management was examined. A reference scenario which includes composting, landfilling and recycling was determined according to the data of 2010, and compared with two different scenarios which are; i) complete incineration and ii) complete landfilling. The results showed that the scenario includes separate collection, classification and recycling has better environmental performance than the assumption scenarios. Similarly, in the study of Geyhan et al. (2016), packaging waste separation methods of Istanbul was determined as their environmental performances. Eight different separated collection scenarios were defined and analyzed by LCA and compared with the existing collection system for packaging wastes. The result of the study showed that the existing system in Istanbul, which was defined as separation of recyclable packaging waste into 2 fractions, has better environmental performance than the other alternative scenarios. In the current system, mixed packaging wastes consist of paper-cardboard, glass, metal and plastic were collected by door-to-door system, and glass wastes were collected by the drop off points where the stable containers on the street but a greater distance between 500m to 1000m. The other beneficial scenarios were similar to existing and separated into 2 and 3 fractions. However, the only difference than the existing system is the curbside collection system instead of door-to-door collection or drop-off points.

LCA studies about packaging doesn't only include the comparison of recycling with different disposal methods, it has also conducted by the comparison of different recycling methods. Shen et al. (2010), determined the environmental impacts of four different polyethylene terephthalate (PET)-to-fibre recycling cases (open-loop recycling, semi-mechanical recycling, back to oligomer recycling and back-to monomer recycling) under nine impact indicators. These indicators were; non-renewable energy use (NREU), global warming potential (GWP), abiotic depletion, acidification, eutrophication, human toxicity, freshwater aquatic ecotoxicity, terrestrial ecotoxicity and photochemical oxidant formation. The result of the study show that recycled PET is more environmentally friendly than the virgin PET. Also, it is found that the mechanical recycling showed

better environmental performance than chemical recycling while the usage area of chemically recycled fibre is larger.

According to study of Saleh (2016), after the implementation of life cycle assessment (LCA) in order to compare and evaluate the packaging types of beverages. These are PET, glass and aluminum (Al). More specifically, investigation covers the 2000 ml PET bottles, the 330 ml Al-cans and the 300 ml glass bottles. These packaging materials generate, consumed and eliminated in West Bank in Palestine. Investigation conducted based on these categories as follows; solid waste, global warming potential, terrestrial acidification, respiratory effects, non-renewable energy, human toxicity, consumption of water. According to results, packaging materials line up most to least based on the environmental impacts as follows 2000 ml PET bottles, 330 ml Al cans, 300 ml glass bottles, respectively. Furthermore, environmental impacts of these packaging materials could be decrease by enhancing the rate of recycling according to sensitivity analysis results.

2.2. Legislation and Standards Regarding Packaging Wastes in Turkey

According to the Regulation on Packaging Waste Control of Turkey (O.G. No. 30283, 27.12.2017), supported by the Regulation on Waste Management, (O.G. No.29314, 02.04.2015) packaging; including products that are made from any material used to transport, protect, store and sell a product from the raw material to the finished product, in the process of delivering the product to the consumer or consumer, including those that are not recyclable. In order to ensure the successful implementation of the Regulation, the environmental impacts of the packaging products must be decreased by the manufacturers and this must be submitted for the consumer's information. European Packaging Standards, the standards that should be considered in the "Packaging Design and Production" stage were published by the CEN (Committee European de Normalization) and translated into Turkish by TSE (Turkish Standards Institution) are;

•**TS EN 13427:2006:** Packaging – Requirements for the use of standards in the field of packaging and packaging waste;

•**TS EN 13428:2007:** Packaging – Requirements specific to manufacturing and composition – Prevention by source reduction;

•**TS EN 13429:2007:** Packaging – Reuse Standards

•**TS EN 13430:2007:** Packaging – Requirements for packaging recoverable by material recycling;

•**TS EN 13431:2007:** Packaging – Requirements for packaging recoverable in the form of energy recovery, including specification of minimum inferior calorific value;

•**TS EN 13432:2003:** Packaging - Requirements for packaging recoverable through composting and biodegradation – Test scheme and evaluation criteria for the final acceptance of packaging.

3. METHODOLOGY

3.1. Life Cycle Assessment

Life Cycle Assessment is a methodology for the evaluation of environmental impacts of a product or process during the life cycle, including the raw material procurement, production, usage, final disposal and the transportation between these stages. To determine these effects, a detailed inventory of all energy, water and raw material inputs and their resulting waste and emissions are collected and evaluated throughout the life cycle and the potential environmental impacts of the product or process are calculated. Standard LCA method based on the ISO 14040 (2006a) and ISO 14044 (2006b), consist of four main stages; goal and scope definition, life cycle inventory analysis, life cycle impact assessment and interpretation.

One of the challenging aspects of current LCA studies is associated with integration of datasets from different LCA databases and software into the study. The challenge is not only due to technical, format-related issues but also due to concerns over accuracy, reliability and lack of information regarding the technical, geographic and temporal scope of the available information. The Global LCA Data Access (GLAD) network developed by the UN Environment Program aims to improve the accessibility and interoperability of LCA databases around the world by standardizing the documentation and meta data requirements for datasets. In this way, LCA practitioners will be able to assess the fitness of a given datasets for their LCA study. The network will consist of independently operated LCA databases and promote LCA with an easier access of data sources in the world (Ciroth et al., 2017). The datasets that were developed within the scope of this study include the necessary documentation and meta-descriptors which allow them to be integrated into other LCA databases, in necessary.

3.1.1. Goal and Scope Definition

The goal of this study is to assess the environmental sustainability aspects of selected packaging waste recycling in Turkey with cradle to cradle approach based on the relevant national and international targets. LCA study was carried out for selected glass and plastic packaging product that

provide the same service. Recycling rate scenarios for plastic and glass packaging were evaluated under two different parts; current state of affairs and future targets.

- Current state (2017,2018)
- National targets (2020, 2025)

Since polyethylene terephthalate (PET) has substantial usage in plastic packaging products with 23% of total share, the study will focus on PET bottles (Figure 3.1.). Recycling is one of the most important routes of reducing the raw material requirement for packaging production. A resource conservation and potential environmental impact reduction can be obtained by recycling. This study aims to quantify the environmental benefits associated with reduced petrol consumption due to PET bottle recycling.

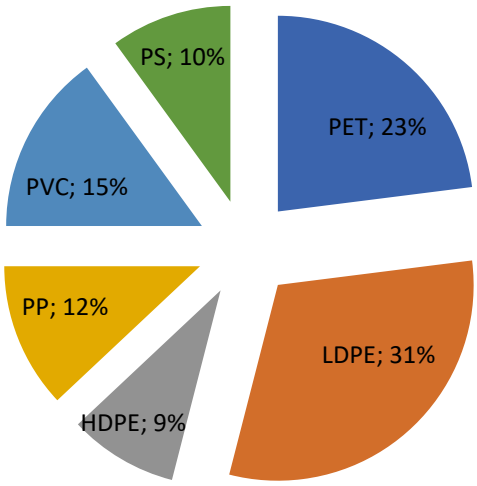


Figure 3.1. Plastic Raw Material Production, Source: Turkey Plastic Industry Follow up Report, PAGEV, 2017.

To determine the current environmental impacts of Turkey's PET and glass packaging materials, two different scenarios were applied to year 2017 and 2018, for each material. Landfill scenarios are the assumption scenarios that are evaluated to compare the environmental impacts of different disposal methods. Recycling scenarios of 2017 and 2018 are the scenarios including the recycling process with the calculated recycling ratio of the related year, based on the previous recycling rates according to the Packaging Bulletins of Ministry of Environment and Urbanization. For the future

scenarios, recycling rates are calculated as the target ratio of the related material, which are given in the Regulation on the Packaging Waste Control (Ministry of Environment and Urbanization, O.G:30283, 27.12.2017). In Scenario 7, it is assumed that incineration is applied instead of landfill. In Scenario 8, recycling amounts are calculated according to the EU Circular Economy Package.

Table 3.1. PET Bottle Scenarios

PET Scenarios	Year	Landfill Ratio	Recycling Ratio	Incineration Ratio
Scenario 1	2017	100 %	-	-
Scenario 2	2017	48 %	52 %	-
Scenario 3	2018	100%	-	-
Scenario 4	2018	47 %	53 %	
Scenario 5	Future	100%	-	-
Scenario 6	Future	45 %	55 %	-
Scenario 7	Future	-	55 %	45 %
Scenario 8	EU	45 %	55 %	-

Table 3.2. Glass Bottle Scenarios

Glass Scenarios	Year	Landfill Ratio	Recycling Ratio	Incineration Ratio
Scenario 1	2017	100 %	-	-
Scenario 2	2017	69 %	31 %	-
Scenario 3	2018	100%	-	-
Scenario 4	2018	69 %	31 %	
Scenario 5	Future	100%	-	-
Scenario 6	Future	40 %	60 %	-
Scenario 7	Future	-	60 %	40 %
Scenario 8	EU	25 %	75 %	-

3.1.1.1. Electric Energy Calculation of Desired Scenarios

In order to accurately assess the impacts of all scenarios, primary energy resource composition of electricity power grid for each year was considered. For 2017 and 2018 scenarios; primary energy

resource distribution of Turkey is considered, according to the reports of Ministry of Energy and Natural Resources.

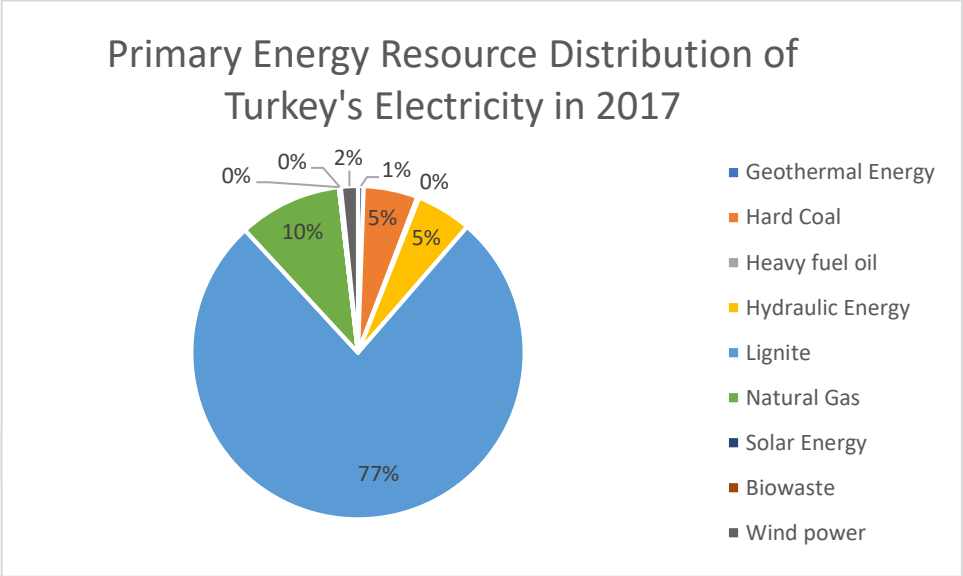


Figure 3.2. Primary energy Distribution of Turkey's Electricity in 2017

In terms of resources, as of 2018, 37.4% of total electricity production is from coal, 29.9% from natural gas, 19.8% from hydraulic resources, 6.6% from wind and 2.5% from geothermal, 0.3% from liquid fuels, 3.3% from biofuels and solar energy, and 0.2% from waste heat (Figure 3.2.)

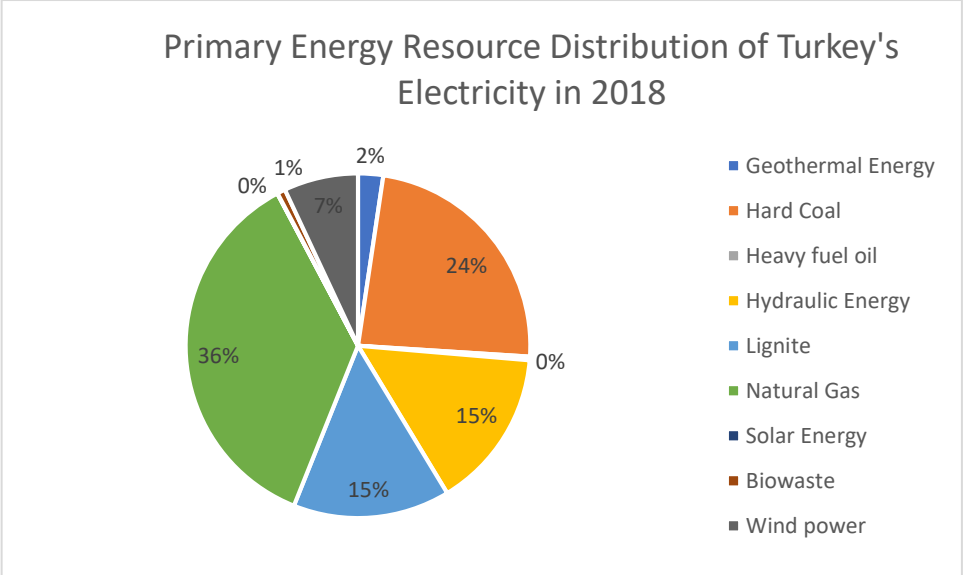


Figure 3.3. Primary Energy Resource Distribution of Turkey's Electricity in 2018, Ministry of Energy and Natural Resources, 2019

For the future scenarios including Turkey's recycling targets, electricity grid mix was calculated according to the target renewable energy production ratios of Turkey Renewable Energy Action Plan (Ministry of Energy and Natural Resources, 2019). The action plan was regulated for the year 2023. Therefore, the electric power resource distribution of 2025 future scenarios were assumed as 2023 target values (Figure 3.4.)

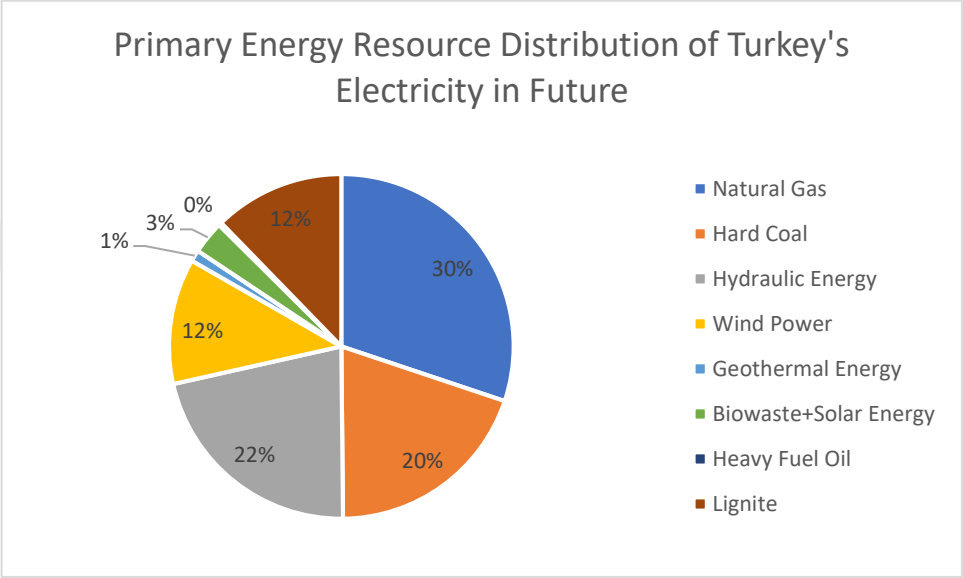


Figure 3.4. Primary Energy Resource Distribution of Turkey's Electricity in 2023, Ministry of Energy and Natural Resources

For the scenario including EU recycling target, the electrical energy flow is taken form the Gabi's EU-27 electricity grid mix. The data set represents the average national or region-specific electricity mix including main activity producers and auto producers as well as electricity imports (Figure 3.5)

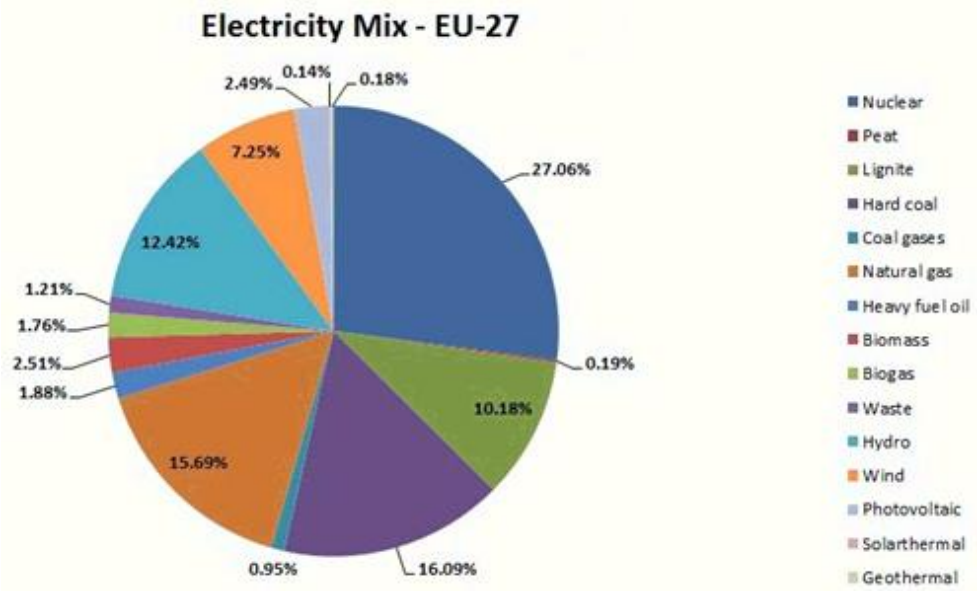


Figure 3.5. Primary Energy Resource Distribution of EU- 27 Electricity mix, Gabi 6.0

3.1.2. Functional Unit

Functional unit (FU) is a reference flow which all inputs and outputs of a Life Cycle Inventory (LCI) and results of the Life Cycle Impact Assessment (LCIA) are evaluated. In this study, since all of the scenarios were calculated for the annual production amounts of PET and glass bottle, functional units are not the same.

Table 3.3. Product Properties

Function	**PET Bottle**	**Glass Bottle**
Weight	32.5 g/L	340 g/L
Containers Per Pallet	1650	1287
Pallets Per Truck	24	24

3.1.3. System Boundaries

System boundaries determine the included processes of the LCA study (ISO 2006a). In this study, raw material acquisition, transport of the raw materials to the production plant, transport of the

related bottle to beverage production plant, transport of bottled beverage to the consumer, transport of waste packaging material to landfill, recycling plant and incineration plant were included in the system. Disposal processes were also included in the system boundaries. Secondary packaging materials of the PET and glass bottle, production and filling of the beverage product, wastes from the recycling plants were excluded from the system. The transport of the output product of the recycling plants to production plants for both PET and glass packaging materials were not included in the study. The system boundaries of PET bottle and glass bottle is given in the Figure 3. 5..

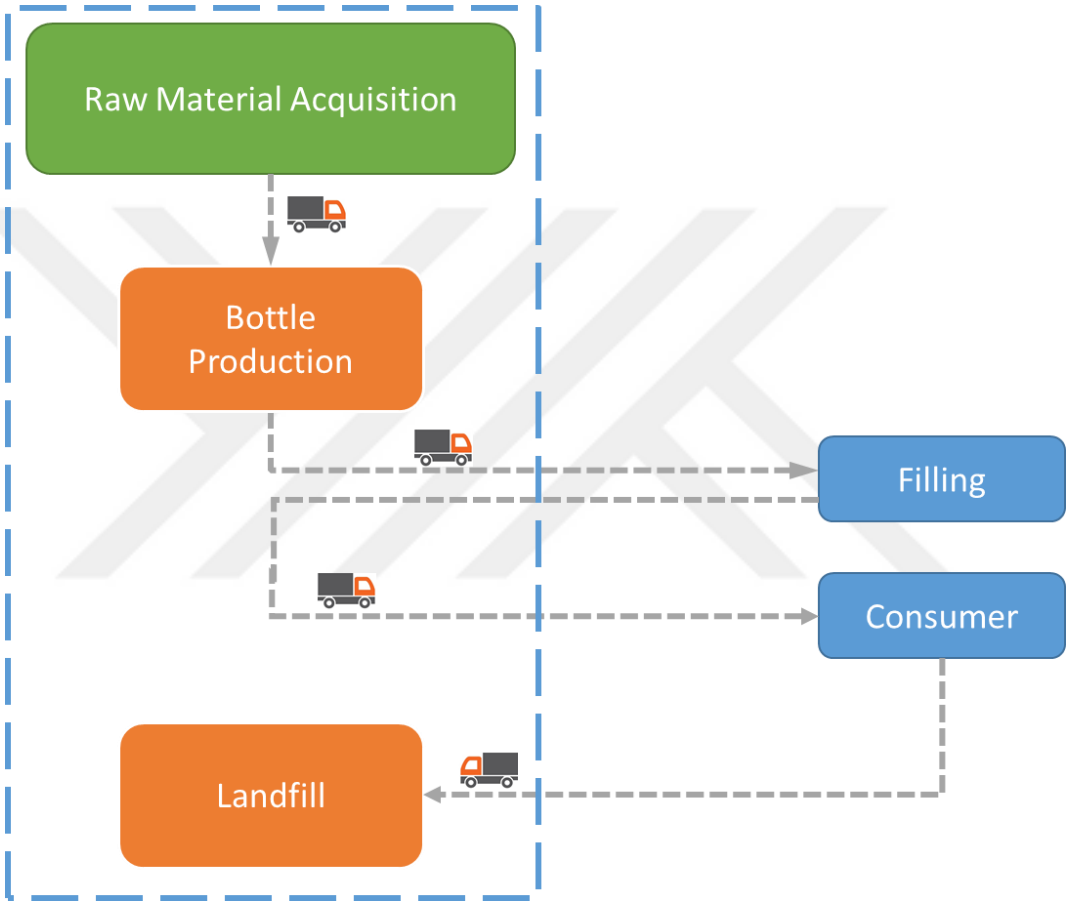


Figure 3.6. System boundaries of both PET and glass bottles

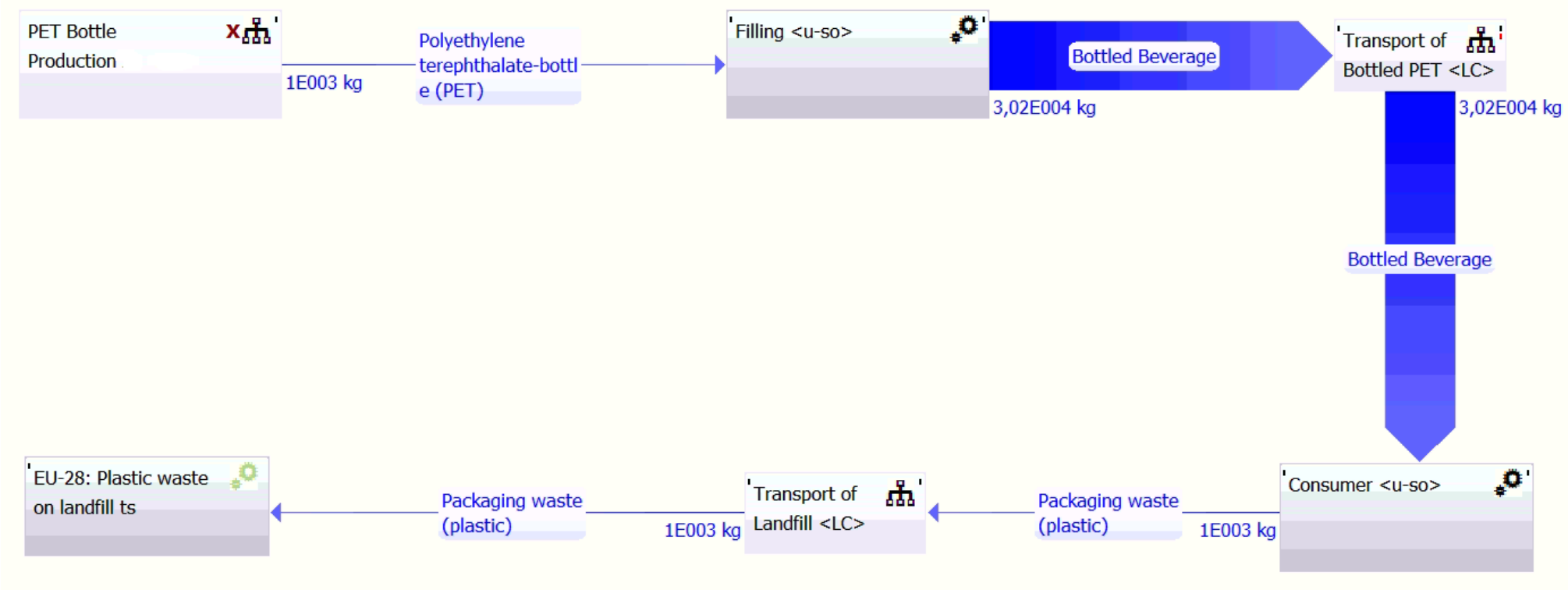


Figure 3.7. Landfill scenario of 1-ton PET bottle

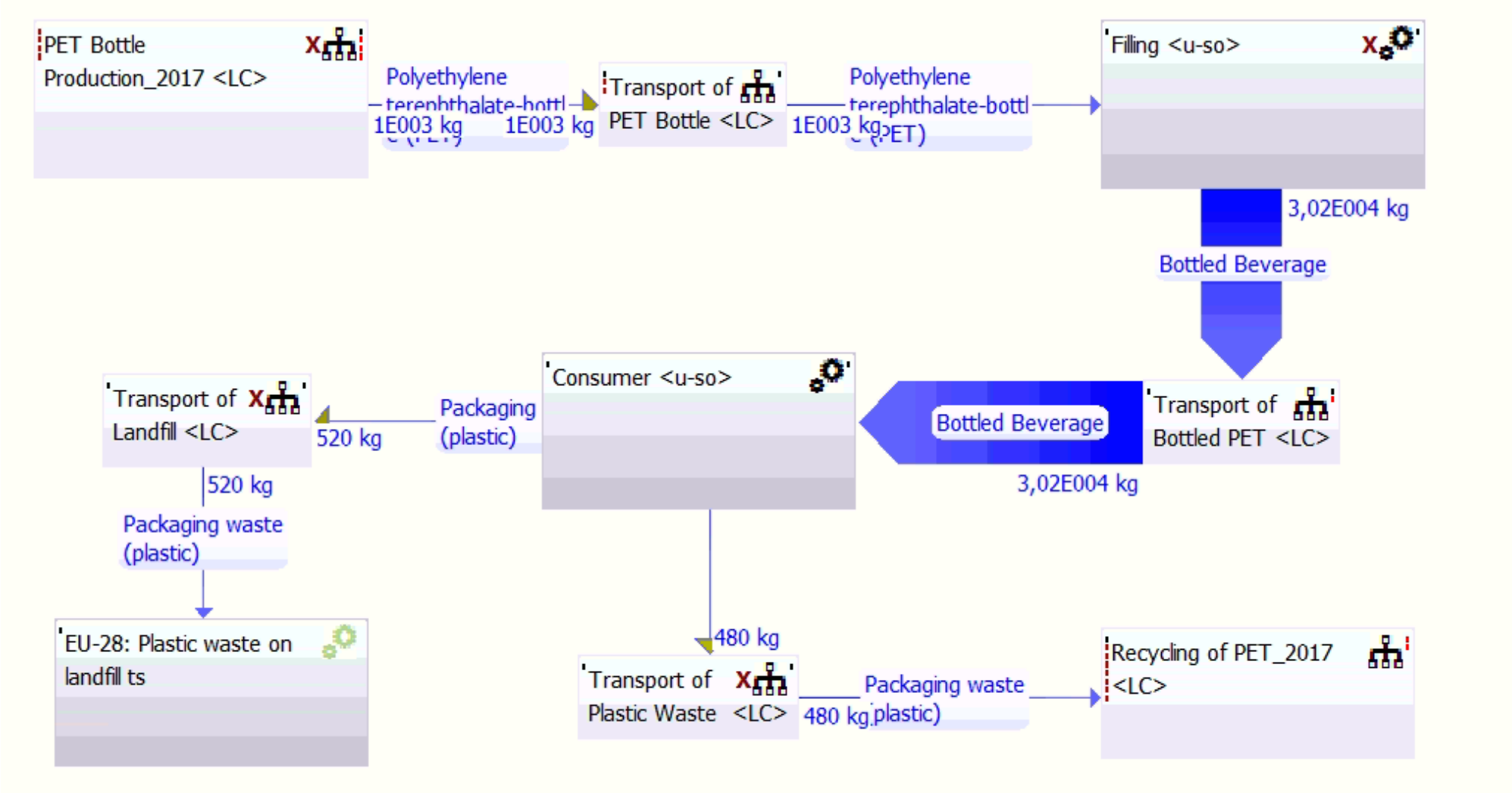


Figure 3.8. Recycling scenario of 1-ton PET bottle

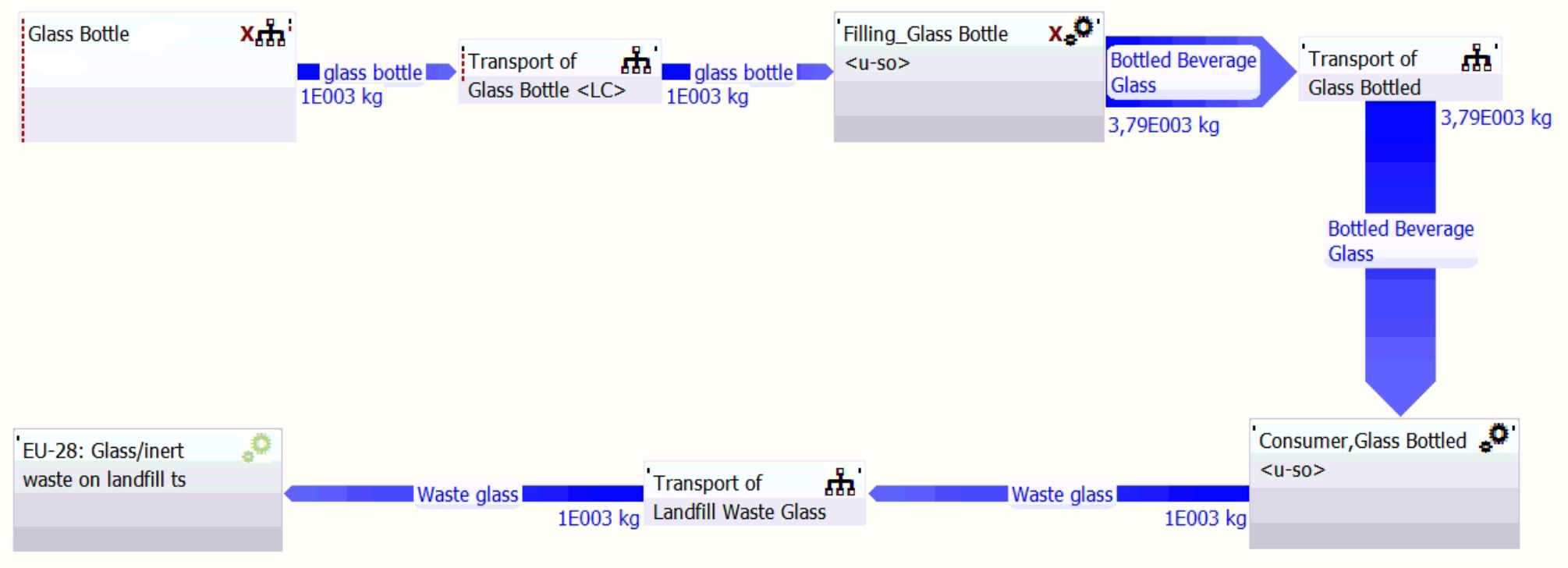


Figure 3.9. Landfill scenario for 1-ton glass bottle

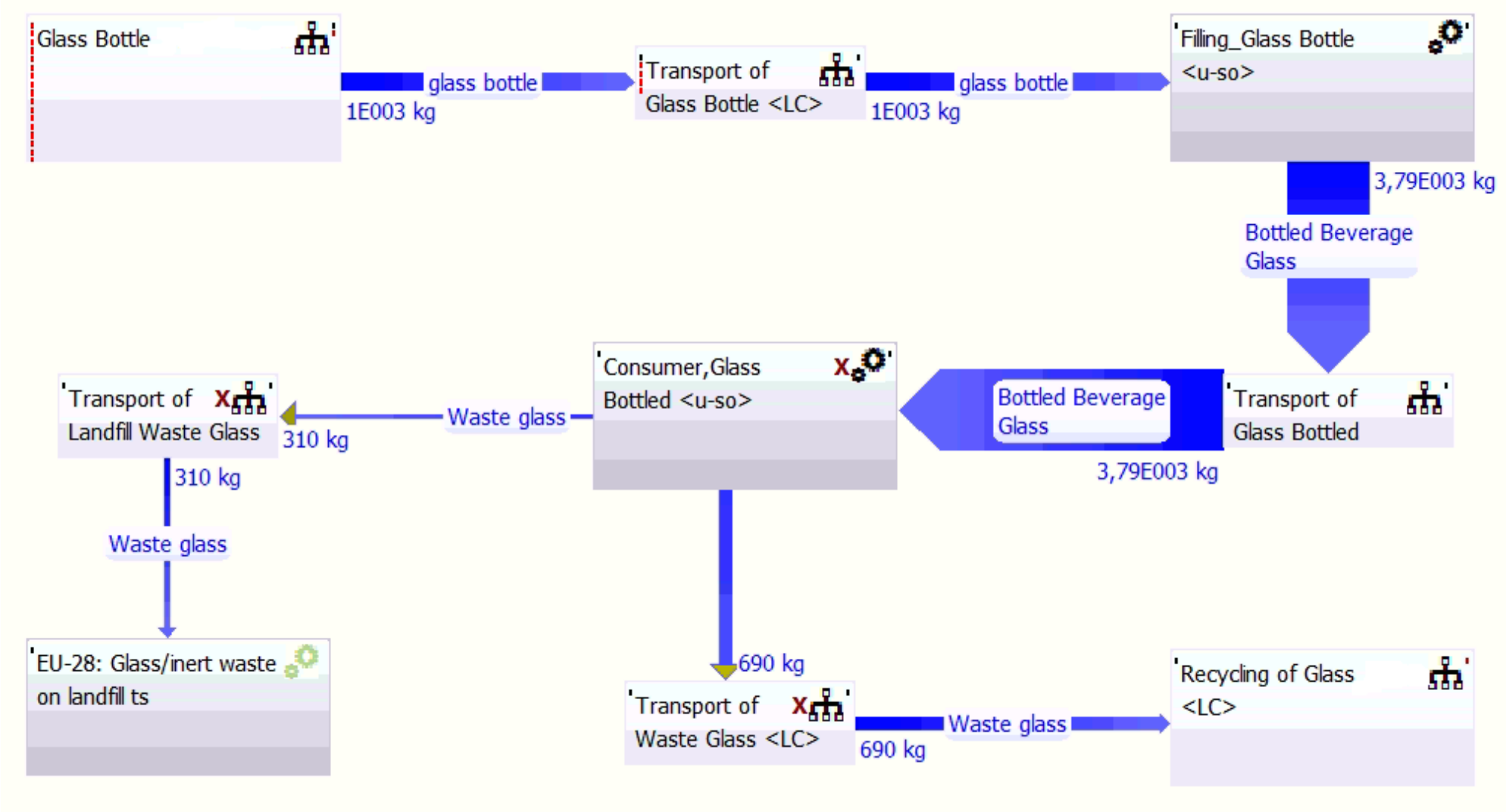


Figure 3.10. Recycling scenario for 1-ton glass bottle

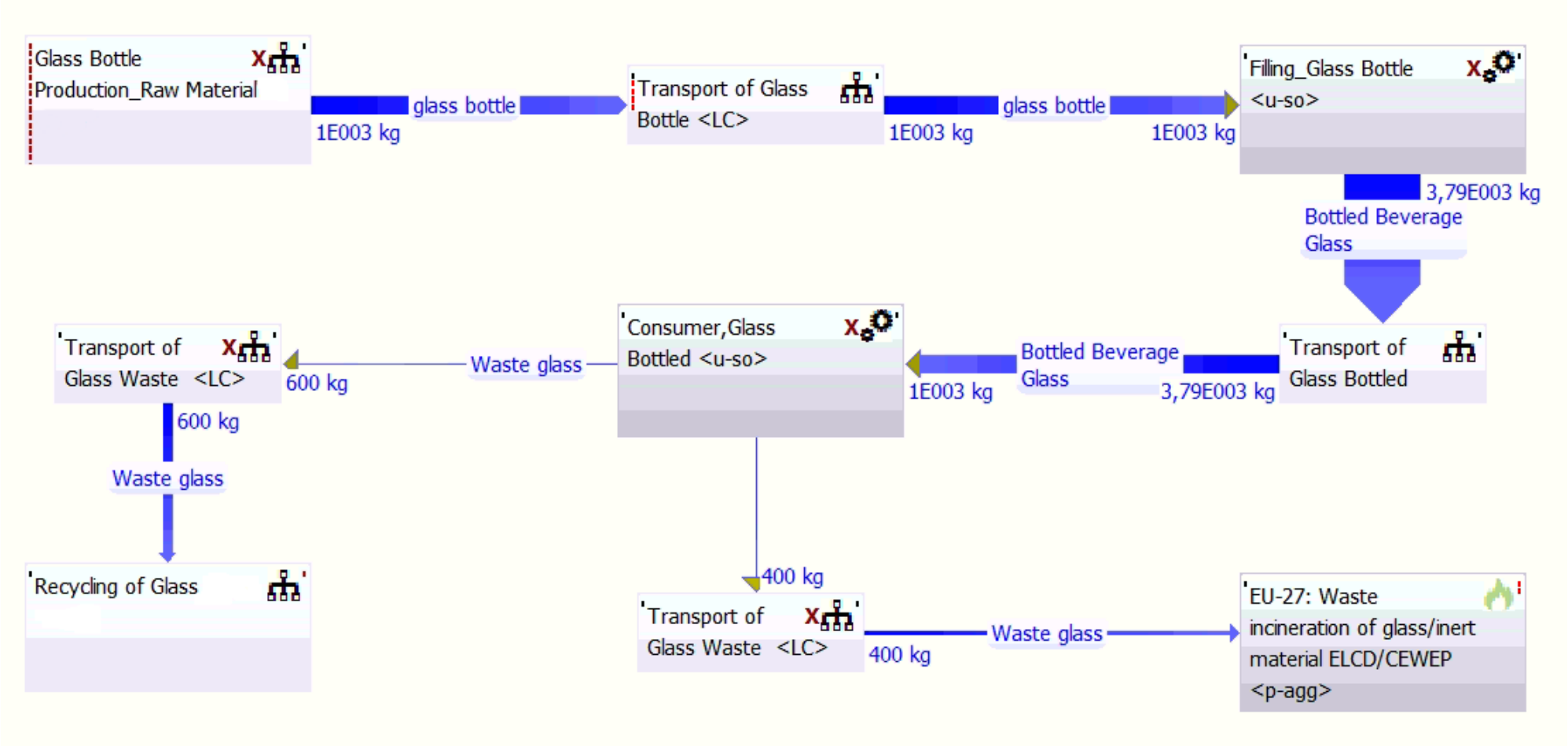


Figure 3.11. Incineration scenario for 1-ton glass bottle

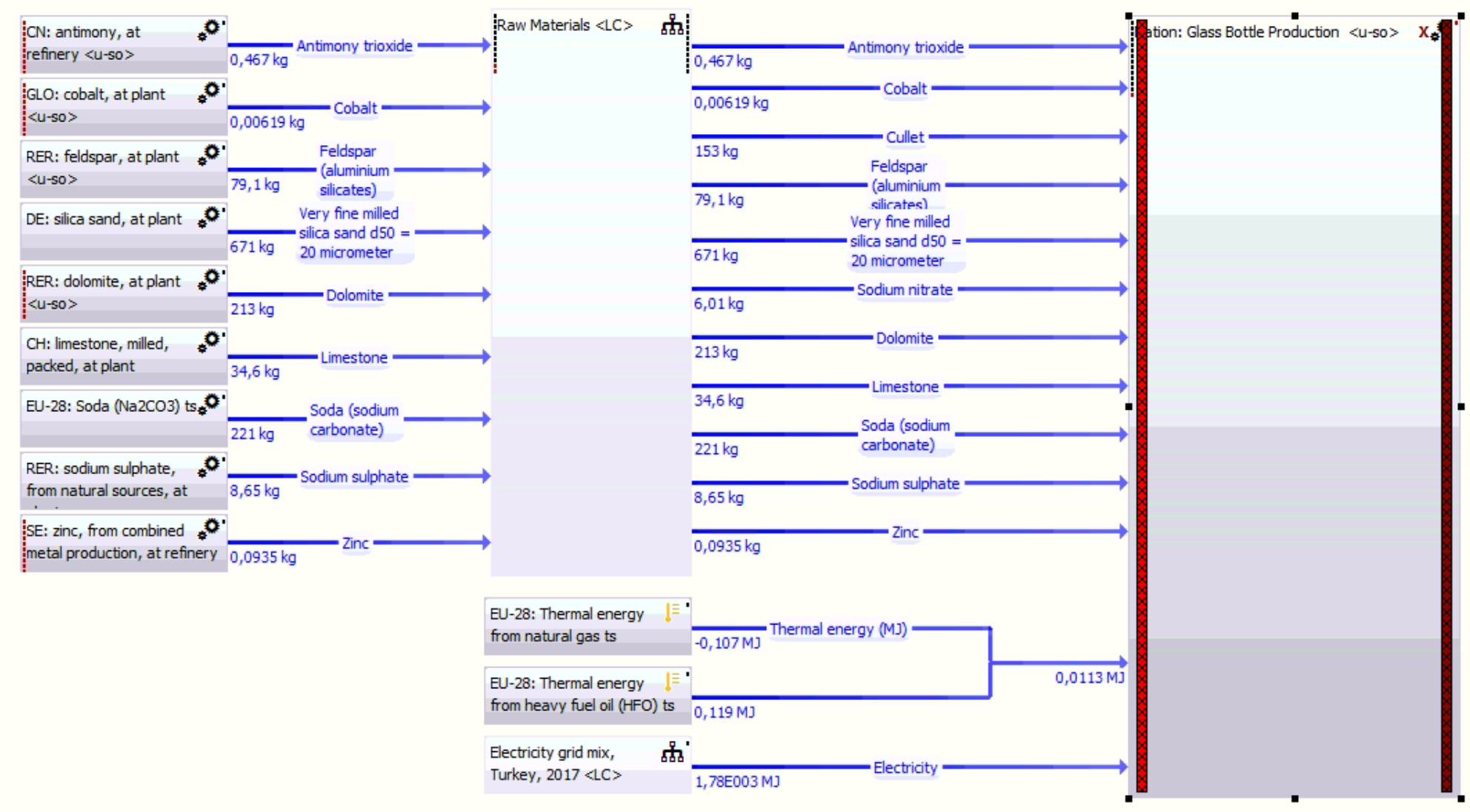


Figure 3.12. Production flow of 1-ton glass bottle

3.2. PET Bottle Production and Recycling Processes

PET bottle production consists of three main stages; preform production, heating and blowing. At first, the system is fed by raw material, polyethylene terephthalate granulates. The raw material is melted by the heat and molded by 7 bar low air injection pressure. After the shaping, the system is cooled by water with a temperature of -18 $^{\circ}$C. The last step of the PET bottle production is blowing stage. It happens under the conditions of 40 bar high air pressure and 7 bar low air pressure. After blowing, bottles are ionized, and their qualities are controlled before they are packed. For this study, PET bottle production factory in Lüleburgaz was visited.

After the consumption of the beverage, the PET bottle becomes a waste. In the scenarios including recycling, the wastes which are sent to the recycling plant were assumed as separately collected. In the recycling process, separately collected wastes enters to the plant and removed from their contaminated materials such sticker, other type of wastes, other type of plastic materials etc. After this separation, they enter to the granulator machine and become a PET flake which is a very tiny piece of PET. These PET flakes are washed with detergents in the pools and leave for to dry. The wastewater coming from the system is treated and reused again for washing process.

Glass bottle production is consisting of five main stages; glass furnace, glass shaping, hot coating, cooling, cold coating. At first raw material mixture is melted at 1500 – 1600^{o}C. Then, melted glass is shaped by blowing air and becomes a bottle. In order to protect the surface of the glass bottle, it is coated with a chemical under the high temperatures. After that, glass bottle is cooled to decrease their inner tension. Finally, before the quality control step, cold coating is applied to glass bottle, in order to protect the surface from scratches.

After the consumption of the beverage, the glass becomes a waste. In the scenarios including recycling, the wastes which are sent to the recycling plant were assumed as separately collected. The recycling process is glass bottle is similar to PET bottle recycling. At first, glass wastes are removed from their contaminated materials then enter to the granulator machine and becomes a cullet. In this study, all of the recycled materials are assumed as a raw material for the same purpose product, beverage bottle.

3.3. Life Cycle Inventory Analysis

In inventory analysis step, based on the scope of the system, energy, water, raw material usage, and according to these, solid wastes, wastewater and environmental emissions are determined. For this study, the input and output balance for packaging production and recycling processes of both PET and glass bottle were required. The data of the plastic and glass packaging production that were collected from the packaging factories and recycling plant are given in Table 3.4 and Table 3.5 respectively.

Table 3.4. Data for the PET Bottle Production and PET Recycling Processes

	Parameters		**Quantity**	**Unit**
Raw Materials	Polyethylene terephthalate granulate		32.5	gr/one bottle
Energy Requirements	Electrical energy		0.0018	kw/gr
Waste	No waste from the production process			
Transport	**Cargo Material/ Destination**	**Transport Type/Subtype**	**Distance**	**Unit**
Raw Material	Polyethylene terephthalate granulate	Highway	50	km
Bottle Product	PET Bottle	Highway	250	km
Filled Bottle	Bottled Beverage	Highway	200	km
Waste Bottle	Landfill	Highway	120	km
	Recycling Plant	Highway	100	km
	Incineration Plant	Highway	100	km
Recycling Plant	**Parameters**		**Quantity**	**Unit**
Energy Requirements	Electricity		0,005416667	kwh/one bottle
	Thermal energy		0.047255	MJ/one bottle
Raw Materials	Water		97.5	gr/one bottle
Waste	Wastes such as stickers, dust, bottle cap were ignored in this study.			

Table 3.5. Data for the Glass Bottle Production and Glass Recycling Processes

	Parameters	**Quantity**	**Unit**	**Transport Type/Subtype**	**Distance**	**Unit**
Raw Materials	Soda	75.25714259	gr/one bottle	Highway	150	km
	Dolomite	72.50865898	gr/one bottle	Highway	150	km
	Feldspar	26.89453219	gr/one bottle	Highway	120	km

	Limestone	11.77260541	gr/one bottle	Highway	130	km
	Soldium sulphate	2.939564656	gr/one bottle	Highway	100	km
	Sodium nitrate	2.044951207	gr/one bottle	Airway	13.311,15	km
				Highway	50.00	km
	Cobalt	0.002104696	gr/one bottle	Highway	3000	km
	Zinc selenite	0.03180375	gr/one bottle	Highway	2600	
	Antimony oxide	0.158943224	gr/one bottle	Highway	200	km
	Silica sand	228.2909812	gr/one bottle	Highway	2.590	km
	Glass Cullet	52.10366409	gr/one bottle	Highway	150	km

Energy Requirements	**Parameters**		**Quantity**	**Unit**
	Electrical energy		0.16827609	kwh/one bottle
	Thermal energy (diesel) [Thermal energy]		3.84E-06	MJ/one bottle
	Thermal energy (MJ) [Thermal energy]		3.174846154	MJ/one bottle
Waste	No waste from the production process			
Transport	**Cargo Material/ Destination**	**Transport Type/Subtype**	**Distance**	**Unit**
Bottle Product	Glass Bottle	Highway	180	km
Filled Bottle	Bottled Beverage	Highway	200	km
Waste Bottle	Landfill	Highway	100	km
	Recycling Plant	Highway	200	km
	Incineration Plant	Highway	200	km

3.3.1. Key Assumptions

In this study, the production amounts of PET and glass bottle for each year were assumed same as the waste data from the Packaging Waste Bulletins of the Ministry of Environment and Urbanization. Since the bulletins of 2017 and 2018 are not published yet, future production amounts were calculated in the excel based on the previous data of packaging wastes from the bulletins. The recycling rates were assumed and calculated as it is given in the Regulation on Packaging Waste Control. Future recycling rates were also calculated as the same. In the Packaging Waste Bulletins,

the plastic waste amounts are not separately given as their types of plastics. Therefore, it was assumed that the PET bottle waste amounts are 30% of the total plastic wastes for each year. This assumption is an average of the percentage of PET wastes at the separation and collection center of plastic wastes. In this study, the PET flakes produced from the PET bottle was assumed as a raw material for the PET bottle production again.

For glass bottle production amounts, it was assumed that the 39% of the glass packaging materials is colorless glass bottle (Alkan, 2014). The recycled material was assumed to be used for the same purpose; beverage packaging.

3.3.2. Ecoinvent Database

For this study, the Ecoinvent processes given in the Table 3.6 were applied in order to evaluate the environmental results of the PET and glass bottle production and disposal. Since the recycling processes of PET and glass packaging products are not readily available in the software, the system was set by the Ecoinvent database. The selected flows and processes used in this study for PET and glass packaging systems are given in Table 3.6 and 3.7 respectively.

Table 3.6. Selected data from Ecoinvent for PET bottle

Raw Materials of PET Bottle	Selected Ecoinvent Data
Polyethylene terephthalate granulate	olyethylene terephthalate, granulate, bottle grade, at plant [polymers]
PET flake	Recycled PET granulate [Packaging]

Table 3.7. Selected data from Ecoinvent for glass bottle

Raw Materials of Glass Bottle	Selected Ecoinvent Data
Antimony oxide	Antimony, [Inorganic intermediate products]
Cobalt	Cobalt [Metals]
Granulated glass in the production factory	Cullet [Waste for recovery]
Dolomite	Dolomite [Minerals]

Feldspar	Feldspar (aluminium silicates) [Non renewable resources]
Limestone	Limestone [Minerals]
Soda	Soda (sodium carbonate) [Inorganic intermediate products]
Sodium nitrate	Sodium nitrate [Inorganic intermediate products]
Sodium sulphate	Sodium sulphate [Inorganic intermediate products]
Silica sand	Very fine milled silica sand d50 = 20 micrometer [Minerals]
Zinc selenite	Zinc [Metals]

4. RESULTS AND DISCUSSION

4.1. Life Cycle Impact Assessment

The potential impacts of water, energy, raw material usage and emissions on environment and human health determined in the inventory analysis are assessed in the impact assessment step. ISO 14040 specifies the mandatory classification and characterization of the impact assessment phase, and the optional normalization and weighting sub-stages.

In this study, the following impact categories were considered; acidification potential (AP), eutrophication potential (EP), global warming potential (GWP), ozone layer depletion potential (ODP) and photochemical ozone creation potential (POCP).

4.1.1. Life Cycle Impact Assessment for PET Bottle Production

Life cycle impact assessment of PET bottle has been conducted by using GaBi 6.0 software. At first, required raw materials have been listed for production step. All flow diagrams which includes production, recycling, landfill, incineration, and transportation steps have been generated in program with respect to desired scenario. Results of generated flow have been analyzed by considering classification, characterization, normalization, and weighting procedures. Environmental impacts have been assessed with these results.

4.1.1.1. Classification

At classification step, life cycle impact results are analyzed and correlated with the environmental impact categories. In this study, global warming potential, acidification, photochemical ozone creation, eutrophication, and ozone layer depletion are selected as environmental impact categories and determined by emissions calculation with cradle to grave strategy. These impact categories are also used in glass bottle life cycle assessment in next section.

4.1.1.2. Characterization

Life cycle assessment of PET bottle production is conducted with GaBi 6.0 Software. In characterization step, emissions of created PET bottle production flow are calculated for environmental impact categories. Contribution of these emissions to relevant impact categories are decided with the software. Similar to LCI of glass bottle production, 2017 Turkey's Landfill scenario was selected as a base scenario for PET bottle LCI results comparison. Table 4.1. shows characterization results of PET bottle production of base scenario for annual scale.

Table 4.1. Characterization results for PET bottle production in Turkey's 2017 Landfill Scenario

Impact Category	**Unit**	**2017 Total**
Global Warming Potential (GWP)	[kg CO2-eq.]	6733725685
Acidification Potential (AP)	[kg SO2-eq.]	620606957.9
Eutrophication Potential (EP)	[kg Phosphate-eq.]	2237153.492
Ozone Layer Depletion Potential (ODP)	[kg R11 eq.]	965.8530446
Photochemical Ozone Creation Potential (POCP)	[kg Ethene-eq.]	8002166.929

Global Warming Potential (GWP) is the one of the environmental impact categories. 2017 Turkey's Landfill scenario is the worst option for GWP. In Scenario 2 , GWP decreases 35.4% and this corresponds 2386104843.9 kg CO_2 in annual scale. Similarly, other scenarios which include other disposal processes (3, 4, 5, 6, 7), CO_2 emissions decrease 0.9%, 40.2%, 53.1%, 57.2%, and 54.5% respectively. However, if the best scenario which is EU scenario is utilized, GWP decreases 82.7% and this equals to 5571581165.4 kg CO_2 per year.

Acidification Potential (AP) is the second impact category in this study. In case of the worst scenario which is 2017 Turkey's Landfill scenario was applied, 620606957.9 kg SO_2 is released into the environment. If other scenarios (2, 3, 4, 5, 6, 7, 8) are considered, this value decreases 92.4%, 69.9%, 92.5%, 94.6%, 94.8%, 94.9%, and 97.9% respectively. EU scenario is the best option for reduction of AP. In this scenario, this percentage decrease corresponds 607560920.9 kg SO_2 for one-year period.

Table 4.2. Characterization results of PETs bottle production for all scenarios

Scenarios	**Impact Categories**				
	GWP, kg CO2 eq	AP, kg SO2 eq.	EP, kg PO4 eq.	ODP, kg R11 eq.	POCP, kg C2H4 eq.
2017 Landfill (1)	6733725685	620606957.9	2237153.492	965.8530446	8002166.929
2018 Landfill (2)	4347620841	47364750.56	1753272.412	3223.49781	2536350.912
2017 Recycling (3)	6672846446	186944008.4	2222490.885	463.6116448	7994782.245
2018 Recycling (4)	4027102066	46364470.69	1656483.142	1515.050089	2359975.322
Turkey Future Landfill (5)	3159705887	33261162.02	1269594.325	2675.04037	1837032.289
Turkey Future Recycling (6)	2882681493	32360492.78	38625.38172	1203.771041	1683403.422
Turkey Future Recycling & Incineration (7)	3065368489	31713981.52	1165118.959	1203.892574	1651651.985
EU (8)	1162144520	13046036.98	477744.6467	485.2967356	678659.112

Another impact category is eutrophication potential (EP). Similarly, Scenario 1 is the worst option for EP. If comparison is conducted between Scenario 1 and other scenarios (2, 3, 4, 5, 6, 7, and 8), EP impact decreases 21.6%, 0.6%, 25.9%, 43.3%, %98.3, 47.9%, and 78.6% respectively. In this case, the best option for reduction of PO_4 emission is Turkey's Future Recycling scenario. If Turkey utilize this scenario, 2198528.1 kg PO_4 emissions can be prevented for one-year period.

Ozone layer depletion (ODP) is another environmental impact category. Annual emissions quantity of this category is relatively small. Scenario 2 is the worst option for ODP. In Scenario 2, R 11 emissions increase by 233.8%. Turkey's future scenarios also have a bad impact on ODP. If these scenarios (5, 6, and 7) are applied, ODP increases by 177.0%, 24.6%, and 24.7% respectively. On the other hand, if EU scenario is implemented, ODP decreases by 49.7% and this corresponds 480.6 kg R 11 for annual period. As can be seen, EU scenario is the best option for ODP.

The last impact category is POCP. The best scenario to reduce this impact is EU scenario. If it is utilized, POCP decreases by 91.5% and this change equivalent to 7323507.8 kg C_2H_4 for yearly period. Other scenarios have also positive impact on C_2H_4 emissions. If these scenarios (2, 3, 4, 5, 6, and 7) are applied, POCP decreases by 68.3%, 0.1%, 70.5%, 77.1%, 79%, and 79.4% respectively.

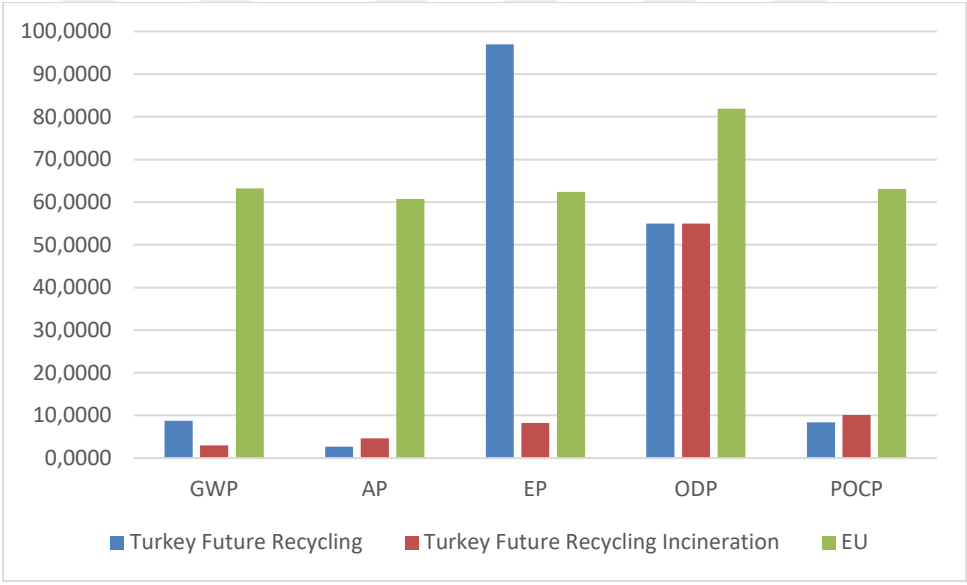
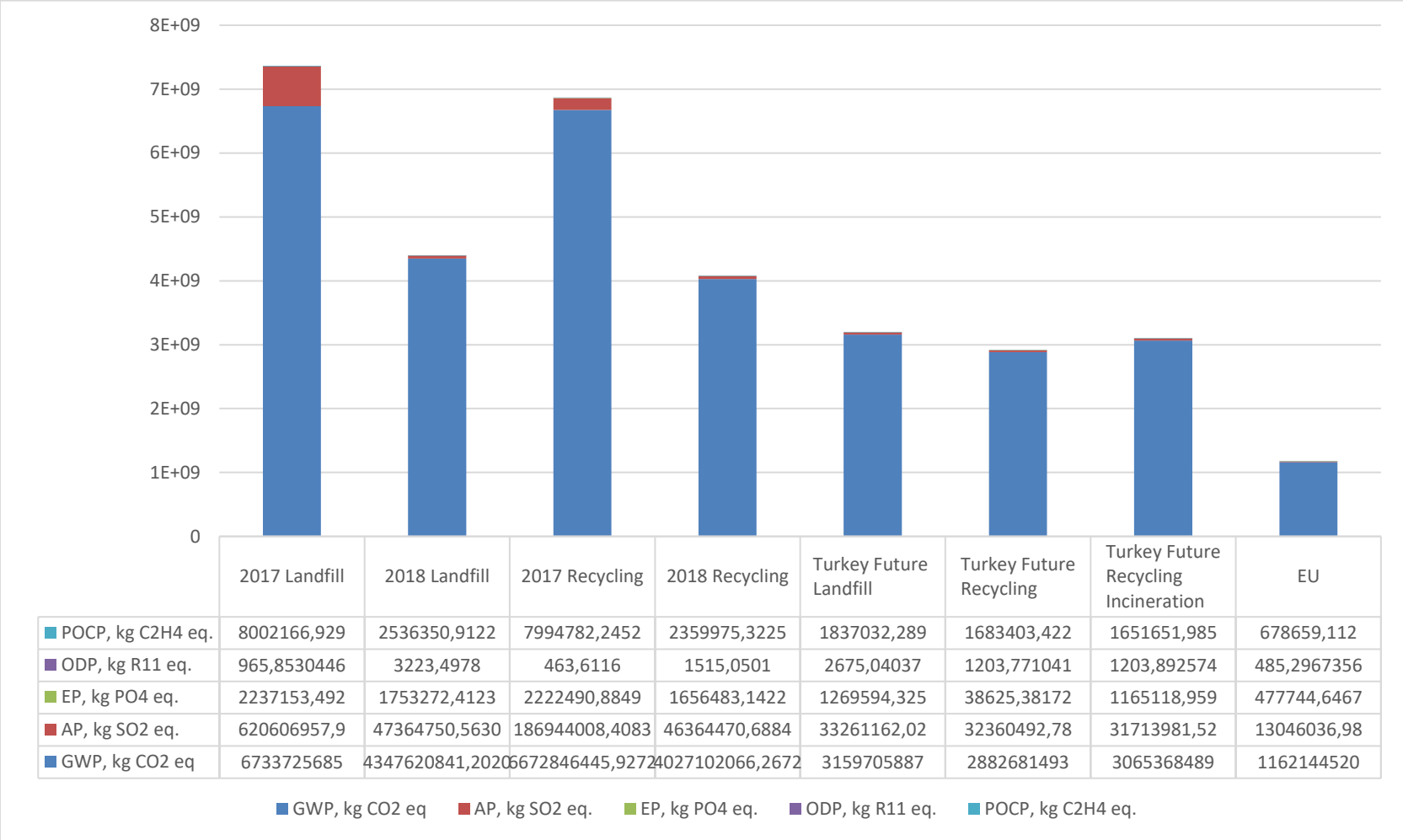


Figure 4.1. Percentage Change of Given PET Production Scenarios with Turkey Future Landfill Scenario

To get clear comparison of future scenarios and EU scenario, Figure 4.2. is given above. All future scenarios are compared with Turkey's Future Landfill scenario which is the worst future scenario for all impact categories. As can be seen in Figure 4. 2., EU is the best option for almost all environmental impact categories. In case of GWP, EU scenario decreases CO_2 emissions by 63.2%. On the other hand, if Turkey's Future Scenarios (6 and 7) are applied, GWP just decrease by 8.8% and 3% respectively. This difference corresponds 1720536973 kg CO_2 for yearly period. For AP reduction, EU scenario is the best option. SO_2 emissions decrease by 60.7% with this scenario and this corresponds 18667944.5 kg for annual time period. EP is the only environmental impact category

which Turkey's Future Recycling scenario is better than EU scenario. If Scenario 6 is utilized, EP decreases by 96.9% which corresponds 1230968.9 kg PO_4 for one-year time period. Next impact category is ODP. There are no major changes in this category. However, EU scenario is the best option for this category. If it is utilized, 2189.7 kg R 11 emissions can be prevented. The last impact category is POCP. If EU scenario is applied, POCP decreases by 63.1% and this means EU scenario is far better than Turkey's future scenarios.



	2017 Landfill	2018 Landfill	2017 Recycling	2018 Recycling	Turkey Future Landfill	Turkey Future Recycling	Turkey Future Recycling Incineration	EU
POCP, kg C2H4 eq.	8002166,929	2536350,9122	7994782,2452	2359975,3225	1837032,289	1683403,422	1651651,985	678659,112
ODP, kg R11 eq.	965,8530446	3223,4978	463,6116	1515,0501	2675,04037	1203,771041	1203,892574	485,2967356
EP, kg PO4 eq.	2237153,492	1753272,4123	2222490,8849	1656483,1422	1269594,325	38625,38172	1165118,959	477744,6467
AP, kg SO2 eq.	620606957,9	47364750,5630	186944008,4083	46364470,6884	33261162,02	32360492,78	31713981,52	13046036,98
GWP, kg CO2 eq	6733725685	4347620841,2020	6672846445,9272	4027102066,2672	3159705887	2882681493	3065368489	1162144520

Figure 4.2. Annual impacts of PET bottle life cycle for all scenarios

4.1.1.3. Normalization

Environmental impact units of life cycle assessment are usually different to each other, such as kg CO_2 equivalent, kg Phosphate equivalent, kg SO_2 equivalent, kg R 11 equivalent and kg Ethane equivalent. This situation make comparison difficult. Therefore, normalization step is necessary for clear comparison of different impact categories. All characterization results of performed LCIA calculation are divided by the reference value. Total impact of different emission sources is showed with this reference value per impact category for EU25+3, over a year. Normalization results do not have any unit, and this makes possible to compare different impact potentials.

Figure 4.3. shows normalization results of different impact categories. As can be seen, acidification potential is the major impact category for all scenarios. All environmental impact potential decreases with the future scenarios. Two best scenarios are Turkey's Future Recycling scenario and EU scenario. If Turkey's Future Recycling scenario is applied, AP, EP, GWP, ODP, and POCP decrease by 94.7%, 82.6%, 87.6%, 62.7%, and 94.1% respectively. Similarly, if EU scenarios is utilized, these decrease ratios become 97.8%, 92.9%, 94.9%, 84.9%, and 97.6% respectively.

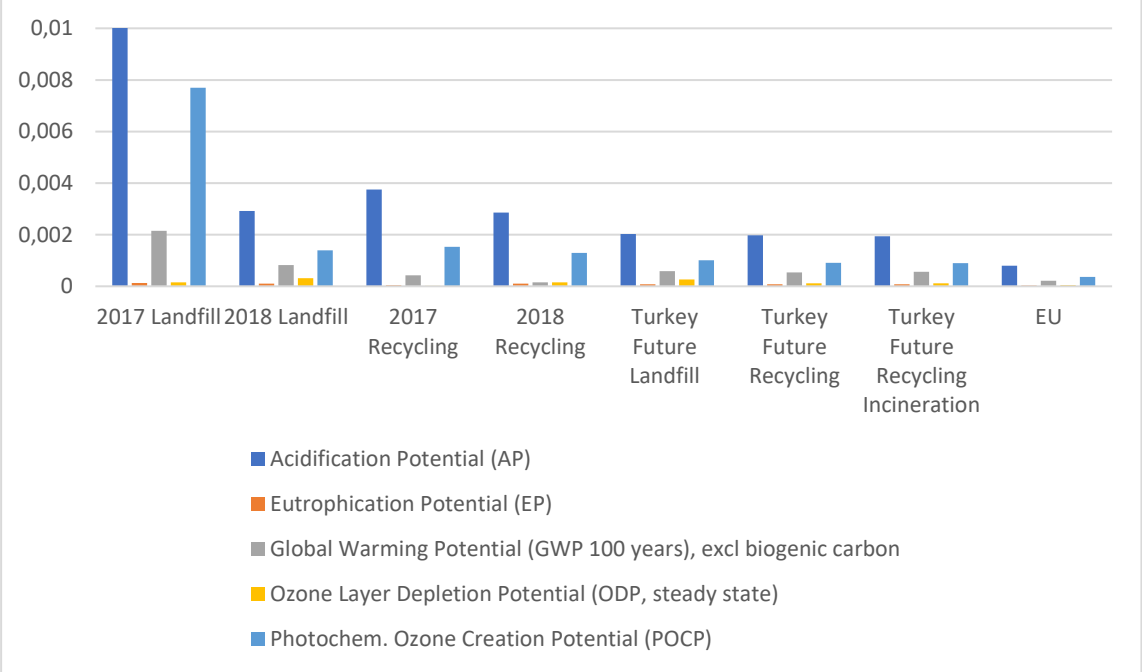


Figure 4.3. Normalization results of PET Bottle Production for different scenarios

4.1.1.4. Weighting

After normalization step, weighting is final step for LCIA. Showing relative importance of environmental impact category is the main purpose of this step. In order to do that, normalization results are multiplied with the weighting factor. In this study, CML 2001- Dec. 07, Experts IKP (Southern Europe) is selected for weighting step. The weighted results are comprised of same unit and can be calculated for single score of each environmental impact category. Figure 4.4 shows weighting results of PET bottle production. Acidification potential is the most dominant impact category for PET bottle production for all scenarios. Eutrophication potential is the least important impact category for all scenarios.

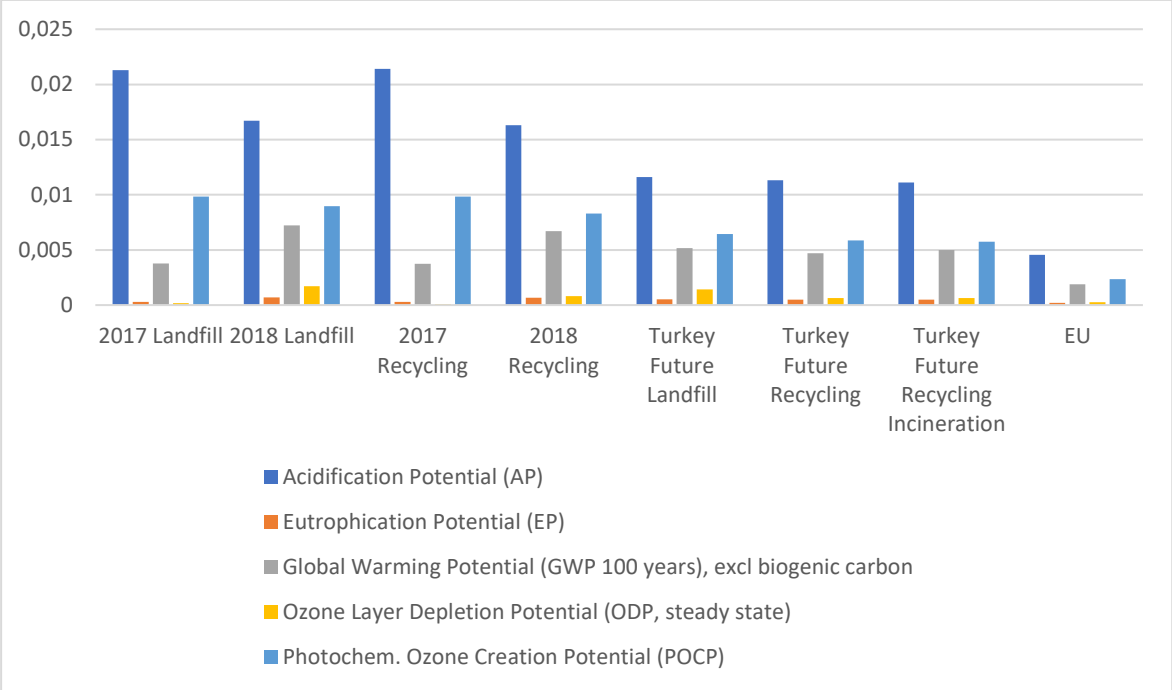


Figure 4.4. Weighting results of PET Bottle Production for different scenarios.

4.1.2. Life Cycle Impact Assessment for Glass Bottle in Turkey

Life cycle impact assessment of glass bottle has been conducted by using GaBi 6.0 software. At first, required raw materials have been listed for production step. All flow diagrams which includes production, recycling, landfill, incineration, and transportation steps have been generated in program with respect to desired scenario. Results of generated flow have been analyzed by considering

classification, characterization, normalization, and weighting procedures. Environmental impacts have been assessed with these results.

4.1.2.1. Classification

Inventory results are determined under different impact categories, according to the expected impacts on the environment. In Table.4.3. selected LCI data and impact categories for this study are given.

Table 4.3. Selected impact categories

Impact Categories	**Selected LCI Data**	**Unit**
Global Warming Potential (GWP)	CO_2, N_2O, SF_6, NMVOC, CH_4	kg CO_2 eq.
Acidification Potential (AP)	NH_3, NO_x, SO_2, H_2SO_4	kg SO_2 eq.
Eutrophication Potential (EP)	NH_3, NO_x, N_2O, PO_4^{3-}, P	kg PO_4 eq.
Photochemical Ozone Creation Potential (POCP)	CO, NO_x, SO_2, NMVOC, CH_4, VOC (unspecified)	kg Ethane eq.
Ozone Layer Depletion Potential (ODP)	CH_4, Halon 1211, Halon 1301, R11, R114, R12	kg R11 eq.

4.1.2.2. Characterization

In characterization step, LCI results can be directly compared within the scope of selected impact categories. Generated flow in software calculates the amount of emissions for each impact category. Emissions can vary for different scenarios. Content of these scenarios are given in previous section. In this study, Turkey's 2017 landfill scenario is selected as a base scenario and all comparison have been conducted with this scenario. In Table 4.4 LCA characterization results of glass bottle in base scenario for annual scale are given.

Table 4.4. Characterization results for glass bottle production in Turkey's 2017 Landfill Scenario

Impact Category	**Unit**	**Annual**
Global Warming Potential (GWP)	[kg CO2-eq.]	661286573.7

Acidification Potential (AP)	[kg SO2-eq.]	16633007.11
Eutrophication Potential (EP)	[kg Phosphate-eq.]	207364.2023
Ozone Layer Depletion Potential (ODP)	[kg R11 eq.]	0.000445553
Photochemical Ozone Creation Potential (POCP)	[kg Ethene-eq.]	716325.6265

Characterization results of glass bottle for all scenarios is given in Table 4.5. All these results are given in annual scale. In 2017, annual production quantity was 310286.73 tons and environmental impact assessments have been conducted with this amount. Production quantity is estimated to increase up to 452596.56 tons. Governments plastic reduction strategies may be the reason of increasing glass bottle amounts. This estimated quantity has been used to calculate environmental impacts of future scenarios and EU scenario.

Table 4.5. Characterization results of glass bottle production for all scenarios

Scenarios	**Impact Categories**				
	GWP, kg CO2 eq	AP, kg SO2 eq.	EP, kg PO4 eq.	ODP, kg R11 eq.	POCP, kg C2H4 eq.
2017 Landfill (1)	661286573.7	16633007.11	207364.2023	0.002227766	716325.6265
2018 Landfill (2)	510083652.3254	2067302.3173	121414.3746	0.8298	139770.3252
2017 Recycling (3)	360295659.0747	4548192.3606	82513.9083	0.234441543	214474.1925
2018 Recycling (4)	374732645.5733	1270353.4587	62916.7751	0.241385979	86348.1617
Turkey Future Landfill (5)	720603312.2	6721437.478	510397.4591	0.740114288	318507.3089
Turkey Future Recycling (6)	535034668	1776971.43	93830.75432	0.46122214	123749.1332
Turkey Future Recycling & Incineration (7)	545257158.5	1787586.565	98154.8833	0.685719909	124382.193
EU (8)	504448153.3	1649598.275	80437.13072	0.28922208	113297.8459

One of the environmental impact categories is GWP (Global Warming Potential). 2017 Turkey's Landfill scenario for glass bottle production has the worst impact on global warming. If 2017

Turkey's Recycling scenario is applied and recycling ratio is increased 0% to 31% GWP decreases by 45.51% in annual scale. If Turkey's future scenarios which are Scenario 6, 7 and EU scenarios are utilized, GWP decreases by 19.1%, 18.3%, 17.5%, and 23.7 respectively. 2017 Turkey's Recycling scenario may have seen better for GWP. However, production quantity between these scenarios are different and it has a huge impact on the system. Therefore, EU scenario is the best way to decrease GWP.

The second impact category is acidification potential (AP). Scenario 1 is the worst option for AP. If 2017 recycling scenario is applied, AP decreases by 72.6% annually, which corresponds 12084814.75 kg SO_2. If Scenario 4 is used, AP decreases 92.4% and 15362653.65 kg SO_2 will not spread to environment. If future scenarios (5, 6, 7, and 8) are implemented, SO_2 emission decreases by 59.6%, 89.3%, 89.2%, and 90.1% respectively. If production quantity considered, these results demonstrate that EU scenario is the best option for AP reduction.

Another impact category is eutrophication potential (EP). Similarly, Scenario 1 is the worst option for EP. If Scenario 3 is considered, EP decreases 60.2% and this corresponds 124850.3 kg PO_4 in annual scale. If Scenario 5 is implemented, EP increases 146.2%, this scenario includes 100% landfill as a disposal method which is similar to Scenario 1. This critical rise shows that importance of production quantity. If other future scenarios (6, 7, and 8) are applied, PO_4 emission decreases by 54.7%, 52.6%, and 61.2% respectively. Similarly, EU scenario is the best performer. Another outcome of this result is incineration method effect. Scenario 7 includes 60% recycling and 40% incineration. Whereas, Scenario 6 includes 60% recycling 40% landfilling. These results show that, incineration is not good as landfilling for the PO_4 reduction.

Ozone Layer Depletion (ODP) is another impact category. However, ODP results are very small for glass production life cycle assessment and there is no major change between scenarios. In case of Scenario 1, ODP is 0.002227766 kg. Similarly, other scenarios (2, 3, 4, 5, 6, 7, and 8) are utilized, 0.83, 0.23, 0.24, 0.74, 0.46, 0.69, 0.29 kg R 11 are produced. If production quantity is considered, best option for ODP is EU scenario.

Final impact category is POCP. If Scenario 3 is applied, POCP decreases 70.1% and this corresponds 501851.4 kg for annual scale. If future scenarios of Turkey (5, 6, and 7) are utilized, POCP decreases by 55.5%, 82.7%, and 82.6. In order to reduce POCP, EU scenario is the best option, it reduces C_2H_4 values 84.2% with respect to base scenario.

Production quantity has an important effect on environmental impact categories. Future production quantity will be increased by 45%. To get clear comparison of future scenarios, Figure 4.5 is given below. In this figure, all scenarios have been compared with Turkey Future Landfill scenario which is the worst scenario for future. As can be seen in Figure 4.5, EU scenario is the best choice for all environmental impact category. Second best scenario is Turkey Future Recycling Scenario. In case of GWP, EU and Scenario 6 decrease GWP 29.9% and 25.7% respectively. This 4.2% difference corresponds 30586514.6 kg CO_2.

Similarly, AP is reduced by both scenarios. Annual impact of difference between two best scenarios is 127373.2 kg SO_2. EP is another environmental impact category. EU and Scenario 6 decrease by 81.6% and 84.24. This small difference corresponds 13393.6 kg PO_4 for yearly period. The most critical percentage difference between these two scenarios is occurred in ODP category. However, this does not create any major changes in annual production. Annual difference is just 0.17 kg R 11. Final impact category is POCP. EU Scenario and Scenario 6 can decrease C_2H_4 emission by 64.4% and 61.2% respectively. This difference equates 10451.3 kg C_2H_4 for annual scale.

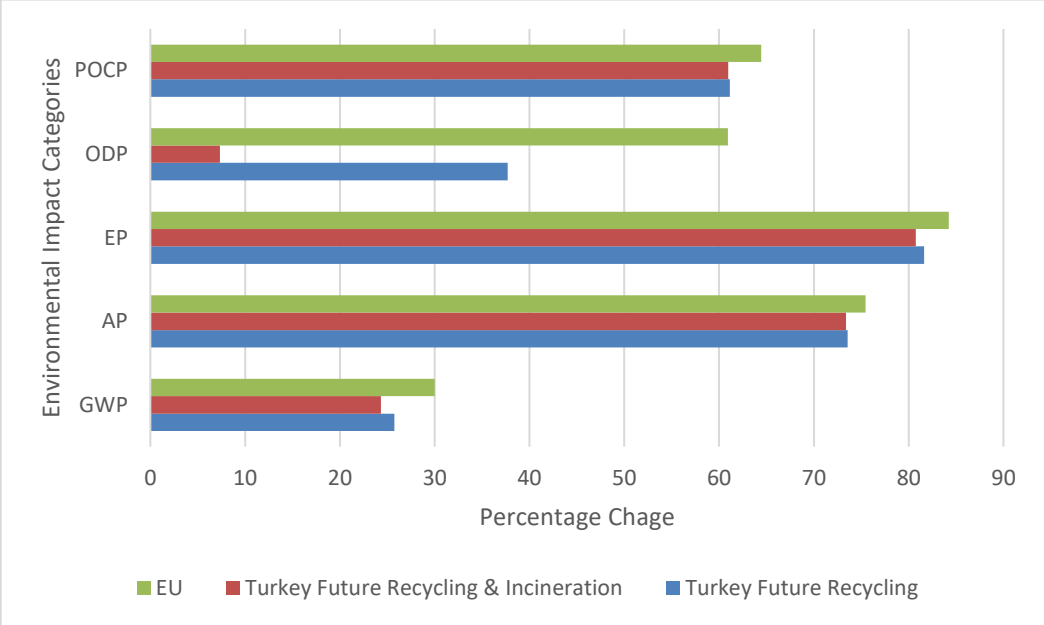
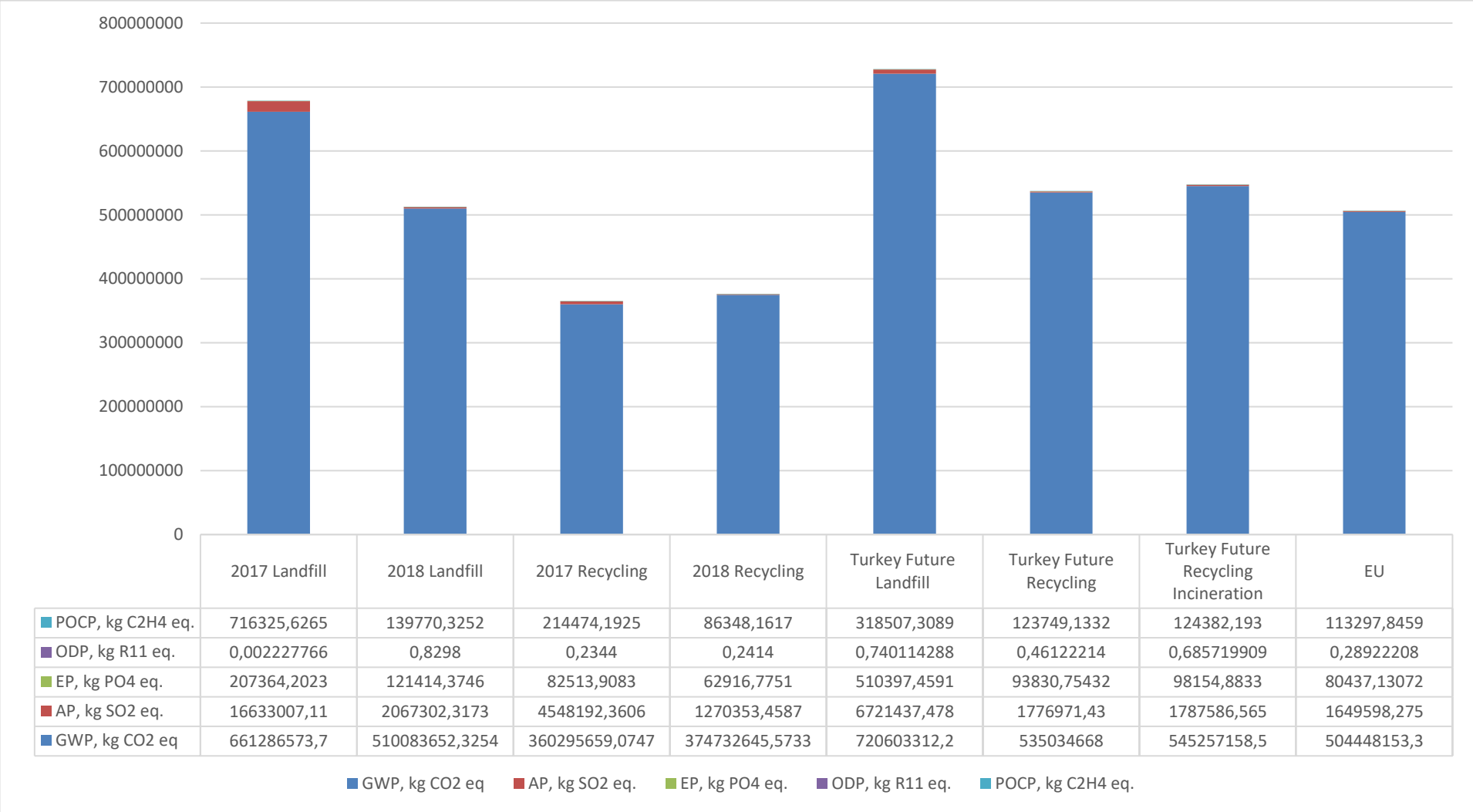


Figure 4.5. Percentage Change of Given Scenarios with Turkey Future Landfill Scenario



	2017 Landfill	2018 Landfill	2017 Recycling	2018 Recycling	Turkey Future Landfill	Turkey Future Recycling	Turkey Future Recycling Incineration	EU
POCP, kg C2H4 eq.	716325,6265	139770,3252	214474,1925	86348,1617	318507,3089	123749,1332	124382,193	113297,8459
ODP, kg R11 eq.	0,002227766	0,8298	0,2344	0,2414	0,740114288	0,46122214	0,685719909	0,28922208
EP, kg PO4 eq.	207364,2023	121414,3746	82513,9083	62916,7751	510397,4591	93830,75432	98154,8833	80437,13072
AP, kg SO2 eq.	16633007,11	2067302,3173	4548192,3606	1270353,4587	6721437,478	1776971,43	1787586,565	1649598,275
GWP, kg CO2 eq	661286573,7	510083652,3254	360295659,0747	374732645,5733	720603312,2	535034668	545257158,5	504448153,3

Figure 4.6. Annual impacts of glass bottle life cycle for all scenarios

4.1.2.3. Normalization

Purpose of normalization step for glass bottle production is same as the PET bottle production. In this study, CML2001 – April 2015, EU25+3, year 2000 are used for normalized results calculation.

Figure 4.7. shows normalization results of different impact categories. Acidification potential is the major impact category for all scenarios. Global warming potential is second important environmental impact factor for glass bottle production. Best scenarios for future are EU and Turkey's Future Recycling scenario. If EU scenario is implemented, GWP and AP decreases by 25.1% and 71.5% respectively. Similarly, if Turkey's Future Recycling scenario is applied, GWP and AP decreases by 20.6% and 71.1% respectively.

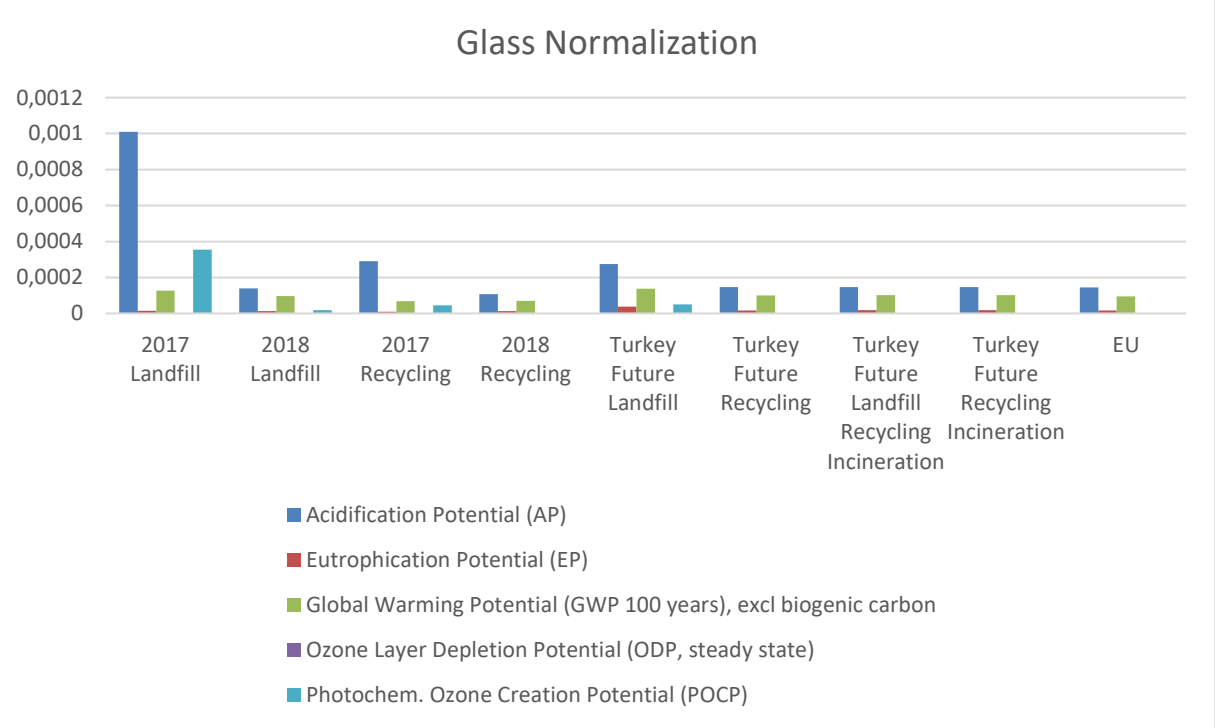


Figure 4.7. Normalization results of Glass Bottle Production for different scenarios

4.1.2.4. Weighting

As mentioned before, normalization results are multiplied with the weighting factor to calculate relative importance of environmental impact category without any unit. In this study, CML 2001- Dec. 07, Experts IKP (Southern Europe) is selected for weighting step. Similar to

PET bottle production, acidification potential is the most critical environmental impact category for most scenarios. However, global warming potential become more important than AP in future. Figure 4.8 can show this alteration in future scenarios.

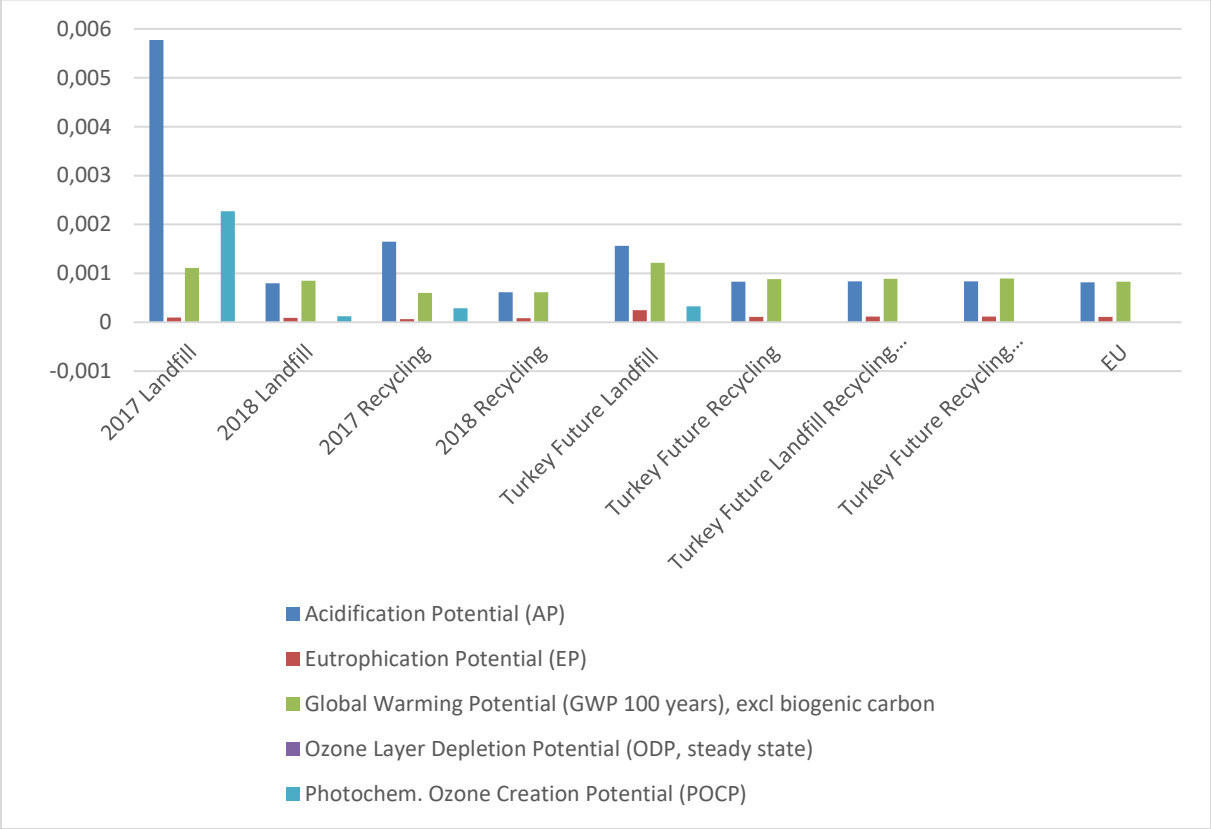


Figure 4.8. Weighting results of Glass Bottle Production for different scenarios.

4.1.3. Comparison of Life Cycle Impact Assessment of PET and Glass Bottle Production

In this study, it is assumed that the calculated glass and PET bottles are used to serve the same amount of the same beverage. Processes of both packaging types from raw material procurement to disposal stages were included in the study. When calculating the environmental impacts of sustainable packaging methods and recycling, PET and glass bottle packages were compared with each other in order to observe the environmental impacts of the two packaging types at different stages. Life cycle impact assessments of PET and glass bottle have been conducted by using GaBi 6.0 software. Functional unit in all scenarios have been calculated 1 million bottles. Electricity grid mix of 2017 is used to calculate the electricity demand of the production process. Also recycling rations of both PET and glass is same with 2017.

4.1.3.1. Classification

As stated in the previous chapters, inventory results are assigned to different impact categories. The selected categories are the same as before. Global warming, acidification, eutrophication, photochemical ozone creation and ozone layer depletion potentials are considered while comparing the environmental performance of these two products.

4.1.3.2. Characterization

Potential environmental impacts of emissions are calculated by using science-based conversion factors for each impact category, called characterization factors or equivalency factors. Table 4.6. summarizes the characterization results of PET and glass bottles for 1 million bottles.

Table 4.6. Characterization results of 1 million PET and glass bottle scenarios

Environmental Impact Category	Unit	Glass Landfill	PET Landfill	Glass Recycling	PET Recycling
Acidification Potential (AP)	[kg SO2-eq.]	1,82E+04	6,57E+03	4,98E+03	2,07E+03
Eutrophication Potential (EP)	[kg Phosphate-eq.]	2,26E+02	9,30E+01	8,96E+01	3,26E+01
Global Warming Potential (GWP)	[kg CO2-eq.]	7,25E+05	3,02E+05	3,95E+05	1,13E+05
Ozone Layer Depletion Potential (ODP)	[kg R11 eq.]	4,88E-07	3,46E-01	2,57E-04	1,66E-01
Photochemical Ozone Creation Potential (POCP)	[kg Ethene-eq.]	7,85E+02	3,08E+02	2,35E+02	1,02E+02

Except ODP, glass bottle characterization results have higher values than PET bottle in selected impact categories. When the scenarios were compared, it was observed that AP, EP, GWP, POCP of glass packaging were 2.78, 2.43, 2,40, and 2,55 more than the effects of PET packaging in landfill scenarios, respectively. The main reason for this difference is the higher electricity consumption for glass bottle production. The impacts of electricity consumption of

each scenario are shown in Table 4.7. The energy required for melting of raw materials in glass production increases the CO_2 emissions affecting GWP, as well as the SO_2 emissions affecting AP.

Table 4.7. Characterization results of electricity consumption for each scenario

Impact Categories	Glass Landfill	PET Landfill	Glass Recycling	PET Recycling
Acidification Potential (AP)	1,81E+04	6,30E+03	4,39E+03	1,53E+03
Eutrophication Potential (EP)	2,12E+02	7,36E+01	5,13E+01	1,78E+01
Global Warming Potential (GWP)	6,36E+05	2,21E+05	1,53E+05	5,33E+04
Ozone Layer Depletion Potential (ODP)	4,04E-07	1,40E-07	9,78E-08	3,40E-08
Photochemical Ozone Creation Potential (POCP)	7,71E+02	2,68E+02	1,87E+02	6,49E+01

Another reason of glass bottles scenarios' higher impacts than PET is transport processes. As a heavier product, transport of glass bottle to filling plant, transport of bottled beverage to consumer, and transport of waste material to disposal area requires more fuel than transport of PET bottle and this results with the higher CO2 emissions. However, when raw material acquisition stages of each scenario are analyzed, the impacts of raw material required for PET bottle production causes higher impacts in the selected categories then the raw materials used in the production of glass packaging. (Table 4.8.) The impact of this process is also seen in ODP results. The higher ODP of PET packaging is due to methyl bromide emissions from the raw material acquisition process. In landfill scenarios, methyl bromide emissions from PET bottle production is 2.97E+12 times of the methyl bromide emissions from glass bottle. The effects of raw material processes are given in Figure 4.12.

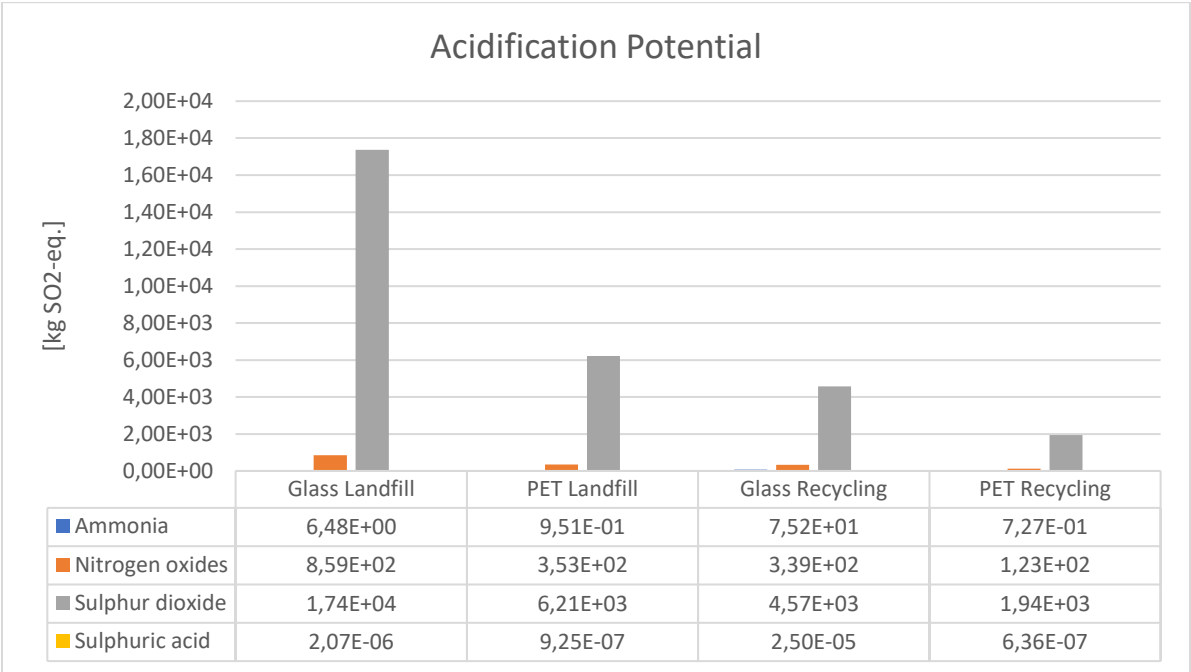
Table 4.8. Characterization results of raw material acquisition process for each scenario

Impact Categories	Glass Landfill	PET Landfill	Glass Recycling	PET Recycling
Acidification Potential (AP)	6,97E+01	2,59E+02	1,95E+02	1,24E+02
Eutrophication Potential (EP)	2,12E+02	7,36E+01	5,13E+01	1,78E+01
Global Warming Potential (GWP)	6,36E+05	2,21E+05	1,53E+05	5,33E+04
Ozone Layer Depletion Potential (ODP)	4,04E-07	1,40E-07	9,78E-08	3,40E-08
Photochemical Ozone Creation Potential (POCP)	7,71E+02	2,68E+02	1,87E+02	6,49E+01

Characterization results show that the highest impact of each scenario is GWP because of the CO_2 emissions. By recycling, the required raw material as well as energy demand decreases the CO_2 emissions for both PET and glass bottle packaging (Figure 4.11.).

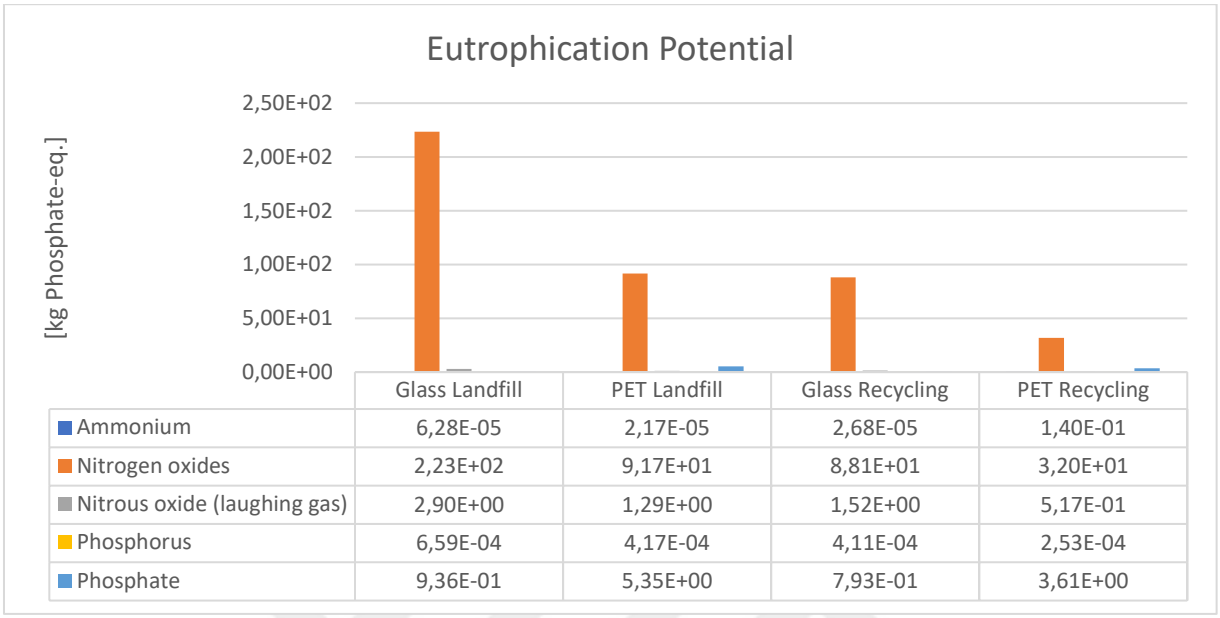
Another significant impact, AP also decreases with the recycling methods. Even though the ammonia emissions are higher in raw material acquisition of PET bottle then raw material acquisition of glass bottle, the total AP is higher in glass scenarios as similar to GWP (Figure 4.9.).

Rather than ODP, EP and POCP results are similar to GWP and AP. Glass landfill scenario has higher nitrogen oxides and sulphur dioxide emissions (Figure 4.10. and 4.13.).



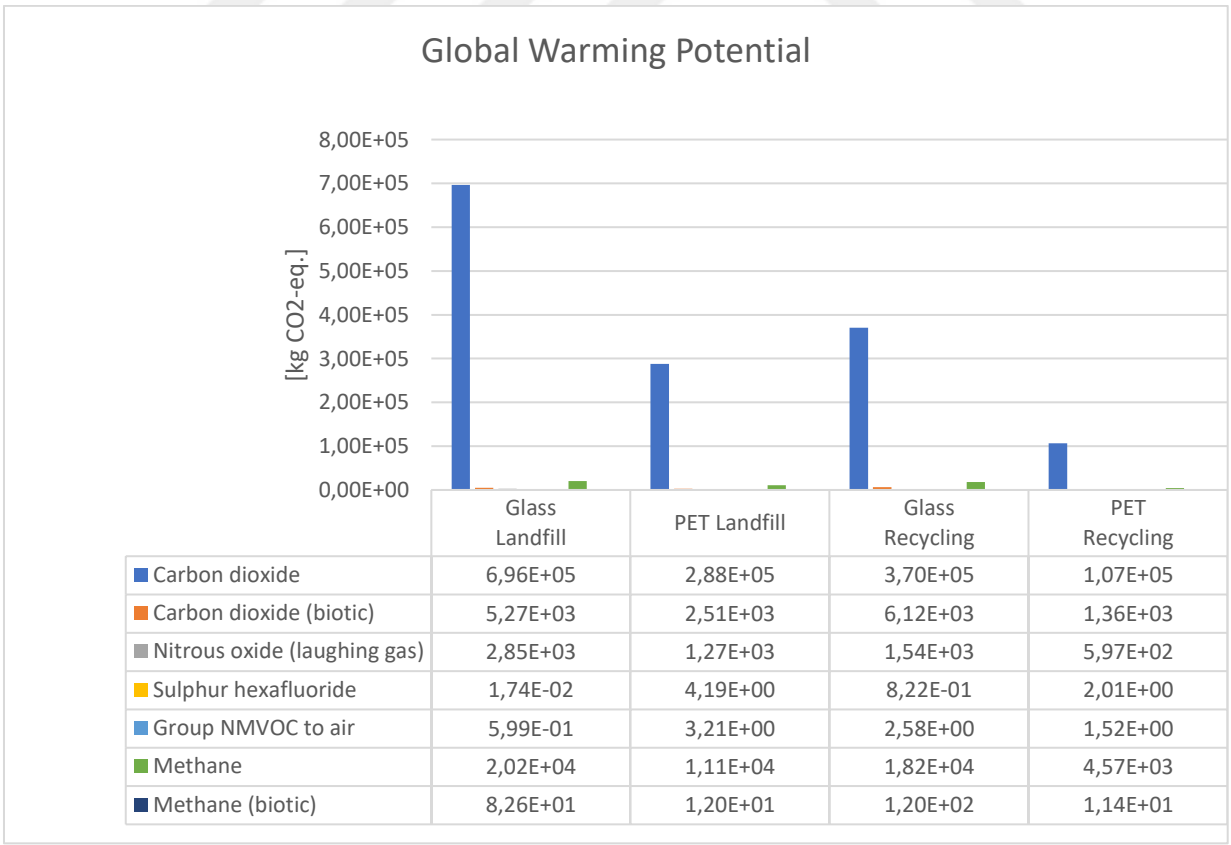
	Glass Landfill	PET Landfill	Glass Recycling	PET Recycling
Ammonia	6,48E+00	9,51E-01	7,52E+01	7,27E-01
Nitrogen oxides	8,59E+02	3,53E+02	3,39E+02	1,23E+02
Sulphur dioxide	1,74E+04	6,21E+03	4,57E+03	1,94E+03
Sulphuric acid	2,07E-06	9,25E-07	2,50E-05	6,36E-07

Figure 4.9. Acidification potential comparison of PET and glass bottle scenarios



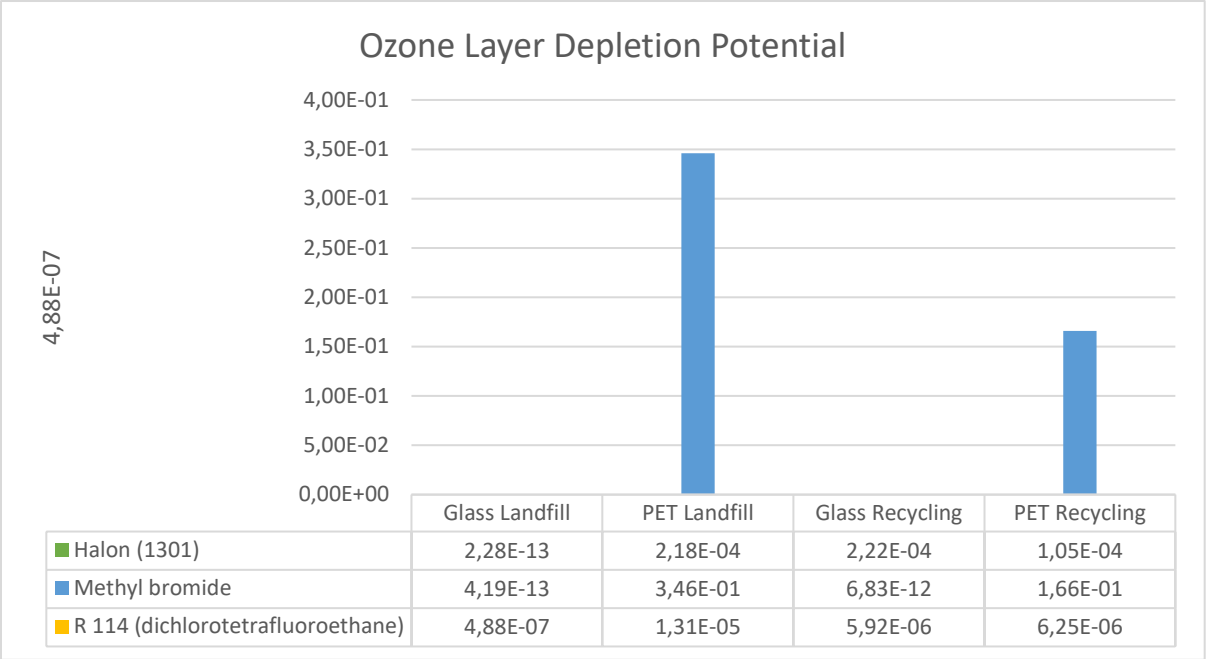
	Glass Landfill	PET Landfill	Glass Recycling	PET Recycling
Ammonium	6,28E-05	2,17E-05	2,68E-05	1,40E-01
Nitrogen oxides	2,23E+02	9,17E+01	8,81E+01	3,20E+01
Nitrous oxide (laughing gas)	2,90E+00	1,29E+00	1,52E+00	5,17E-01
Phosphorus	6,59E-04	4,17E-04	4,11E-04	2,53E-04
Phosphate	9,36E-01	5,35E+00	7,93E-01	3,61E+00

Figure 4.10. Eutrophication potential comparison of PET and glass bottle scenarios



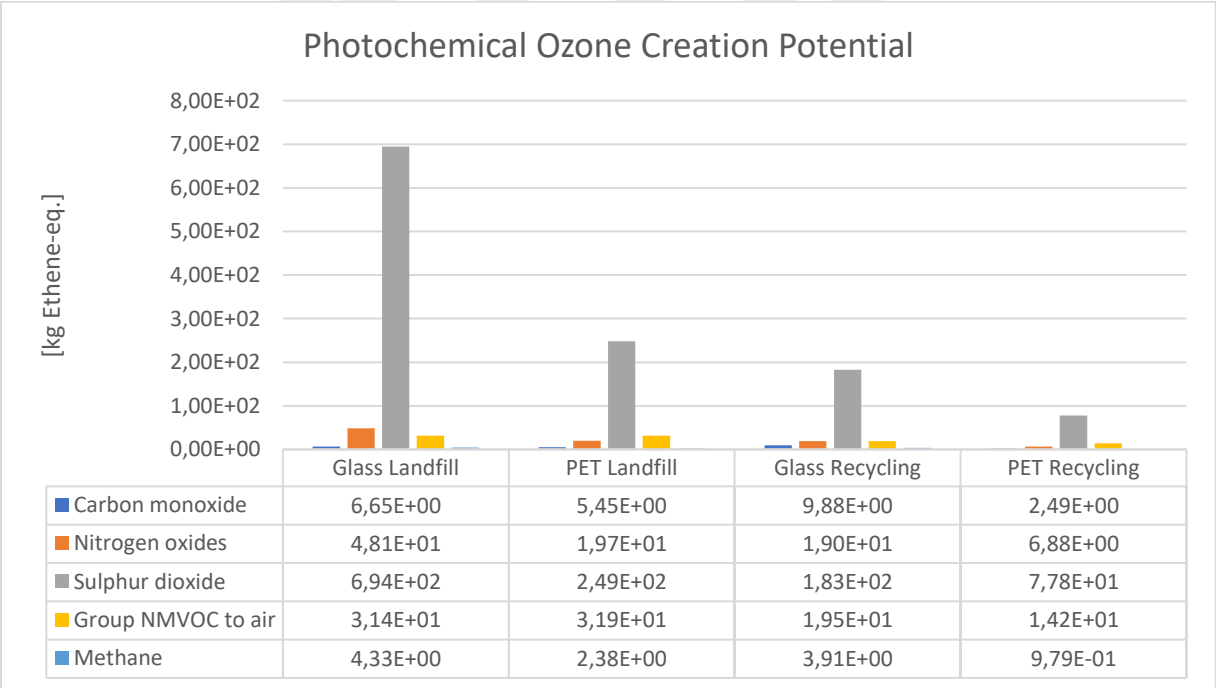
	Glass Landfill	PET Landfill	Glass Recycling	PET Recycling
Carbon dioxide	6,96E+05	2,88E+05	3,70E+05	1,07E+05
Carbon dioxide (biotic)	5,27E+03	2,51E+03	6,12E+03	1,36E+03
Nitrous oxide (laughing gas)	2,85E+03	1,27E+03	1,54E+03	5,97E+02
Sulphur hexafluoride	1,74E-02	4,19E+00	8,22E-01	2,01E+00
Group NMVOC to air	5,99E-01	3,21E+00	2,58E+00	1,52E+00
Methane	2,02E+04	1,11E+04	1,82E+04	4,57E+03
Methane (biotic)	8,26E+01	1,20E+01	1,20E+02	1,14E+01

Figure 4.11. Global warming potential comparison of PET and glass bottle scenarios



	Glass Landfill	PET Landfill	Glass Recycling	PET Recycling
Halon (1301)	2,28E-13	2,18E-04	2,22E-04	1,05E-04
Methyl bromide	4,19E-13	3,46E-01	6,83E-12	1,66E-01
R 114 (dichlorotetrafluoroethane)	4,88E-07	1,31E-05	5,92E-06	6,25E-06

Figure 4.12. Ozone later depletion potential comparison of PET and glass bottle scenarios



	Glass Landfill	PET Landfill	Glass Recycling	PET Recycling
Carbon monoxide	6,65E+00	5,45E+00	9,88E+00	2,49E+00
Nitrogen oxides	4,81E+01	1,97E+01	1,90E+01	6,88E+00
Sulphur dioxide	6,94E+02	2,49E+02	1,83E+02	7,78E+01
Group NMVOC to air	3,14E+01	3,19E+01	1,95E+01	1,42E+01
Methane	4,33E+00	2,38E+00	3,91E+00	9,79E-01

Figure 4.13. Photochemical ozone creation potential comparison of PET and glass bottle scenarios

4.1.3.3. Normalization

In this step, individual impacts converted to a dimensionless final score by the software, which is suitable for weighting, to compare all environmental impacts using the same scale. The normalization results show that GWP, AP and POCP are the main contributors of environmental concerns, especially when the glass bottle landfill scenario is concerned. PET recycling scenario represents the best performance considering the overall environmental impact.

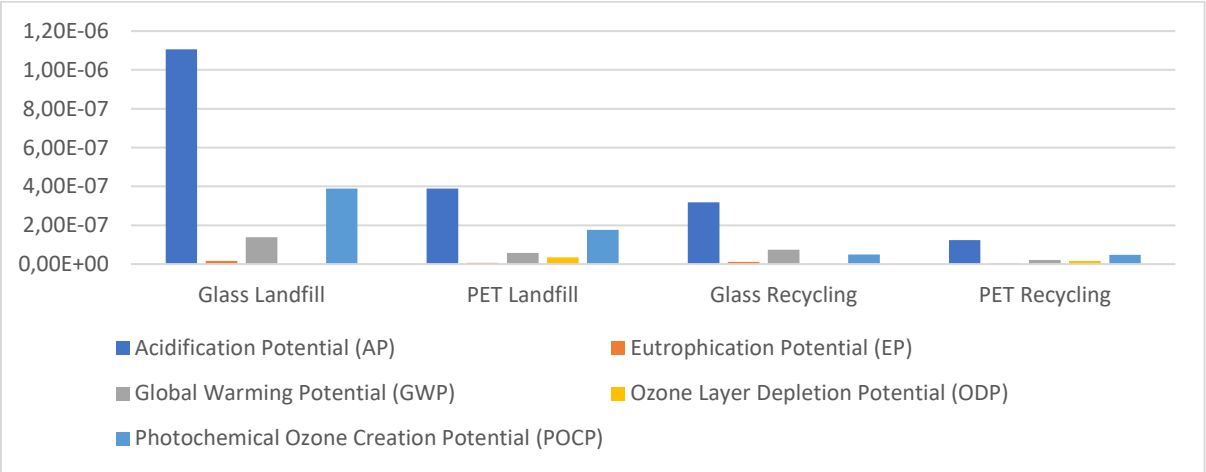


Figure 4.14. Comparison of normalization results of PET and glass bottle scenarios

4.1.3.4. Weighting

In this study, the results from weighting of two different types of packaging materials and two different types of disposal methods are evaluated and the results are similar to normalization step.

The positive influence of the recycling of both type of bottle packaging is observed in terms of GWP, AP, EP, POCP and ODP. GWP is the highest environmental impact category for the both landfill scenarios, and decreased significantly in recycling scenarios according to the weighting results.

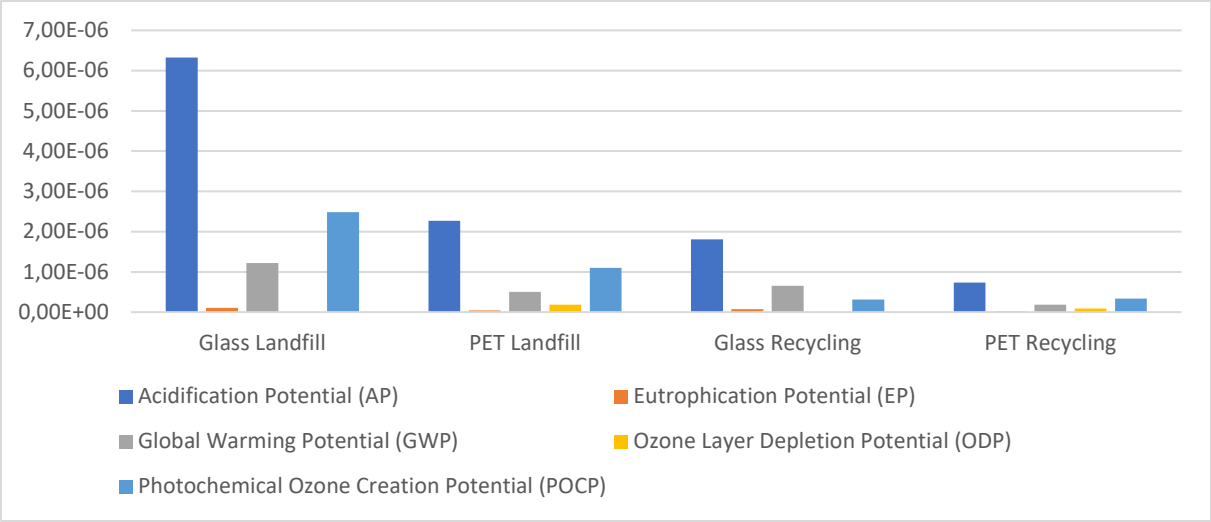


Figure 4.15. Comparison weighting results of PET and glass bottle scenarios

5. CONCLUSION

For this study, the selected plastic and glass beverage packaging production processes and their recycling processes were determined. The processes and its inputs and outputs were taken from packaging factories and recycling plants. The region, time and technology information of the collected date were included in the study.

As a result of the study, it was aimed to observe the total environmental impacts of Turkey's current recycling strategies and environmental benefits of the improvements. In addition, it was planned to evaluate Turkey's position in the future according to the recycling targets by comparing with the recycling strategies of the EU countries. Considering the recycling targets of both EU and Turkey, it is predicted to observe better results from EU scenario in terms of selected environmental impact categories. This study analysed the main stages which have the highest impact for the related environmental categories. Disposal methods are not the only criteria that effects the environmental impacts of packaging life cycle. The production amounts, transportation of the bottle during its life cycle and also the primary energy resources for the electricity energy demand of all process included in the study are considered as a factor.

From the point of resource consumption, recycling is aimed at reducing resource consumption compared to landfilling. It is expected that the 100% recycling scenario will be the scenario that needs raw materials in larger amounts. When the raw material acquisition stage is evaluated, it will not be appropriate to directly compare the environmental effects of the raw material acquisition stage, since the quantities of PET and glass packaging are different. Instead, the impact ratio of the raw material acquisition stage in the production of both types of packaging in the total life cycle can be compared. Accordingly, in the future scenario where PET packaging is landfilled, the effect of raw material acquisition on total AP, EU, GWP, ODP and POCP categories is 5.9%, 14.72%, 17.7%, 99.9%, and 16,9% respectively. Regarding the landfill scenario of glass packaging, the contribution of raw material acquisition to total environmental impacts is 4% for AP, 5% for EP, 4% for GWP, 28% for ODP and 6% for POCP. However, when the recycling scenarios are considered, the effect of PET raw material on AP decreases to 3%, to EP to 7%, to GWP to 9% and to POCP to 8%, while ODP

has the same effect. For glass packaging, the effect of raw material acquisition decreased to 2.4% in AP, 3% in EP, 1.8% in GWP, and 16.8% and 3.6% for ODP and POCP, respectively. Accordingly, it was observed that recycling not only reduces resource consumption, but also reduces the emission values resulting from the production and processing of these resources.

Even though the target recycling ratios of both Turkey and EU for plastic packaging are the same, there is a considerable difference between the results of both scenarios. According to the results, the main reason of this difference is electrical energy. As it is mentioned in methodology, in this study, electrical energy flow is calculated according to the primary energy distribution of electricity grid mix for the related years. For the future scenarios, the renewable energy action plan for 2023 was calculated and used as electrical power flow. In EU scenarios, the electrical energy flow is taken from the Gabi's EU-27 electricity grid mix. Therefore, the difference between renewable energy sources of the Turkey and EU-27 is the reason of sulfur dioxide emissions reduction in AP of PET bottle production, which is 2,48 higher in Turkey's electricity grid mix process.

Although recycling is a solution in terms of reducing resource consumption, as the number of disposal methods increases, the distance traveled during the transportation of waste and accordingly the amount of fuel used increase. When calculating the increase of transport processes effects compared to the the landfill scenario, the sum of the effects during transportation of filled packaging and waste packaging into disposal facilities was examined. Accordingly, compared transport processes in landfill of glass packaging scenario, the transport processes of recycling scenario Turkey increased 9.8% in AP, 9.9% in EP, 7.4% in GWP, 7.3% in ODP and 11.4% in POCP. This means that the emissions from transport have increased. The impact of transport processes in the EU recycling scenario increased by 14.6%, 14.8%, 11%, 10% and 17% for AP, EP, GWP, ODP and POCP, respectively. It is probably because of the increase in the amount of cargo transported to the recycling facility and type of fuel consumed by the vehicle in S8 which is different from S6. Since the transport processes for S7 were considered same as S6, the results are the same.

For the future work of this study, the collected data could be used for analyzing the most environmentally friendly waste management system for food packaging as well as plastic and glass materials. Also, the results can be used in order to determine the situation of Turkey in terms of Sustainable Development Goals and Circular Economy Strategy for reduction of greenhouse gases.

Finally, the data collected for PET and glass bottle recycling processes contributes to Turkey's LCA database for energy, recycling and packaging production.

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APPENDIX A: LCIA Characterization for Glass Bottle Production

Table A.1. Glass bottle production emissions by each scenario for GWP - kg CO_2-Equiv.

Global Warming Potential (GWP 100 years) [kg CO2-Equiv.]											
Scenarios			**Glass Bottle Production**								
	Flow	**Total**	**Electricity grid mix, Turkey, 2017**	**Raw Materials**	**EU-28: Thermal energy from heavy fuel oil (HFO) ts**	**EU-28: Thermal energy from natural gas ts**	**Transport of Glass Bottled Beverage**	**Transport of Landfill Waste Glass**	**EU-27: Landfill for inert matter (Glass) PE**		
2017 Turkey's Landfill	Emissions to air	661286573.7	580037023.1	56254358.1	0.0	242.0	17898992.0	2509104.5	4586853.9		
	Inorganic emissions to air	642772655.4	564232196.9	54409971.2	0.0	223.3	17314555.0	2426880.1	4388828.8		
	Carbon dioxide	635365852.1	560887602.4	51884757.9	0.0	221.6	16339824.9	2289421.9	3964023.4		
	Carbon dioxide (biotic)	4809208.0	1332941.4	2093156.5	0.0	1.0	858584.5	120298.9	404225.7		
	Nitrous oxide (laughing gas)	2597579.5	2011637.2	432056.8	0.0	0.7	116145.7	17159.3	20579.7		
	Sulphur hexafluoride	15.9	15.9	0.0	0.0	0.0	0.0	0.0	0.0		
	Organic emissions to air (group VOC)	18513918.3	15804826.2	1844386.9	0.0	18.8	584437.0	82224.4	198025.1		

	Group NMVOC to air	546.7	498.0	19.2	0.0	0.0	6.6	0.9	22.0		
	Methane	18438005.1	15804328.2	1793017.5	0.0	18.7	563365.6	79272.0	198003.1		
	Methane (biotic)	75366.4	0.0	51350.1	0.0	0.0	21064.8	2951.5	0.0		
2018 Turkey's Landfill	Emissions to air	510083652.3	100649112.7	173386908.0	324.6	209892261.7	18723478.2	2623757.7	4807809.4		
	Inorganic emissions to air	478933068.2	94622115.9	165487031.0	314.5	193578985.9	18108127.2	2537184.1	4599309.7		
	Carbon dioxide	470545061.9	93371622.6	160637212.9	314.2	192747560.5	17204127.5	2410522.0	4173702.2		
	Carbon dioxide (biotic)	8385341.5	1250474.4	4847172.3	0.3	831425.3	903999.7	126662.1	425607.5		
	Sulphur hexafluoride	2664.7	18.8	2645.8	0.0	0.1	0.0	0.0	0.0		
	Organic emissions to air (group VOC)	31150584.1	6026996.9	7899876.9	10.2	1631327 5.8	615351.1	86573.7	208499.7		
	Group NMVOC to air	5838.5	588.2	4781.0	0.0	438.3	7.0	1.0	23.1		
	Methane	31001193.2	6026408.7	7795247.4	10.2	1629442 0.3	593165.0	83465.1	208476.6		
	Methane (biotic)	143552.4	0.0	99848.5	0.0	18417.3	22179.1	3107.6	0.0		
			Glass Bottle Production								
	Flow	**Total**	**Electricity grid mix, Turkey, 2017**	**Raw Materials**	**EU-28: Thermal energy from heavy fuel oil (HFO) ts**	**EU-28: Thermal energy from natural gas ts**	**Transport of Glass Bottled Beverage**	**Transport of Landfill Waste Glass**	**EU-27: Landfill for inert matter (Glass) PE**	**Transport of Recycling Waste**	**Recycling**
	Emissions to air	360295659.1	140033766.4	48712398.3	961.0	59161219.5	17782846.4	172166 3.4	3154799.4	1540563.6	88187441.2

2017 Turkey's Recycling	Inorganic emissions to air	343549328.7	136204852.7	46490927.7	930.9	54563082.9	17198409.3	166485.3	3017985.6	1489731.0	82918553.2
	Carbon dioxide	337964740.6	135881927.4	45131636.7	930.0	54328733.5	16339824.9	158174 1.8	2738709.5	1415360.2	80545876.6
	Carbon dioxide (biotic)	5583838.2	322921.5	1358545.3	0.9	234349.4	858584.5	83113.4	279276.1	74370.8	2372676.3
	Sulphur hexafluoride	749.9	3.8	745.8	0.0	0.0	0.0	0.0	0.0	0.0	0.2
	Organic emissions to air (group VOC)	16746330.4	3828913.7	2221470.5	30.1	4598136.6	584437.0	56808.1	136813.8	50832.5	5268888.0
	Group NMVOC to air	2358.6	120.6	1347.6	0.0	123.5	6.6	0.6	15.2	0.6	743.8
	Methane	16634469.3	3828793.1	2192168.2	30.1	4592821.9	563365.6	54768.3	136798.6	49007.3	5216716.2
	Methane (biotic)	109502.5	0.0	27954.8	0.0	5191.2	21064.8	2039.1	0.0	1824.6	51428.0
2018 Turkey's Recycling	Emissions to air	374732645.6	23842669.4	50340094.8	990.3	60906460.4	18845767.5	1816580.7	3320862.2	1650488.0	21400873 2.2
	Inorganic emissions to air	352682087.4	22419131.7	48059711.0	959.4	56186381.5	18230416.4	175705 0.6	3177493.0	1596400.9	20125454 2.9
	Carbon dioxide	342364581.8	22053773.1	46328525.2	954.7	55769528.4	17204127.5	165753 1.5	2869935.6	1505980.9	19497422 4.9
	Carbon dioxide (biotic)	9036822.7	295354.0	1394573.8	0.9	240564.4	903999.7	87095.8	292657.7	79132.5	5743443.8
	Nitrous oxide (laughing gas)	1279912.3	70000.2	335846.5	3.8	176288.7	122289.3	12423.3	14899.6	11287.4	536873.5
	Sulphur hexafluoride	770.6	4.4	765.5	0.0	0.0	0.0	0.0	0.0	0.0	0.6
	Organic emissions to air (group VOC)	22050558.2	1423537.7	2280383.8	30.9	4720078.9	615351.1	59530.1	143369.3	54087.2	12754189.3

	Group NMVOC to air	3473.7	138.9	1383.3	0.0	126.8	7.0	0.7	15.9	0.6	1800.6
	Methane	21862312.4	1423398.7	2250304.4	30.9	4714623.3	593165.0	57392.6	143353.4	52145.1	12627899.1
	Methane (biotic)	184772.0	0.0	28696.1	0.0	5328.8	22179.1	2136.8	0.0	1941.5	124489.7
			Glass Bottle Production								
	Flow	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Materials**	**EU-28: Thermal energy from heavy fuel oil (HFO) ts**	**EU-28: Thermal energy from natural gas ts**	**Transport of Glass Bottled Beverage**	**Transport of Landfill Waste Glass**	**EU-27: Landfill for inert matter (Glass) PE**		
Turkey's Future Landfill	Emissions to air	720603312.2	356.9558717	720.6101064	1114.566034	720601011.4	77.81629997	10.9045508	19.98164718		
	Inorganic emissions to air	664596567.1	336.0733213	687.7775748	1079.681575	664594358.6	75.25885083	10.54474364	19.11510546		
	Carbon dioxide	661742080	321.3789189	667.6213359	1078.636617	661739913.4	71.50175443	10.01832558	17.34624622		
	Carbon dioxide (biotic)	2854486.771	14.69436689	20.1452427	1.044957915	2854444.834	3.757096387	0.52641806	1.768859237		
	Sulphur hexafluoride	0.33782541	3.55098E-05	0.0109962 1	1.64612E-07	0.326793508	1.27367E-08	1.78458E-09	2.71655E-09		
	Organic emissions to air (group VOC)	56006745.17	20.88255039	32.83253166	34.88445951	56006652.79	2.557449137	0.359807159	0.866541718		
	Group NMVOC to air	1504.669797	0.0088655 35	0.0198703 91	0.000366417	1504.640565	2.894E-05	4.05487E-06	9.61475E-05		
	Methane	55942009.93	20.87368485	32.39768271	34.85980458	55941918.12	2.465242209	0.346887769	0.86644557		
	Methane (biotic)	63230.57484	0	0.4149785 59	0.02428852	63230.03048	0.092177989	0.012915335	0		
			Glass Bottle Production								

	Flow	Total	Electricity grid mix, Turkey, Future	Raw Materials	EU-28: Thermal energy from heavy fuel oil (HFO) ts	EU-28: Thermal energy from natural gas ts	Transport of Glass Bottled Beverage	Transport of Landfill Waste Glass	EU-27: Landfill for inert matter (Glass) PE	Transport of Recycling Waste	Recycling
Turkey's Future Recycling	Emissions to air	535034668.0	38851488.1	95767044.2	1889.3	116309098.4	25938766.7	145394 0.1	2664219.6	4361820.3	24968640 1.2
	Inorganic emissions to air	503276795.3	36578607.3	91399702.9	1830.2	107269306.4	25086283.6	140596 5.8	2548680.7	4217897.5	23476852 0.9
	Carbon dioxide	490057627.1	34979251.6	88727379.5	1828.4	106808582.7	23833918.1	133577 6.7	2312832.8	4007330.2	22805072 6.9
	Carbon dioxide (biotic)	13217697.4	1599351.8	2670857.3	1.8	460723.6	1252365.5	70189.1	235847.9	210567.2	6717793.3
	Sulphur hexafluoride	1470.8	3.9	1466.2	0.0	0.1	0.0	0.0	0.0	0.0	0.7
	Organic emissions to air (group VOC)	31757872.6	2272880.8	4367341.2	59.1	9039792.0	852483.0	47974.3	115538.9	143922.9	14917880.3
	Group NMVOC to air	5987.7	964.9	2649.3	0.0	242.9	9.6	0.5	12.8	1.6	2106.0
	Methane	31503498.1	2271915.9	4309733.8	59.1	9029343.5	821747.4	46251.7	115526.1	138755.1	14770165.5
	Methane (biotic)	248386.8	0.0	54958.2	0.0	10205.7	30726.0	1722.0	0.0	5166.1	145608.8
			Glass Bottle Production								
	Flow	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Materials**	**EU-28: Thermal energy from heavy fuel oil (HFO) ts**	**EU-28: Thermal energy from natural gas ts**	**Transport of Glass Bottled Beverage**	**Transport of Recycling Waste**	**Recycling**	**Transport of Glass Waste for Incineration**	**Incineration**
	Emissions to air	545257158.5	38851488.1	95767044.2	1889.3	116309098.4	25938766.7	436182 0.3	2496864 01.2	2907880.2	11432770.0

Turkey's Future Recycling Incineration	Inorganic emissions to air	512189234.9	36578607.3	91399702.9	1830.2	107269306.4	25086283.6	4217897.5	234768520.9	2811931.6	10055154.5
	Carbon dioxide	497188664.5	34979251.6	88727379.5	1828.4	106808582.7	23833918.1	4007330.2	228050726.9	2671553.5	8108093.4
	Carbon dioxide (biotic)	14999103.7	1599351.8	2670857.3	1.8	460723.6	1252365.5	210567.2	6717793.3	140378.1	1947065.1
	Sulphur hexafluoride	1466.7	3.9	1466.2	0.0	0.1	0.0	0.0	0.7	0.0	-4.0
	Organic emissions to air (group VOC)	33067923.6	2272880.8	4367341.2	59.1	9039792.0	852483.0	143922.9	14917880.3	95948.6	1377615.6
	Group NMVOC to air	-236739.1	964.9	2649.3	0.0	242.9	9.6	1.6	2106.0	1.1	-242714.5
	Methane	33054553.8	2271915.9	4309733.8	59.1	9029343.5	821747.4	138755.1	14770165.5	92503.4	1620330.1
	Methane (biotic)	250108.9	0.0	54958.2	0.0	10205.7	30726.0	5166.1	145608.8	3444.1	0.0
			Glass Bottle Production								
	Flows	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Materials**	**EU-28: Thermal energy from heavy fuel oil (HFO) ts**	**EU-28: Thermal energy from natural gas ts**	**Transport of Glass Bottled Beverage**	**Transport of Landfill Waste Glass**	**EU-27: Landfill for inert matter (Glass) PE**	**Transport of Recycling Waste**	**Recycling**
EU	Emissions to air	504448153.3	24282180.1	59854402.6	1180.8	72693186.5	25938766.7	1453940.1	2664219.6	5452275.4	31210801.5
	Inorganic emissions to air	474804857.4	22861629.6	57124814.3	1143.9	67043316.5	25086283.6	1405965.8	2548680.7	5272371.8	29346065.1
	Carbon dioxide	461628250.5	21862032.3	55454612.2	1142.8	66755364.2	23833918.1	1335776.7	2312832.8	5009162.8	28506340.6
	Carbon dioxide (biotic)	13175687.1	999594.9	1669285.8	1.1	287952.3	1252365.5	70189.1	235847.9	263209.0	8397241.6
	Sulphur hexafluoride	919.7	2.4	916.4	0.0	0.0	0.0	0.0	0.0	0.0	0.9

	Organic emissions to air (group VOC)	29643296.0	1420550.5	2729588.3	37.0	5649870.0	852483.0	47974.3	115538.9	179903.6	18647350.4
	Group NMVOC to air	5068.2	603.1	1655.8	0.0	151.8	9.6	0.5	12.8	2.0	2632.5
	Methane	29376583.6	1419947.4	2693583.6	36.9	5643339.7	821747.4	46251.7	115526.1	173443.9	18462706.9
	Methane (biotic)	261644.1	0.0	34348.9	0.0	6378.6	30726.0	1722.0	0.0	6457.7	182011.0

Table A.2. Glass bottle production emissions by each scenario for AP - kg SO_2-Equiv.

Acidification Potential (AP) - kg SO2-Equiv.											
Scenarios			**Glass Bottle Production**								
	Flow	**Total**	**Electricity grid mix, Turkey, 2017**	**Raw Materials**	**EU-28: Thermal energy from heavy fuel oil (HFO) ts**	**EU-28: Thermal energy from natural gas ts**	**Transport of Glass Bottled Beverage**	**Transport of Landfill Waste Glass**	**EU-27: Landfill for inert matter (Glass) PE**		
2017 Turkey's Landfill	Emissions to air	16633007.11	16530633.64	63613.75077	1.32E-06	0.152692496	10987.95113	1543.720051	26227.89397		
	Inorganic emissions to air	16633007.11	16530633.64	63613.75077	1.32E-06	0.152692496	10987.95113	1543.720051	26227.89397		
	Ammonia	5910.534964	935.4799795	3160.357032	3.37E-09	0.001402208	1295.952326	185.7450042	332.9992201		
	Nitrogen oxides	784088.3002	735524.0436	34391.20096	2.72E-07	0.084120686	2400.816899	336.3856627	11435.76891		
	Sulphur dioxide	15843008.27	15794174.11	26062.19278	1.04E-06	0.067169602	7291.181903	1021.589384	14459.12585		
	Emissions to fresh water	0.001890913	0.000935863	0.000386313	2.47E-15	7.07E-09	0.000136478	1.91E-05	0.000413129		
	Inorganic emissions to fresh water	0.001890913	0.000935863	0.000386313	2.47E-15	7.07E-09	0.000136478	1.91E-05	0.000413129		
	Sulphuric acid	0.001890913	0.000935863	0.000386313	2.47E-15	7.07E-09	0.000136478	1.91E-05	0.000413129		
	Emissions to air	2067302.297	1261576.105	632110.7361	1.148133589	132804.5373	11569.16388	1625.375836	27615.23055		
	Inorganic emissions to air	2067302.297	1261576.105	632110.7361	1.148133589	132804.5373	11569.16388	1625.375836	27615.23055		
	Ammonia	182122.5723	265.0465895	178727.2643	0.00292934	1219.572674	1364.502324	195.570072	350.6133678		

2018 Turkey's Landfill	Nitrogen oxides	452507.8994	163631.6514	200789.2555	0.236525606	73164.09864	2527.809218	354.1789378	12040.66919		
	Sulphur dioxide	1432671.825	1097679.407	252594.2163	0.908678643	58420.866	7676.852339	1075.626826	15223.94799		
	Emissions to fresh water	0.020169695	0.00180292	0.011621465	2.14689E-09	0.006146495	0.000143697	2.01338E-05	0.000434982		
	Inorganic emissions to fresh water	0.020169695	0.00180292	0.011621465	2.14689E-09	0.006146495	0.000143697	2.01338E-05	0.000434982		
	Sulphuric acid	0.020169695	0.00180292	0.011621465	2.14689E-09	0.006146495	0.000143697	2.01338E-05	0.000434982		
			Glass Bottle Production								
	Flow	**Total**	**Electricity grid mix, Turkey, 2017**	**Raw Materials**	**EU-28: Thermal energy from heavy fuel oil (HFO) ts**	**EU-28: Thermal energy from natural gas ts**	**Transport of Glass Bottled Beverage**	**Transport of Landfill Waste Glass**	**EU-27: Landfill for inert matter (Glass) PE**	**Transport of Recycling Waste**	**Recycling**
2017 Turkey's Recycling	Emissions to air	4548192.338	4004749.525	178073.1845	3.398726341	37432.91118	10987.95113	1066.542841	18120.62526	954.3544196	296803.8
	Inorganic emissions to air	4548192.338	4004749.525	178073.1845	3.398726341	37432.91118	10987.95113	1066.542841	18120.62526	954.3544196	296803.8
	Ammonia	68661.7817	226.6315427	50365.89648	0.008671486	343.7544869	1295.952326	128.329618	230.0662831	114.8307723	15956.31
	Nitrogen oxides	309244.4011	178189.7554	56574.53909	0.700167484	20622.37677	2400.816899	232.4059471	7900.873901	207.9594314	43114.97
	Sulphur dioxide	4170286.155	3826333.138	71132.74895	2.68988737	16466.77992	7291.181903	705.8072759	9989.685079	631.5642159	237732.6
	Emissions to fresh water	0.022828127	0.000226724	0.003274495	6.36E-09	0.00173248	0.000136478	1.32E-05	0.000285428	1.18E-05	0.017147
	Inorganic emissions to fresh water	0.022828127	0.000226724	0.003274495	6.36E-09	0.00173248	0.000136478	1.32E-05	0.000285428	1.18E-05	0.017147
	Sulphuric acid	0.022828127	0.000226724	0.003274495	6.36E-09	0.00173248	0.000136478	1.32E-05	0.000285428	1.18E-05	0.017147

2018 Turkey's Recycling	Emissions to air	1270353.411	297976.1125	182795.6754	3.488860372	38425.62987	11569.16388	1117.646588	18988.88091	1015.458497	718461.4
	Inorganic emissions to air	1270353.411	297976.1125	182795.6754	3.488860372	38425.62987	11569.16388	1117.646588	18988.88091	1015.458497	718461.4
	Ammonia	92604.14673	62.60228933	51701.59722	0.008901453	352.8708365	1364.502324	134.4785734	241.0899839	122.1829973	38624.81
	Nitrogen oxides	233532.4167	38648.73721	58074.89268	0.718735887	21169.28104	2527.809218	243.5417535	8279.446842	221.2743686	104366.7
	Sulphur dioxide	944216.8478	259264.773	73019.18546	2.761223032	16903.47799	7676.852339	739.6262609	10468.34409	672.0011313	575469.8
	Emissions to fresh water	0.047543062	0.000425838	0.003361335	6.52E-09	0.001778425	0.000143697	1.38E-05	0.000299104	1.26E-05	0.041508
	Inorganic emissions to fresh water	0.047543062	0.000425838	0.003361335	6.52E-09	0.001778425	0.000143697	1.38E-05	0.000299104	1.26E-05	0.041508
	Sulphuric acid	0.047543062	0.000425838	0.003361375	6.52E-09	0.001778425	0.000143697	1.38E-05	0.000299104	1.26E-05	0.041508
			Glass Bottle Production								
	Flow	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Materials**	**EU-28: Thermal energy from heavy fuel oil (HFO) ts**	**EU-28: Thermal energy from natural gas ts**	**Transport of Glass Bottled Beverage**	**Transport of Landfill Waste Glass**	**EU-27: Landfill for inert matter (Glass) PE**		
Turkey's Future Landfill	Emissions to air	6721437.209	43.35425748	30.08081259	42.30088183	6721319.353	0.511439455	0.071773234	1.537213785		
	Inorganic emissions to air	6721437.209	43.35425748	30.08081259	42.30088183	6721319.353	0.511439455	0.071773234	1.537213785		
	Ammonia	26173.70804	0.012360291	4.642531644	0.062856211	26168.94066	0.035443642	0.005080032	0.009107361		
	Nitrogen oxides	5023777.75	11.58868319	16.68992988	16.24076937	5023731.991	0.210115618	0.02943993	1.00084003		
	Sulphur dioxide	1671485.751	31.753214	8.748351073	25.99725625	1671418.422	0.265880195	0.037253272	0.527266395		

	Emissions to fresh water	0.269164099	3.71785E-06	6.16068E-07	9.4014E-08	0.26915964	7.61755E-09	1.06732E-09	2.30589E-08		
	Inorganic emissions to fresh water	0.269164099	3.71785E-06	6.16068E-07	9.4014E-08	0.26915964	7.61755E-09	1.06732E-09	2.30589E-08		
	Sulphuric acid	0.269164099	3.71785E-06	6.16068E-07	9.4014E-08	0.26915964	7.61755E-09	1.06732E-09	2.30589E-08		
			Glass Bottle Production								
	Flow	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Materials**	**EU-28: Thermal energy from heavy fuel oil (HFO) ts**	**EU-28: Thermal energy from natural gas ts**	**Transport of Glass Bottled Beverage**	**Transport of Landfill Waste Glass**	**EU-27: Landfill for inert matter (Glass) PE**	**Transport of Recycling Waste**	**Recycling**
Turkey's Future Recycling	Emissions to air	1776971.34	478008.2959	350086.2847	6.681789179	73591.92702	16027.46235	900.692575	15302.81954	2702.077725	840345.1
	Inorganic emissions to air	1776971.34	478008.2959	350086.2847	6.681789179	73591.92702	16027.46235	900.692575	15302.81954	2702.077725	840345.1
	Ammonia	147604.3005	215.2493247	99017.76971	0.017047869	675.8105186	1890.327585	108.374019	194.2903604	325.1220569	45177.34
	Nitrogen oxides	347865.6864	63066.28117	111223.766	1.376507271	40542.94467	3501.926974	196.2662003	6672.266866	588.798601	122072.1
	Sulphur dioxide	1281501.353	414726.7654	139844.7491	5.288234039	32373.17184	10635.20779	596.0523557	8436.262315	1788.157067	673095.7
	Emissions to fresh water	0.090603217	0.031724986	0.006437555	1.24943E-08	0.003406001	0.000199072	1.1157E-05	0.000241043	3.34711E-05	0.04855
	Inorganic emissions to fresh water	0.090603217	0.031724986	0.006437555	1.24943E-08	0.003406001	0.000199072	1.1157E-05	0.000241043	3.34711E-05	0.04855
	Sulphuric acid	0.090603217	0.031724986	0.006437555	1.24943E-08	0.003406001	0.000199072	1.1157E-05	0.000241043	3.34711E-05	0.04855
			Glass Bottle Production								

	Flow	Total	Electricity grid mix, Turkey, Future	Raw Materials	EU-28: Thermal energy from heavy fuel oil (HFO) ts	EU-28: Thermal energy from natural gas ts	Transport of Glass Bottled Beverage	Transport of Recycling Waste	Recycling	Transport of Glass Waste for Incineration	Incineration
Turkey's Future Recycling Incineration	Emissions to air	1787586.459	478008.2959	350086.2847	6.681789179	73591.92702	16027.46235	2702.077725	840345.0982	1801.38515	25017.25
	Inorganic emissions to air	1787586.459	478008.2959	350086.2847	6.681789179	73591.92702	16027.46235	2702.077725	840345.0982	1801.38515	25017.25
	Ammonia	147522.8225	215.2493247	99017.76971	0.017047869	675.8105186	1890.327585	325.1220569	45177.33983	216.748038	4.438374
	Nitrogen oxides	364277.4521	63066.28117	111223.766	1.376507271	40542.94467	3501.926974	588.798601	122072.0594	392.5324007	22887.77
	Sulphur dioxide	1275786.185	414726.7654	139844.7491	5.288234039	32373.17184	10635.20779	1788.157067	673095.6989	1192.104711	2125.042
	Emissions to fresh water	0.105573282	0.031724986	0.006437555	1.24943E-08	0.003406001	0.000199072	3.34711E-05	0.048549919	2.23141E-05	0.0152
	Inorganic emissions to fresh water	0.105573282	0.031724986	0.006437555	1.24943E-08	0.003406001	0.000199072	3.34711E-05	0.048549919	2.23141E-05	0.0152
	Sulphuric acid	0.105573282	0.031724986	0.006437555	1.24943E-08	0.003406001	0.000199072	3.34711E-05	0.048549919	2.23141E-05	0.0152
			Glass Bottle Production								
	Flows	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Materials**	**EU-28: Thermal energy from heavy fuel oil (HFO) ts**	**EU-28: Thermal energy from natural gas ts**	**Transport of Glass Bottled Beverage**	**Transport of Landfill Waste Glass**	**EU-27: Landfill for inert matter (Glass) PE**	**Transport of Recycling Waste**	**Recycling**
	Emissions to air	1649598.188	298755.185	218803.928	4.176118237	45994.95439	16027.46235	900.692575	15302.81954	3377.597156	1050431
	Inorganic emissions to air	1649598.188	298755.185	218803.928	4.176118237	45994.95439	16027.46235	900.692575	15302.81954	3377.597156	1050431
	Ammonia	121514.0984	134.530828	61886.10607	0.010654918	422.3815741	1890.327585	108.374019	194.2903604	406.4025712	56471.67

EU	Nitrogen oxides	297968.0128	39416.42573	69514.85372	0.860317044	25339.34042	3501.926974	196.2662003	6672.266866	735.9982513	152590.1
	Sulphur dioxide	1230116.077	259204.2284	87402.96816	3.305146275	20233.2324	10635.20779	596.0523557	8436.262315	2235.196334	841369.6
	Emissions to fresh water	0.087160856	0.019828116	0.004023472	7.80891E-09	0.002128751	0.000199072	1.1157E-05	0.000241043	4.18388E-05	0.060687
	Inorganic emissions to fresh water	0.087160856	0.019828116	0.004023472	7.80891E-09	0.002128751	0.000199072	1.1157E-05	0.000241043	4.18388E-05	0.060687
	Sulphuric acid	0.087160856	0.019828116	0.004023472	7.80891E-09	0.002128751	0.000199072	1.1157E-05	0.000241043	4.18388E-05	0.060687

Table A.3. Glass bottle production emissions by each scenario for EP - kg Phosphate-Equiv.

Eutrophication Potential (EP) - kg Phosphate-Equiv.											
Scenarios			**Glass Bottle Production**								
	Flow	**Total**	**Electricity grid mix, Turkey, 2017**	**Raw Materials**	**EU-28: Thermal energy from heavy fuel oil (HFO) ts**	**EU-28: Thermal energy from natural gas ts**	**Transport of Glass Bottled Beverage**	**Transport of Landfill Waste Glass**	**EU-27: Landfill for inert matter (Glass) PE**		
2017 Turkey's Landfill	Emissions to air	206509.6058	193285.9004	9381.921533	7.22E-08	0.022585122	742.5496568	104.9433634	2994.26822		
	Inorganic emissions to air	206509.6058	193285.9004	9381.921533	7.22E-08	0.022585122	742.5496568	104.9433634	2994.26822		
	Ammonium	0.05733161	0.056462233	0.000417854	1.44E-15	5.45E-09	0.0001562	2.19E-05	0.000273432		
	Nitrogen oxides	203862.958	191236.2513	8941.712249	7.07E-08	0.021871378	624.2123937	87.46027231	2973.299916		
	Nitrous oxide (laughing gas)	2646.59042	2049.592635	440.2088658	1.45E-09	0.000713738	118.3371069	17.48306922	20.96803005		
	Emissions to fresh water	854.5964865	15.20666381	568.8883921	2.22E-10	4.22E-05	232.1025299	32.52058222	5.878276239		
	Inorganic emissions to fresh water	854.5964865	15.20666381	568.8883921	2.22E-10	4.22E-05	232.1025299	32.52058222	5.878276239		
	Phosphate	854.5964865	15.20666381	568.8883921	2.22E-10	4.22E-05	232.1025299	32.52058222	5.878276239		
	Emissions to air	119927.6554	42846.23893	53392.93531	0.062761243	19643.44547	781.8271641	110.4943911	3152.651421		
	Inorganic emissions to air	119927.6554	42846.23893	53392.93531	0.062761243	19643.44547	781.8271641	110.4943911	3152.651421		
	Ammonium	0.05900126	0.049589904	0.004191902	1.25E-09	0.004744053	0.000164462	2.30E-05	0.000287895		
	Nitrogen oxides	117652.0538	42544.22937	52205.20643	0.061496657	19022.66565	657.2303968	92.08652384	3130.573989		

2018 Turkey's Landfill	Nitrous oxide (laughing gas)	2274.212035	301.9599678	1186.394132	0.001264584	620.7750798	124.5966028	18.40784425	22.07714369		
	Phosphorus	1.330559621	0	1.330559621	0	0	0	0	0		
	Emissions to fresh water	1486.719155	3.468267748	1161.711799	0.000193088	36.7292117	244.3797005	34.24077344	6.189210377		
	Inorganic emissions to fresh water	1486.719155	3.468267748	1161.711799	0.000193088	36.7292117	244.3797005	34.24077344	6.189210377		
	Phosphate	1486.719155	3.468267748	1161.711799	0.000193088	36.7292117	244.3797005	34.24077344	6.189210377		
			Glass Bottle Production								
	Flow	**Total**	**Electricity grid mix, Turkey, 2017**	**Raw Materials**	**EU-28: Thermal energy from heavy fuel oil (HFO) ts**	**EU-28: Thermal energy from natural gas ts**	**Transport of Glass Bottled Beverage**	**Transport of Landfill Waste Glass**	**EU-27: Landfill for inert matter (Glass) PE**	**Transport of Recycling Waste**	**Recycling**
2017 Turkey's Recycling	Emissions to air	81790.48785	46825.88913	15043.09938	0.185786994	5536.79388	742.5496568	72.50446277	2068.714034	64.8778	11435.87
	Inorganic emissions to air	81790.48785	46825.88913	15043.09938	0.185786994	5536.79388	742.5496568	72.50446277	2068.714034	64.8778	11435.87
	Ammonium	0.024472549	0.013678671	0.00118016	3.70E-09	0.001337181	0.0001562	1.51E-05	0.000188912	1.35E-05	0.007903
	Nitrogen oxides	80403.54427	46329.33646	14709.38016	0.182043546	5361.817961	624.2123937	60.42554623	2054.227214	54.06945	11209.89
	Nitrous oxide (laughing gas)	1386.544059	496.5390504	333.3429998	0.003743444	174.9745821	118.3371069	12.07890142	14.48663074	10.80834	225.9727
	Phosphorus	0.375042558	0	0.375042558	0	0	0	0	0	0	0
	Emissions to fresh water	723.4204503	3.684001533	325.3630544	0.000571583	10.35266827	232.1025299	22.46818918	4.061250248	20.10479	105.2834
	Inorganic emissions to fresh water	723.4204503	3.684001533	325.3630544	0.000571583	10.35266827	232.1025299	22.46818918	4.061250248	20.10479	105.2834
	Phosphate	723.4204503	3.684001533	325.3630544	0.000571583	10.35266827	232.1025299	22.46818918	4.061250248	20.10479	105.2834
	Emissions to air	62022.90872	10120.00438	15442.04153	0.190714055	5683.629342	781.8271641	75.97853767	2167.837139	69.03171	27682.37

2018 Turkey's Recycling	Inorganic emissions to air	62022.90872	10120.00438	15442.041533	0.190714055	5683.629342	781.8271641	75.97853767	2167.837139	69.03171	27682.37
	Ammonium	0.033819513	0.011712814	0.001211458	3.79E-09	0.001372643	0.000164462	1.58E-05	0.000197963	1.44E-05	0.01913
	Nitrogen oxides	60718.42833	10048.67168	15099.4721	0.186871331	5504.013072	657.2303968	63.32085592	2152.656179	57.53134	27135.35
	Nitrous oxide (laughing gas)	1304.061574	71.32099043	342.1832374	0.00384272	179.6148982	124.5966028	12.65766591	15.18076236	11.50036	547.0032
	Phosphorus	0.384988665	0	0.384988665	0	0	0	0	0	0	0
	Emissions to fresh water	893.8663572	0.819182399	333.9916643	0.000586741	10.62722045	244.3797005	23.54475977	4.255846374	21.39203	254.8554
	Inorganic emissions to fresh water	893.8663572	0.819182399	333.9916643	0.000586741	10.62722045	244.3797005	23.54475977	4.255846374	21.39203	254.8554
	Phosphate	893.8663572	0.819182399	333.9916643	0.000586741	10.62722045	244.3797005	23.54475977	4.255846374	21.39203	254.8554
			Glass Bottle Production								
	Flow	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Materials**	**EU-28: Thermal energy from heavy fuel oil (HFO) ts**	**EU-28: Thermal energy from natural gas ts**	**Transport of Glass Bottled Beverage**	**Transport of Landfill Waste Glass**	**EU-27: Landfill for inert matter (Glass) PE**		
Turkey's Future Landfill	Emissions to air	510271.3538	1.163465868	1.687256887	1.640156811	510266.7364	0.022929466	0.003227343	0.100423838		
	Inorganic emissions to air	510271.3538	1.163465868	1.687256887	1.640156811	510266.7364	0.022929466	0.003227343	0.100423838		
	Ammonium	0.049356391	9.91763E-07	5.27936E-08	1.29891E-08	0.049355328	2.07126E-09	2.90211E-10	3.6258E-09		
	Nitrogen oxides	502377.775	1.158868319	1.668992988	1.624076937	502373.1991	0.021011562	0.002943993	0.100084003		
	Nitrous oxide (laughing gas)	7893.529429	0.004596558	0.018262039	0.016079861	7893.487949	0.001917902	0.00028335	0.000339831		
	Phosphorus	1.80716E-06	0	1.80716E-06	0	0	0	0	0		
	Emissions to fresh water	126.1052946	8.29221E-05	0.004828169	0.000662909	126.0985369	0.001015662	0.000142307	2.57229E-05		

	Inorganic emissions to fresh water	126.1052946	8.29221E-05	0.004828169	0.000662909	126.0985369	0.001015662	0.000142307	2.57229E-05		
	Phosphate	126.1052946	8.29221E-05	0.004828169	0.000662909	126.0985369	0.001015662	0.000142307	2.57229E-05		
			Glass Bottle Production								
	Flow	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Materials**	**EU-28: Thermal energy from heavy fuel oil (HFO) ts**	**EU-28: Thermal energy from natural gas ts**	**Transport of Glass Bottled Beverage**	**Transport of Landfill Waste Glass**	**EU-27: Landfill for inert matter (Glass) PE**	**Transport of Recycling Waste**	**Recycling**
Turkey's Future Recycling	Emissions to air	92445.74987	16532.34829	29574.26065	0.365251392	10885.16277	1083.11245	61.22982478	1747.023466	183.6895	32378.56
	Inorganic emissions to air	92445.74987	16532.34829	29574.26065	0.365251392	10885.16277	1083.11245	61.22982478	1747.023466	183.6895	32378.56
	Ammonium	0.063384435	0.03562173	0.002320157	7.26598E-09	0.002628856	0.000227839	1.27693E-05	0.000159535	3.83E-05	0.022375
	Nitrogen oxides	90445.07846	16397.2331	28918.17915	0.35789189	10541.16561	910.5010133	51.02921209	1734.789385	153.0876	31738.74
	Nitrous oxide (laughing gas)	1999.870698	135.07956	655.341862	0.007359494	343.9945298	172.6112086	10.20059992	12.23392089	30.6018	639.7999
	Phosphorus	0.737321883	0	0.737321883	0	0	0	0	0	0	0
	Emissions to fresh water	1385.00445	9.025331929	639.6535402	0.001123713	20.35302048	338.5539775	18.97432564	3.429714966	56.92298	298.0904
	Inorganic emissions to fresh water	1385.00445	9.025331929	639.6535402	0.001123713	20.35302048	338.5539775	18.97432564	3.429714966	56.92298	298.0904
	Phosphate	1385.00445	9.025331929	639.6535402	0.001123713	20.35302048	338.5539775	18.97432564	3.429714966	56.92298	298.0904
			Glass Bottle Production								

	Flow	Total	Electricity grid mix, Turkey, Future	Raw Materials	EU-28: Thermal energy from heavy fuel oil (HFO) ts	EU-28: Thermal energy from natural gas ts	Transport of Glass Bottled Beverage	Transport of Recycling Waste	Recycling	Transport of Glass Waste for Incineration	Incineration
Turkey's Future Recycling Incineration	Emissions to air	96753.78472	16532.34829	29574.26065	0.365251392	10885.16277	1083.11245	183.6894743	32378.55769	122.4596	5993.828
	Inorganic emissions to air	96753.78472	16532.34829	29574.26065	0.365251392	10885.16277	1083.11245	183.6894743	32378.55769	122.4596	5993.828
	Ammonium	0.063252749	0.03562173	0.002320157	7.26598E-09	0.002628856	0.000227839	3.83079E-05	0.022375233	2.55E-05	1.51E-05
	Nitrogen oxides	94712.13755	16397.2331	28918.17915	0.35789189	10541.16561	910.5010133	153.0876363	31738.73546	102.0584	5950.819
	Nitrous oxide (laughing gas)	2040.846595	135.07956	655.341862	0.007359494	343.9945298	172.6112086	30.60179977	639.7998579	20.4012	43.00922
	Phosphorus	0.737321883	0	0.737321883	0	0	0	0	0	0	0
	Emissions to fresh water	1401.098581	9.025331929	639.6535402	0.001123713	20.35302048	338.5539775	56.92297691	298.0904386	37.94865	0.54952
	Inorganic emissions to fresh water	1401.098581	9.025331929	639.6535402	0.001123713	20.35302048	338.5539775	56.92297691	298.0904386	37.94865	0.54952
	Phosphate	1401.098581	9.025331929	639.6535402	0.001123713	20.35302048	338.5539775	56.92297691	298.0904386	37.94865	0.54952
			Glass Bottle Production								
	Flows	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Materials**	**EU-28: Thermal energy from heavy fuel oil (HFO) ts**	**EU-28: Thermal energy from natural gas ts**	**Transport of Glass Bottled Beverage**	**Transport of Landfill Waste Glass**	**EU-27: Landfill for inert matter (Glass) PE**	**Transport of Recycling Waste**	**Recycling**
	Emissions to air	79214.2603	10332.71768	18483.91291	0.22828212	6803.226732	1083.11245	61.22982478	1747.023466	229.6118	40473.2
	Inorganic emissions to air	79214.2603	10332.71768	18483.91291	0.22828212	6803.226732	1083.11245	61.22982478	1747.023466	229.6118	40473.2

EU	Ammonium	0.053773789	0.022263581	0.001450098	4.54124E-09	0.001643035	0.000227839	1.27693E-05	0.000159535	4.79E-05	0.027969
	Nitrogen oxides	77471.68333	10248.27069	18073.86197	0.223682432	6588.228508	910.5010133	51.02921209	1734.789385	191.3595	39673.42
	Nitrous oxide (laughing gas)	1742.062371	84.42472499	409.5886638	0.004599684	214.9965811	172.6112086	10.20059992	12.23392089	38.25225	799.7498
	Phosphorus	0.460826177	0	0.460826177	0	0	0	0	0	0	0
	Emissions to fresh water	1222.870423	5.640832456	399.7834627	0.000702321	12.7206378	338.5539775	18.97432564	3.429714966	71.15372	372.613
	Inorganic emissions to fresh water	1222.870423	5.640832456	399.7834627	0.000702321	12.7206378	338.5539775	18.97432564	3.429714966	71.15372	372.613
	Phosphate	1222.870423	5.640832456	399.7834627	0.000702321	12.7206378	338.5539775	18.97432564	3.429714966	71.15372	372.613

Table A.4. Glass bottle production emissions by each scenario for ODP - kg R11-Equiv.

Ozone Layer Depletion Potential (ODP) - kg R11-Equiv.											
Scenarios			**Glass Bottle Production**								
	Flow	**Total**	**Electricity grid mix, Turkey, 2017**	**Raw Materials**	**EU-28: Thermal energy from heavy fuel oil (HFO) ts**	**EU-28: Thermal energy from natural gas ts**	**Transport of Glass Bottled Beverage**	**Transport of Landfill Waste Glass**	**EU-27: Landfill for inert matter (Glass) PE**		
2017 Turkey's Landfill	Emissions to air	0.000445553	0.000368373	1.51E-05	8.95E-17	2.33E-10	5.20E-06	7.29E-07	5.61E-05		
	Organic emissions to air (group VOC)	0.000445553	0.000368373	1.51E-05	8.95E-17	2.33E-10	5.20E-06	7.29E-07	5.61E-05		
	Group NMVOC to air	0.000445553	0.000368373	1.51E-05	8.95E-17	2.33E-10	5.20E-06	7.29E-07	5.61E-05		
	Halogenated organic emissions to air	0.000445553	0.000368373	1.51E-05	8.95E-17	2.33E-10	5.20E-06	7.29E-07	5.61E-05		
	Halon (1301)	2.08E-10	6.23E-11	5.78E-11	1.65E-22	4.01E-16	2.02E-11	2.84E-12	6.49E-11		
	Methyl bromide	3.82E-10	1.14E-10	1.06E-10	3.03E-22	7.36E-16	3.72E-11	5.21E-12	1.19E-10		
	R 114 (dichlorotetrafluoroethane)	0.000445553	0.000368372	1.51E-05	8.95E-17	2.33E-10	5.20E-06	7.29E-07	5.61E-05		
2018 Turkey's Landfill	Emissions to air	0.829761305	0.000319228	0.829174228	7.78212E-11	0.000202532	5.4777E-06	7.67497E-07	5.91E-05		
	Organic emissions to air (group VOC)	0.829761305	0.000319228	0.829174228	7.78212E-11	0.000202532	5.4777E-06	7.67497E-07	5.91E-05		
	Group NMVOC to air	0.829761305	0.000319228	0.829174228	7.78212E-11	0.000202532	5.4777E-06	7.67497E-07	5.91E-05		
	Halogenated organic emissions to air	0.829761305	0.000319228	0.829174228	7.78212E-11	0.000202532	5.4777E-06	7.67497E-07	5.91E-05		
	Carbon tetrachloride (tetrachloromethane)	0.001569292	0	0.001569292	0	0	0	0	0		
	Halon (1211)	0.091417759	0	0.091417759	0	0	0	0	0		

	Halon (1301)	0.719588301	1.83E-10	0.7195883	1.43448E-16	3.48455E-10	2.13127E-11	2.98619E-12	6.83E-11		
	Methyl bromide	4.52E-09	3.37E-10	3.36805E-09	2.63514E-16	6.40111E-10	3.91514E-11	5.48562E-12	1.26E-10		
	R 114 (dichlorotetrafluoroethane)	0.017185947	0.000319228	0.016598872	7.78208E-11	0.000202531	5.47764E-06	7.67489E-07	5.91E-05		
			Glass Bottle Production								
	Flow	**Total**	**Electricity grid mix, Turkey, 2017**	**Raw Materials**	**EU-28: Thermal energy from heavy fuel oil (HFO) ts**	**EU-28: Thermal energy from natural gas ts**	**Transport of Glass Bottled Beverage**	**Transport of Landfill Waste Glass**	**EU-27: Landfill for inert matter (Glass) PE**	**Transport of Recycling Waste**	**Recycling**
2017 Turkey's Recycling	Emissions to air	0.234441543	8.92E-05	0.23371787	2.30368E-10	5.70867E-05	5.20251E-06	5.03618E-07	3.88E-05	4.51E-07	0.000532
	Organic emissions to air (group VOC)	0.234441543	8.92E-05	0.23371787	2.30368E-10	5.70867E-05	5.20251E-06	5.03618E-07	3.88E-05	4.51E-07	0.000532
	Group NMVOC to air	0.234441543	8.92E-05	0.23371787	2.30368E-10	5.70867E-05	5.20251E-06	5.03618E-07	3.88E-05	4.51E-07	0.000532
	Halogenated organic emissions to air	0.234441543	8.92E-05	0.23371787	2.30368E-10	5.70867E-05	5.20251E-06	5.03618E-07	3.88E-05	4.51E-07	0.000532
	Carbon tetrachloride (tetrachloromethane)	0.000442334	0	0.000442334	0	0	0	0	0	0	0
	Halon (1211)	0.025767767	0	0.025767767	0	0	0	0	0	0	0
	Halon (1301)	0.202829123	1.51E-11	0.20282912	4.24639E-16	9.82172E-11	2.0242E-11	1.95948E-12	4.48E-11	1.75E-12	2.69E-09
	Methyl bromide	6.23E-09	2.77E-11	9.49011E-10	7.8006E-16	1.80425E-10	3.71845E-11	3.59956E-12	8.24E-11	3.22E-12	4.95E-09
	R 114 (dichlorotetrafluoroethane)	0.005402313	8.92E-05	0.004678649	2.30366E-10	5.70864E-05	5.20246E-06	5.03613E-07	3.88E-05	4.51E-07	0.000532
	Emissions to air	0.241385979	7.54E-05	0.239916055	2.36477E-10	5.86006E-05	5.4777E-06	5.27749E-07	4.06E-05	4.79E-07	0.001289
	Organic emissions to air (group VOC)	0.241385979	7.54E-05	0.239916055	2.36477E-10	5.86006E-05	5.4777E-06	5.27749E-07	4.06E-05	4.79E-07	0.001289

2018 Turkey's Recycling	Group NMVOC to air	0.241385979	7.54E-05	0.239916055	2.36477E-10	5.86006E-05	5.4777E-06	5.27749E-07	4.06E-05	4.79E-07	0.001289
	Halogenated organic emissions to air	0.241385979	7.54E-05	0.239916055	2.36477E-10	5.86006E-05	5.4777E-06	5.27749E-07	4.06E-05	4.79E-07	0.001289
	Carbon tetrachloride (tetrachloromethane)	0.000454064	0	0.000454064	0	0	0	0	0	0	0
	Halon (1211)	0.026451127	0	0.026451127	0	0	0	0	0	0	0
	Halon (1301)	0.208208143	4.33E-11	0.208208137	4.359E-16	1.00822E-10	2.13127E-11	2.05337E-12	4.7E-11	1.87E-12	6.52E-09
	Methyl bromide	1.34E-08	7.96E-11	9.74179E-10	8.00747E-16	1.8521E-10	3.91514E-11	3.77204E-12	8.63E-11	3.43E-12	1.2E-08
	R 114 (dichlorotetrafluoroethane)	0.006272631	7.54E-05	0.004802726	2.36476E-10	5.86004E-05	5.47764E-06	5.27743E-07	4.06E-05	4.79E-07	0.001289
			Glass Bottle Production								
	Flow	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Materials**	**EU-28: Thermal energy from heavy fuel oil (HFO) ts**	**EU-28: Thermal energy from natural gas ts**	**Transport of Glass Bottled Beverage**	**Transport of Landfill Waste Glass**	**EU-27: Landfill for inert matter (Glass) PE**		
Turkey's Future Landfill	Emissions to air	0.003447108	7.20631E-07	0.003446116	3.23438E-13	-2.0782E-17	2.27658E-08	3.18978E-09	2.46E-07		
	Organic emissions to air (group VOC)	0.003447108	7.20631E-07	0.003446116	3.23438E-13	-2.0782E-17	2.27658E-08	3.18978E-09	2.46E-07		
	Group NMVOC to air	0.003447108	7.20631E-07	0.003446116	3.23438E-13	-2.0782E-17	2.27658E-08	3.18978E-09	2.46E-07		
	Halogenated organic emissions to air	0.003447108	7.20631E-07	0.003446116	3.23438E-13	-2.0782E-17	2.27658E-08	3.18978E-09	2.46E-07		
	Carbon tetrachloride (tetrachloromethane)	6.52211E-06	0	6.52211E-06	0	0	0	0	0		
	Halon (1211)	0.00037994	0	0.00037994	0	0	0	0	0		
	Halon (1301)	0.002990668	4.56454E-11	0.002990668	5.96196E-19	-3.57552E-23	8.85773E-14	1.24108E-14	2.84E-13		
	Methyl bromide	9.85555E-11	8.38505E-11	1.39979E-11	1.09521E-18	-6.56822E-23	1.62716E-13	2.27987E-14	5.22E-13		

	R 114 (dichlorotetrafluoroethane)	6.99782E-05	7.20501E-07	6.89863E-05	3.23436E-13	-2.07819E-17	2.27655E-08	3.18975E-09	2.46E-07		
			Glass Bottle Production								
	Flow	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Materials**	**EU-28: Thermal energy from heavy fuel oil (HFO) ts**	**EU-28: Thermal energy from natural gas ts**	**Transport of Glass Bottled Beverage**	**Transport of Landfill Waste Glass**	**EU-27: Landfill for inert matter (Glass) PE**	**Transport of Recycling Waste**	**Recycling**
Turkey's Future Recycling	Emissions to air	0.46122214	7.84E-05	0.459481989	4.52896E-10	0.000112231	7.58859E-06	4.25304E-07	3.27E-05	1.28E-06	0.001507
	Organic emissions to air (group VOC)	0.46122214	7.84E-05	0.459481989	4.52896E-10	0.000112231	7.58859E-06	4.25304E-07	3.27E-05	1.28E-06	0.001507
	Group NMVOC to air	0.46122214	7.84E-05	0.459481989	4.52896E-10	0.000112231	7.58859E-06	4.25304E-07	3.27E-05	1.28E-06	0.001507
	Halogenated organic emissions to air	0.46122214	7.84E-05	0.459481989	4.52896E-10	0.000112231	7.58859E-06	4.25304E-07	3.27E-05	1.28E-06	0.001507
	Carbon tetrachloride (tetrachloromethane)	0.000869614	0	0.000869614	0	0	0	0	0	0	0
	Halon (1211)	0.05065862	0	0.05065862	0	0	0	0	0	0	0
	Halon (1301)	0.398755688	4.97E-09	0.398755676	8.34826E-16	1.93092E-10	2.95258E-11	1.65478E-12	3.79E-11	4.96E-12	7.63E-09
	Methyl bromide	2.55E-08	9.13E-09	1.86573E-09	1.53357E-15	3.54709E-10	5.42388E-11	3.03982E-12	6.95E-11	9.12E-12	1.4E-08
	R 114 (dichlorotetrafluoroethane)	0.010938192	7.84E-05	0.009198077	4.52893E-10	0.00011223	7.58851E-06	4.25299E-07	3.27E-05	1.28E-06	0.001507
			Glass Bottle Production								
	Flow	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Materials**	**EU-28: Thermal energy from heavy fuel oil (HFO) ts**	**EU-28: Thermal energy from natural gas ts**	**Transport of Glass Bottled Beverage**	**Transport of Recycling Waste**	**Recycling**	**Transport of Glass Waste for Incineration**	**Incineration**

Turkey's Future Recycling Incineration	Emissions to air	0.685719909	7.84E-05	0.459481989	4.52896E-10	0.000112231	7.58859E-06	1.27591E-06	0.001507	8.51E-07	0.22453
	Organic emissions to air (group VOC)	0.685719909	7.84E-05	0.459481989	4.52896E-10	0.000112231	7.58859E-06	1.27591E-06	0.001507	8.51E-07	0.22453
	Group NMVOC to air	0.685719909	7.84E-05	0.459481989	4.52896E-10	0.000112231	7.58859E-06	1.27591E-06	0.001507	8.51E-07	0.22453
	Halogenated organic emissions to air	0.685719909	7.84E-05	0.459481989	4.52896E-10	0.000112231	7.58859E-06	1.27591E-06	0.001507	8.51E-07	0.22453
	Carbon tetrachloride (tetrachloromethane)	0.000869614	0	0.000869614	0	0	0	0	0	0	0
	Halon (1211)	0.05065862	0	0.05065862	0	0	0	0	0	0	0
	Halon (1301)	0.401556304	4.97E-09	0.398755676	8.34826E-16	1.93092E-10	2.95258E-11	4.96433E-12	7.63E-09	3.31E-12	0.002801
	Methyl bromide	2.54E-08	9.13E-09	1.86573E-09	1.53357E-15	3.54709E-10	5.42388E-11	9.11947E-12	1.4E-08	6.08E-12	0
	R 114 (dichlorotetrafluoroethane)	0.232635346	7.84E-05	0.009198077	4.52893E-10	0.00011223	7.58851E-06	1.2759E-06	0.001507	8.51E-07	0.221729
			Glass Bottle Production								
	Flows	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Materials**	**EU-28: Thermal energy from heavy fuel oil (HFO) ts**	**EU-28: Thermal energy from natural gas ts**	**Transport of Glass Bottled Beverage**	**Transport of Landfill Waste Glass**	**EU-27: Landfill for inert matter (Glass) PE**	**Transport of Recycling Waste**	**Recycling**
EU	Emissions to air	0.28922208	4.90E-05	0.287176243	2.8306E-10	7.01442E-05	7.58859E-06	4.25304E-07	3.27E-05	1.59E-06	0.001884
	Organic emissions to air (group VOC)	0.28922208	4.90E-05	0.287176243	2.8306E-10	7.01442E-05	7.58859E-06	4.25304E-07	3.27E-05	1.59E-06	0.001884
	Group NMVOC to air	0.28922208	4.90E-05	0.287176243	2.8306E-10	7.01442E-05	7.58859E-06	4.25304E-07	3.27E-05	1.59E-06	0.001884
	Halogenated organic emissions to air	0.28922208	4.90E-05	0.287176243	2.8306E-10	7.01442E-05	7.58859E-06	4.25304E-07	3.27E-05	1.59E-06	0.001884
	Carbon tetrachloride (tetrachloromethane)	0.000543509	0	0.000543509	0	0	0	0	0	0	0
	Halon (1211)	0.031661638	0	0.031661638	0	0	0	0	0	0	0

	Halon (1301)	0.24922231	3.11E-09	0.249222297	5.21766E-16	1.20682E-10	2.95258E-11	1.65478E-12	3.79E-11	6.21E-12	9.54E-09
	Methyl bromide	2.48E-08	5.70E-09	1.16608E-09	9.58483E-16	2.21693E-10	5.42388E-11	3.03982E-12	6.95E-11	1.14E-11	1.75E-08
	R 114 (dichlorotetrafluoroethane)	0.007794598	4.90E-05	0.005748798	2.83058E-10	7.01438E-05	7.58851E-06	4.25299E-07	3.27E-05	1.59E-06	0.001884

Table A.5. Glass bottle production emissions by each scenario for POCP - kg Ethene-Equiv.

Photochemical Ozone Creation Potential (POCP) - kg Ethene-Equiv.											
Scenarios			**Glass Bottle Production**								
	Flow	**Total**	**Electricity grid mix, Turkey, 2017**	**Raw Materials**	**EU-28: Thermal energy from heavy fuel oil (HFO) ts**	**EU-28: Thermal energy from natural gas ts**	**Transport of Glass Bottled Beverage**	**Transport of Landfill Waste Glass**	**EU-27: Landfill for inert matter (Glass) PE**		
2017 Turkey's Landfill	Emissions to air	716325.6265	703408.1436	8262.075051	8.60E-08	0.029601817	2096.083808	395.0166	2164.278		
	Inorganic emissions to air	683696.8175	676813.4861	4240.376254	6.03E-08	0.009935645	863.2152945	146.7406	1632.989		
	Carbon monoxide	6067.541875	3857.175117	1271.981289	3.25E-09	0.002538103	437.122272	87.03946	414.2212		
	Nitrogen oxides	43908.94481	41189.34644	1925.907254	1.52E-08	0.004710758	134.4457463	18.8376	640.4031		
	Sulphur dioxide	633720.3308	631766.9645	1042.487711	4.18E-08	0.002686784	291.6472761	40.86358	578.365		
	Organic emissions to air (group VOC)	32628.80895	26594.65747	4021.698797	2.57E-08	0.019666172	1232.868514	248.276	531.2885		
	Group NMVOC to air	28677.80785	23208.01571	3637.48075	2.32E-08	0.015651622	1112.147322	231.2891	488.8593		
	Methane	3951.001098	3386.641758	384.2180462	2.50E-09	0.00401455	120.7211914	16.98685	42.42924		
	Emissions to air	139770.3252	60843.15204	48279.24508	0.074803658	25746.2267	2206.95713	415.9112	2278.758		
	Inorganic emissions to air	103433.6513	53947.34652	38061.9645	0.05242264	8641.5428	908.8754665	154.5025	1719.367		

2018 Turkey's Landfill	Carbon monoxide	20786.33588	876.7977414	16713.99754	0.00283006	2207.518636	460.2440567	91.64345	436.1316		
	Nitrogen oxides	25340.44237	9163.372479	11244.19831	0.013245434	4097.189524	141.5573162	19.83402	674.2775		
	Sulphur dioxide	57306.87302	43907.17629	10103.76865	0.036347146	2336.83464	307.0740936	43.02507	608.9579		
	Organic emissions to air (group VOC)	36336.67398	6895.805528	10217.28058	0.022381018	17104.6839	1298.081663	261.4087	559.3913		
	Group NMVOC to air	29693.56116	5604.432235	8546.870432	0.020205214	13613.02242	1170.974869	243.5233	514.7177		
	Methane	6643.112824	1291.373293	1670.410149	0.002175804	3491.661483	127.1067947	17.88538	44.67355		
			Glass Bottle Production								
	Flow	**Total**	**Electricity grid mix, Turkey, 2017**	**Raw Materials**	**EU-28: Thermal energy from heavy fuel oil (HFO) ts**	**EU-28: Thermal energy from natural gas ts**	**Transport of Glass Bottled Beverage**	**Transport of Landfill Waste Glass**	**EU-27: Landfill for inert matter (Glass) PE**	**Transport of Recycling Waste**	**Recycling**
2017 Turkey's Recycling	Emissions to air	214474.1925	170409.2832	13589.5437	0.221435174	7256.952486	2096.083808	272.9136	1495.281	244.2061	19109.71
	Inorganic emissions to air	193149.9977	163966.4	10720.70013	0.155182471	2435.745876	863.2152945	101.3818	1128.218	90.71759	13843.46
	Carbon monoxide	9020.864997	934.4481618	4707.215982	0.008377597	622.22158	437.122272	60.13481	286.1818	53.8093	1919.723
	Nitrogen oxides	17317.68646	9978.626301	3168.174189	0.039209379	1154.853099	134.4457463	13.01473	442.4489	11.64573	2414.439
	Sulphur dioxide	166811.4462	153053.3255	2845.309958	0.107595495	658.6711967	291.6472761	28.23229	399.5874	25.26257	9509.302
	Organic emissions to air (group VOC)	21324.19484	6442.883206	2868.843567	0.066252704	4821.20661	1232.868514	171.5317	367.0626	153.4885	5266.244

	Group NMVOC to air	17759.66571	5622.427544	2399.093236	0.059811849	3837.030491	1112.147322	159.7957	337.7486	142.987	4148.376
	Methane	3564.529134	820.4556625	469.7503307	0.006440855	984.1761193	120.7211914	11.73607	29.31399	10.50157	1117.868
2018 Turkey's Recycling	Emissions to air	86348.16166	14370.7588	13949.93763	0.227307623	7449.406457	2206.95713	285.9903	1566.928	259.8418	46258.11
	Inorganic emissions to air	62051.77176	12742.01416	11005.01249	0.159297901	2500.341719	908.8754665	106.2396	1182.277	96.52593	33510.33
	Carbon monoxide	11205.28252	207.0939528	4832.051085	0.00859977	638.7228613	460.2440567	63.01619	299.8943	57.25452	4646.997
	Nitrogen oxides	13077.81533	2164.329284	3252.19399	0.04024921	1185.479738	141.5573162	13.63834	463.649	12.39136	5844.536
	Sulphur dioxide	37768.67391	10370.59092	2920.767418	0.110448921	676.1391197	307.0740936	29.58505	418.7338	26.88005	23018.79
	Organic emissions to air (group VOC)	24296.38989	1628.744643	2944.925137	0.068009722	4949.064738	1298.081663	179.7507	384.6506	163.3159	12747.79
	Group NMVOC to air	19611.60866	1323.730628	2462.717054	0.061398056	3938.788323	1170.974869	167.4523	353.932	152.1419	10041.81
	Methane	4684.781231	305.0140153	482.208083	0.006611666	1010.276415	127.1067947	12.29841	30.71858	11.17395	2705.978
			Glass Bottle Production								
	Flow	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Materials**	**EU-28: Thermal energy from heavy fuel oil (HFO) ts**	**EU-28: Thermal energy from natural gas ts**	**Transport of Glass Bottled Beverage**	**Transport of Landfill Waste Glass**	**EU-27: Landfill for inert matter (Glass) PE**		
	Emissions to air	318507.3089	0.534542767	0.64793376	0.620541227	318505.4522	4.17374E-14	0.023376	0.003917		
	Inorganic emissions to air	95022.74558	0.45255516	0.511659604	0.458365989	95021.28708	0	0.011844	0.002078		

Turkey's Future Landfill	Carbon monoxide	28070.11057	0.019136188	0.257276795	0.035985733	28069.78296	0	0.007084	0.001411		
	Nitrogen oxides	50237.7775	0.115886832	0.166899299	0.162407694	50237.31991	0	0.002101	0.000294		
	Sulphur dioxide	16714.85751	0.31753214	0.087483511	0.259972562	16714.18422	0	0.002659	0.000373		
	Organic emissions to air (group VOC)	223484.5633	0.081987608	0.136274156	0.162175238	223484.1651	4.17374E-14	0.011532	0.001839		
	Group NMVOC to air	23691.67073	0.007438733	0.020568146	0.037675936	23691.60041	4.17374E-14	0.002728	0.0006		
	Methane	199792.8926	0.074548874	0.11570601	0.124499302	199792.5647	0	0.008804	0.001239		
			Glass Bottle Production								
	Flow	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Materials**	**EU-28: Thermal energy from heavy fuel oil (HFO) ts**	**EU-28: Thermal energy from natural gas ts**	**Transport of Glass Bottled Beverage**	**Transport of Landfill Waste Glass**	**EU-27: Landfill for inert matter (Glass) PE**	**Transport of Recycling Waste**	**Recycling**
Turkey's Future Recycling	Emissions to air	123749.1332	23417.45449	26716.61585	0.435334594	14266.94053	3057.431173	230.4748	1262.761	691.4244	54105.6
	Inorganic emissions to air	88298.17061	20683.13964	21076.55955	0.305083861	4788.599847	1259.120146	85.61669	952.7772	256.8501	39195.2
	Carbon monoxide	17557.63805	562.3572754	9254.238695	0.016470092	1223.268073	637.603924	50.78368	241.6798	152.3511	5435.339
	Nitrogen oxides	19480.47844	3531.711746	6228.530894	0.077084407	2270.404901	196.1079106	10.99091	373.6469	32.97272	6836.035
	Sulphur dioxide	51260.05412	16589.07062	5593.789962	0.211529362	1294.926874	425.4083115	23.84209	337.4505	71.52628	26923.83
	Organic emissions to air (group VOC)	35450.96255	2734.314849	5640.056297	0.130250733	9478.340686	1798.311027	144.8581	309.9834	434.5743	14910.39

	Group NMVOC to air	28700.21296	2247.475728	4716.541909	0.117588215	7543.481364	1622.222298	134.947	285.2278	404.8411	11745.36
	Methane	6750.749589	486.8391209	923.5143879	0.012662518	1934.859322	176.0887292	9.911079	24.75559	29.73324	3165.035
			Glass Bottle Production								
	Flow	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Materials**	**EU-28: Thermal energy from heavy fuel oil (HFO) ts**	**EU-28: Thermal energy from natural gas ts**	**Transport of Glass Bottled Beverage**	**Transport of Recycling Waste**	**Recycling**	**Transport of Glass Waste for Incineration**	**Incineration**
Turkey's Future Recycling Incineration	Emissions to air	124382.193	23417.45449	26716.61585	0.435334594	14266.94053	3057.431173	691.4244	54105.6	460.9496	1665.346
	Inorganic emissions to air	88283.11225	20683.13964	21076.55955	0.305083861	4788.599847	1259.120146	256.8501	39195.2	171.2334	852.1022
	Carbon monoxide	16852.12755	562.3572754	9254.238695	0.016470092	1223.268073	637.603924	152.3511	5435.339	101.5674	-514.614
	Nitrogen oxides	20399.53732	3531.711746	6228.530894	0.077084407	2270.404901	196.1079106	32.97272	6836.035	21.98181	1281.715
	Sulphur dioxide	51031.44738	16589.07062	5593.789962	0.211529362	1294.926874	425.4083115	71.52628	26923.83	47.68419	85.00166
	Organic emissions to air (group VOC)	36099.08078	2734.314849	5640.056297	0.130250733	9478.340686	1798.311027	434.5743	14910.39	289.7162	813.2435
	Group NMVOC to air	29015.9621	2247.475728	4716.541909	0.117588215	7543.481364	1622.222298	404.8411	11745.36	269.894	466.0299
	Methane	7083.118679	486.8391209	923.5143879	0.012662518	1934.859322	176.0887292	29.73324	3165.035	19.82216	347.2136
			Glass Bottle Production								

	Flows	Total	Electricity grid mix, Turkey, Future	Raw Materials	EU-28: Thermal energy from heavy fuel oil (HFO) ts	EU-28: Thermal energy from natural gas ts	Transport of Glass Bottled Beverage	Transport of Landfill Waste Glass	EU-27: Landfill for inert matter (Glass) PE	Transport of Recycling Waste	Recycling
EU	Emissions to air	113297.8459	14635.90905	16697.8849	0.272084121	8916.837833	3057.431173	230.4748	1262.761	864.2804	67631.99
	Inorganic emissions to air	80705.45717	12926.96227	13172.84972	0.190677413	2992.874905	1259.120146	85.61669	952.7772	321.0626	48994
	Carbon monoxide	14814.60539	351.4732971	5783.899184	0.010293807	764.5425454	637.603924	50.78368	241.6798	190.4388	6794.174
	Nitrogen oxides	16686.20872	2207.319841	3892.831808	0.048177754	1419.003063	196.1079106	10.99091	373.6469	41.2159	8545.044
	Sulphur dioxide	49204.64306	10368.16914	3496.118727	0.132205851	809.329296	425.4083115	23.84209	337.4505	89.40785	33654.78
	Organic emissions to air (group VOC)	32592.38875	1708.946781	3525.035186	0.081406708	5923.962929	1798.311027	144.8581	309.9834	543.2179	18637.99
	Group NMVOC to air	26297.40655	1404.67233	2947.838693	0.073492635	4714.675852	1622.222298	134.947	285.2278	506.0513	14681.7
	Methane	6294.982203	304.2744505	577.1964925	0.007914074	1209.287076	176.0887292	9.911079	24.75559	37.16655	3956.294

APPENDIX B: LCIA Characterization for Pet Bottle Production

Table B.2. Pet bottle production emissions by each scenario for GWP - kg CO_2-Equiv.

Global Warming Potential (GWP) - kg CO2-Equiv.									
			PET Bottle Production'						
Scenarios	**Flows**	**Total**	**Electricity grid mix, Turkey'**	**Raw Material**	**Transport of Bottled PET**	**Transport of Landfill**	**EU-28: Plastic waste on landfill**		
2017 Turkey's Landfill	Emissions to air	6733725685.1	6506513935.0	199440597.5	20863998.7	1.31	6907152.6		
	Inorganic emissions to air	6542176649.0	6329224697.3	186782714.1	20175427.2	1.27	5993809.2		
	Carbon dioxide	6497669054.9	6291707004.2	181280678.0	19038802.6	1.19	5642569.1		
	Carbon dioxide (biotic)	20527475.6	14952152.6	4256197.5	1000385.3	0.06	318740.1		
	Nitrous oxide (laughing gas)	23968260.6	22565362.3	1234159.0	136239.3	0.01	32500.0		
	Sulphur hexafluoride	11857.8	178.2	11679.6	0.0	0.00	0.0		
	Organic emissions to air (group VOC)	191549036.1	177289237.7	12657883.4	688571.5	0.04	913343.5		
	Group NMVOC to air	13996.5	5585.8	8365.5	7.8	0.00	37.5		

	Methane	191501567.2	177283651.9	12645488.3	663745.3	0.04	908681.6		
	Methane (biotic)	33472.4	0.0	4029.6	24818.4	0.00	4624.4		
2018 Turkey's Landfill	Emissions to air	4347620841.2	3589309690.8	665625914.3	69632855.0	4.37	23052376.7		
	Inorganic emissions to air	4085727866.7	3375008287.3	623380677.9	67334772.0	4.22	20004125.3		
	Carbon dioxide	4007397706.7	3320006673.5	605017827.6	63541327.7	3.99	18831873.9		
	Carbon dioxide (biotic)	63070451.5	44463008.8	14204908.0	3338750.6	0.21	1063783.9		
	Nitrous oxide (laughing gas)	15220058.6	10537935.4	4118962.0	454693.7	0.03	108467.5		
	Sulphur hexafluoride	39649.9	669.6	38980.3	0.0	0.00	0.0		
	Organic emissions to air (group VOC)	261892974.5	214301403.6	42245236.4	2298083.0	0.14	3048251.4		
	Group NMVOC to air	48983.5	20913.1	27919.5	26.0	0.00	125.0		
	Methane	261732277.9	214280490.5	42203868.4	2215226.3	0.14	3032692.6		
	Methane (biotic)	111713.1	0.0	13448.6	82830.7	0.01	15433.8		
Scenarios			**PET Bottle Production'**						
	Flows	**Total**	**Electricity grid mix, Turkey'**	**Raw Material**	**Transport of Bottled PET**	**Transport of Landfill**	**EU-28: Plastic waste on landfill**	**Transport of Plastic Wastes**	**PET Recycling'17 GB**
	Emissions to air	6672846445.9	6506513935.0	95731486.8	20863998.7	0.57	3009464.8	413548.5	46314011.6
	Inorganic emissions to air	6486846912.1	6329224697.3	89655702.8	20175427.2	0.55	2611518.6	399996.4	44779569.4

2017 Turkey's Recycling	Carbon dioxide	6444986636.6	6291707004.2	87014725.4	19038802.6	0.52	2458482.3	377340.6	44390281.0
	Carbon dioxide (biotic)	18390524.2	14952152.6	2042974.8	1000385.3	0.03	138875.9	19827.6	236307.9
	Nitrous oxide (laughing gas)	23463965.8	22565362.3	592396.3	136239.3	0.00	14160.3	2828.2	152979.3
	Sulphur hexafluoride	5785.5	178.2	5606.2	0.0	0.00	0.0	0.0	1.1
	Organic emissions to air (group VOC)	185999533.8	177289237.7	6075784.0	688571.5	0.02	397946.2	13552.2	1534442.2
	Group NMVOC to air	9682.7	5585.8	4015.4	7.8	0.00	16.3	0.2	57.2
	Methane	185958141.5	177283651.9	6069834.4	663745.3	0.02	395915.0	13065.5	1531929.4
	Methane (biotic)	31709.6	0.0	1934.2	24818.4	0.00	2014.9	486.5	2455.6
2018 Turkey's Recycling	Emissions to air	4027102066.3	3589309691.0	312844179.7	69632855.0	1.86	9793820.4	1406745.9	44114772.5
	Inorganic emissions to air	3786448211.8	3375008287.4	292988918.6	67334772.0	1.79	8498768.4	1360646.2	41256817.4
	Carbon dioxide	3717562670.8	3320006673.6	284358379.0	63541327.7	1.69	8000736.5	1283579.4	40371973.0
	Carbon dioxide (biotic)	55767260.1	44463008.8	6676306.8	3338750.6	0.09	451949.4	67446.3	769798.1
	Nitrous oxide (laughing gas)	13099286.4	10537935.4	1935912.1	454693.7	0.01	46082.5	9620.5	115042.1
	Sulphur hexafluoride	18994.6	669.6	18320.7	0.0	0.00	0.0	0.0	4.2
	Organic emissions to air (group VOC)	240653854.4	214301403.6	19855261.1	2298083.0	0.06	1295052.0	46099.6	2857955.1

	Group NMVOC to air	34323.7	20913.1	13122.1	26.0	0.00	53.1	0.5	208.9
	Methane	240513814.3	214280490.5	19835818.1	2215226.3	0.06	1288441.8	44444.4	2849393.1
	Methane (biotic)	105716.4	0.0	6320.8	82830.7	0.00	6557.1	1654.8	8353.1
Scenarios			**PET Bottle Production Turkey Future**						
	Flows	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Material**	**Transport of Bottled PET**	**Transport of Landfill**	**EU-28: Plastic waste on landfill ts**		
Turkey's Future Landfill	Emissions to air	3159705887.0	2534300990.5	548956677.8	57408033.9	3.60	19040181.2		
	Inorganic emissions to air	2971950558.3	2386039896.3	513899140.5	55500952.0	3.48	16510566.1		
	Carbon dioxide	2852149950.3	2281713167.1	502078739.3	52730263.9	3.31	15627776.7		
	Carbon dioxide (biotic)	119768007.8	104326477.0	11788053.2	2770688.1	0.17	882789.3		
	Sulphur hexafluoride	32600.2	252.1	32348.1	0.0	0.00	0.0		
	Organic emissions to air (group VOC)	187755328.7	148261094.2	35057537.3	1907082.0	0.12	2529615.1		
	Group NMVOC to air	86237.7	62943.2	23169.2	21.6	0.00	103.7		
	Methane	187576385.1	148198151.1	35023207.7	1838322.7	0.11	2516703.5		
	Methane (biotic)	92705.9	0.0	11160.4	68737.7	0.00	12807.9		

Scenarios			PET Bottle Production Turkey Future						
	Flows	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Material**	**Transport of Bottled PET**	**Transport of Landfill**	**EU-28: Plastic waste on landfill ts**	**Transport of Plastic Wastes**	**PET Recycling Turkey future**
Turkey's Future Recycling	Emissions to air	2882681492.6	2534300990.5	247030505.0	57408033.9	1.45	7675992.7	1203166.9	35062802.1
	Inorganic emissions to air	2713408806.4	2386039896.3	231254613.2	55500952.0	1.40	6656185.9	1163467.1	32793690.5
	Carbon dioxide	2599477421.5	2281713167.1	225935432.7	52730263.9	1.33	6300292.0	1105384.1	31692880.4
	Carbon dioxide (biotic)	113916574.5	104326477.0	5304623.9	2770688.1	0.07	355893.9	58083.0	1100808.5
	Sulphur hexafluoride	14810.4	252.1	14556.6	0.0	0.00	0.0	0.0	1.7
	Organic emissions to air (group VOC)	169272686.2	148261094.2	15775891.8	1907082.0	0.05	1019806.8	39699.8	2269111.6
	Group NMVOC to air	73909.1	62943.2	10426.1	21.6	0.00	41.8	0.4	475.9
	Methane	169111235.3	148198151.1	15760443.5	1838322.7	0.05	1014601.6	38274.3	2261442.2
	Methane (biotic)	87541.8	0.0	5022.2	68737.7	0.00	5163.5	1425.0	7193.5
			PET Bottle Production Turkey Future						
	Flows	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Material**	**Transport of Bottled PET**	**Transport of Plastic Wastes**	**PET Recycling Turkey Future**	**Transport of Plastic Wastes for Incineration**	**EU-27: Waste incineration of plastics**
	Emissions to air	3065368488.6	2534300990.5	247030505.0	57408033.9	1203166.87	35062802.1	812684.5	245277515.8

Turkey's Future Incineration Recycling	Inorganic emissions to air	2900119223.6	2386039896.3	231254613.2	55500952.0	1163467.11	32793690.5	785869.1	245084801.1
	Carbon dioxide	2787241066.4	2281713167.1	225935432.7	52730263.9	1105384.13	31692880.4	746636.7	245084800.3
	Carbon dioxide (biotic)	112863348.9	104326477.0	5304623.9	2770688.1	58082.98	1100808.5	39232.4	0.0
	Sulphur hexafluoride	14808.3	252.1	14556.6	0.0	0.00	1.7	0.0	0.8
	Organic emissions to air (group VOC)	165249265.0	148261094.2	15775891.8	1907082.0	39699.76	2269111.6	26815.4	192714.8
	Group NMVOC to air	75835.1	62943.2	10426.1	21.6	0.45	475.9	0.3	2263.9
	Methane	165118227.2	148198151.1	15760443.5	1838322.7	38274.28	2261442.2	25852.5	190450.8
	Methane (biotic)	55202.8	0.0	5022.2	68737.7	1425.03	7193.5	962.5	0.0
			PET Bottle Production'						
	Flows	**Total**	**Electricity grid mix, Turkey Future**	**Raw Material**	**Transport of Bottled PET**	**Transport of Landfill**	**EU-28: Plastic waste on landfill**	**Transport of Plastic Wastes**	**PET Recycling**
EU	Emissions to air	1162144519.7	1021695950.5	99589617.6	23143879.1	0.59	3094553.8	485053.2	14135465.0
	Inorganic emissions to air	1093902736.8	961924928.7	93229613.5	22375044.7	0.57	2683421.7	469048.3	13220679.4
	Carbon dioxide	1047971635.9	919865916.4	91085201.6	21258050.0	0.54	2539944.1	445632.3	12776891.0
	Carbon dioxide (biotic)	45925130.1	42058910.7	2138543.5	1116994.7	0.03	143477.6	23416.0	443787.7
	Sulphur hexafluoride	5970.8	101.6	5868.5	0.0	0.00	0.0	0.0	0.7

	Organic emissions to air (group VOC)	68241782.9	59771021.7	6360004.1	768834.5	0.02	411132.1	16004.8	914785.6
	Group NMVOC to air	29796.2	25375.4	4203.3	8.7	0.00	16.9	0.2	191.9
	Methane	68176694.5	59745646.4	6353776.2	741114.4	0.02	409033.6	15430.2	911693.7
	Methane (biotic)	35292.2	0.0	2024.7	27711.4	0.00	2081.6	574.5	2900.0

Table B.2. Pet bottle production emissions by each scenario for AP - kg SO_2-Equiv.

Acidification Potential (AP) - kg SO2-Equiv.									
Scenarios			**PET Bottle Production'17**						
	Flows	**Total**	**Electricity grid mix, Turkey'**	**Raw Material**	**Transport of Bottled PET**	**Transport of Landfill**	**EU-28: Plastic waste on landfill**		
2017 Turkey's Landfill	Emissions to air	620606957.9	618103062.6	2402951.0	43138.0	0.0027	57806.3		
	Inorganic emissions to air	620606957.9	618103062.6	2402951.0	43138.0	0.0027	57806.3		
	Ammonia	40506.9	34978.9	83.1	5080.2	0.0003	364.7		
	Nitrogen oxides	28175111.5	27502252.7	642873.5	9428.8	0.0006	20556.6		
	Sulphur dioxide	592391339.5	590565831.0	1759994.4	28629.1	0.0018	36885.0		
	Emissions to fresh water	0.0	0.0	0.0	0.0	0.0000	0.0		
	Inorganic emissions to fresh water	0.0	0.0	0.0	0.0	0.0000	0.0		
	Sulphuric acid	0.0	0.0	0.0	0.0	0.0000	0.0		
2018 Turkey's Landfill	Emissions to air	47364750.5	44857752.0	2405929.1	43191.5	0.0027	57878.0		
	Inorganic emissions to air	47364750.5	44857752.0	2405929.1	43191.5	0.0027	57878.0		
	Ammonia	14959.1	9424.2	83.2	5086.5	0.0003	365.2		
	Nitrogen oxides	6491929.1	5818236.4	643670.2	9440.4	0.0006	20582.1		
	Sulphur dioxide	40857862.3	39030091.3	1762175.6	28664.6	0.0018	36930.7		
	Emissions to fresh water	0.1	0.1	0.0	0.0	0.0000	0.0		
	Inorganic emissions to fresh water	0.1	0.1	0.0	0.0	0.0000	0.0		
	Sulphuric acid	0.1	0.1	0.0	0.0	0.0000	0.0		
			PET Bottle Production'						

Scenarios	Flows	Total	Electricity grid mix, Turkey'	Raw Material	Transport of Bottled PET	Transport of Landfill	EU-28: Plastic waste on landfill	Transport of Plastic Wastes	PET Recycling'17 GB
2017 Turkey's Recycling	Emissions to air	623146694.7	618103062.6	1153416.5	43138.0	0.0012	25186.4	848.1	3821043.1
	Inorganic emissions to air	623146694.7	618103062.6	1153416.5	43138.0	0.0012	25186.4	848.1	3821043.1
	Ammonia	40935.0	34978.9	39.9	5080.2	0.0001	158.9	102.0	575.1
	Nitrogen oxides	28013585.9	27502252.7	308579.3	9428.8	0.0003	8956.6	184.8	184183.8
	Sulphur dioxide	595092173.8	590565831.0	844797.3	28629.1	0.0008	16070.9	561.3	3636284.2
	Emissions to fresh water	0.0401	0.0350	0.0000	0.0005	0.0000	0.0021	0.0000	0.0025
	Inorganic emissions to fresh water	0.0401	0.0350	0.0000	0.0005	0.0000	0.0021	0.0000	0.0025
	Sulphuric acid	0.0401	0.0350	0.0000	0.0005	0.0000	0.0021	0.0000	0.0025
2018 Turkey's Recycling	Emissions to air	46364470.6	44857752.0	1130786.7	43191.5	0.0011	24589.5	865.5	307285.5
	Inorganic emissions to air	46364470.6	44857752.0	1130786.7	43191.5	0.0011	24589.5	865.5	307285.5
	Ammonia	15235.8	9424.2	39.1	5086.5	0.0001	155.1	104.1	426.7
	Nitrogen oxides	6191185.0	5818236.4	302525.0	9440.4	0.0002	8744.3	188.6	52050.3
	Sulphur dioxide	40158049.8	39030091.3	828222.5	28664.6	0.0008	15690.1	572.8	254808.6
	Emissions to fresh water	0.1	0.1	0.0	0.0	0.0000	0.0	0.0	0.0
	Inorganic emissions to fresh water	0.1	0.1	0.0	0.0	0.0000	0.0	0.0	0.0
	Sulphuric acid	0.1	0.1	0.0	0.0	0.0000	0.0	0.0	0.0
Scenarios			**PET Bottle Production'**						
	Flows	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Material**	**Transport of Bottled PET**	**Transport of Landfill**	**EU-28: Plastic waste on landfill ts**		
	Emissions to air	3159705887.0	2534300990.5	548956677.8	57408033.9	3.5997	19040181.2		
	Inorganic emissions to air	2971950558.3	2386039896.3	513899140.5	55500952.0	3.4810	16510566.1		

Turkey's Future Landfill	Carbon dioxide	2852149950.3	2281713167.1	502078739.3	52730263.9	3.3072	15627776.7		
	Carbon dioxide (biotic)	119768007.8	104326477.0	11788053.2	2770688.1	0.1738	882789.3		
	Sulphur hexafluoride	32600.2	252.1	32348.1	0.0	0.0000	0.0		
	Organic emissions to air (group VOC)	187755328.7	148261094.2	35057537.3	1907082.0	0.1188	2529615.1		
	Group NMVOC to air	86237.7	62943.2	23169.2	21.6	0.0000	103.7		
	Methane	187576385.1	148198151.1	35023207.7	1838322.7	0.1145	2516703.5		
	Methane (biotic)	92705.9	0.0	11160.4	68737.7	0.0043	12807.9		
			PET Bottle Production'						
	Flows	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Material**	**Transport of Bottled PET**	**Transport of Landfill**	**EU-28: Plastic waste on landfill ts**	**Transport of Plastic Wastes**	**PET Recycling Turkey Future**
Turkey's Future Recycling	Emissions to air	2882681492.6	2534300990.5	247030505.0	57408033.9	1.4512	7675992.7	1203166.9	35062802.1
	Inorganic emissions to air	2713408806.4	2386039896.3	231254613.2	55500952.0	1.4033	6656185.9	1163467.1	32793690.5
	Carbon dioxide	2599477421.5	2281713167.1	225935432.7	52730263.9	1.3333	6300292.0	1105384.1	31692880.4
	Carbon dioxide (biotic)	113916574.5	104326477.0	5304623.9	2770688.1	0.0701	355893.9	58083.0	1100808.5
	Sulphur hexafluoride	14810.4	252.1	14556.6	0.0	0.0000	0.0	0.0	1.7
	Organic emissions to air (group VOC)	169272686.2	148261094.2	15775891.8	1907082.0	0.0479	1019806.8	39699.8	2269111.6
	Group NMVOC to air	73909.1	62943.2	10426.1	21.6	0.0000	41.8	0.4	475.9
	Methane	169111235.3	148198151.1	15760443.5	1838322.7	0.0462	1014601.6	38274.3	2261442.2
	Methane (biotic)	87541.8	0.0	5022.2	68737.7	0.0017	5163.5	1425.0	7193.5
			PET Bottle Production'						

	Flows	Total	Electricity grid mix, Turkey, Future	Raw Material	Transport of Bottled PET	Transport of Plastic Wastes	PET Recycling Turkey Future	Transport of Plastic Wastes for Incineration	EU-27: Waste incineration of plastics
Turkey's Future Incineration Recycling	Emissions to air	3065368488.6	2534300990.5	247030505.0	57408033.9	1203166.9	35062802.1	812684.5	245277515.8
	Inorganic emissions to air	2900119223.6	2386039896.3	231254613.2	55500952.0	1163467.1	32793690.5	785869.1	245084801.1
	Carbon dioxide	2787241066.4	2281713167.1	225935432.7	52730263.9	1105384.1	31692880.4	746636.7	245084800.3
	Carbon dioxide (biotic)	112863348.9	104326477.0	5304623.9	2770688.1	58083.0	1100808.5	39232.4	0.0
	Sulphur hexafluoride	14808.3	252.1	14556.6	0.0	0.0	1.7	0.0	0.8
	Organic emissions to air (group VOC)	165249265.0	148261094.2	15775891.8	1907082.0	39699.8	2269111.6	26815.4	192714.8
	Group NMVOC to air	75835.1	62943.2	10426.1	21.6	0.4	475.9	0.3	2263.9
	Methane	165118227.2	148198151.1	15760443.5	1838322.7	38274.3	2261442.2	25852.5	190450.8
	Methane (biotic)	55202.8	0.0	5022.2	68737.7	1425.0	7193.5	962.5	0.0
			PET Bottle Production'						
	Flows	**Total**	**Electricity grid mix, Turkey Future**	**Raw Material**	**Transport of Bottled PET**	**Transport of Landfill**	**EU-28: Plastic waste on landfill**	**Transport of Plastic Wastes**	**PET Recycling**
EU	Emissions to air	13046036.1	12570410.1	362211.7	14449.9	0.0004	7806.3	300.5	90857.6
	Inorganic emissions to air	13046036.1	12570410.1	362211.7	14449.9	0.0004	7806.3	300.5	90857.6
	Ammonia	7624.6	5660.5	12.5	1701.7	0.0000	49.3	36.2	164.4
	Nitrogen oxides	1777588.2	1658483.8	96904.3	3158.3	0.0001	2776.0	65.5	16200.3
	Sulphur dioxide	11260823.4	10906265.8	265294.9	9589.9	0.0002	4981.0	198.9	74492.9
	Emissions to fresh water	0.8413	0.8343	0.0000	0.0002	0.0000	0.0006	0.0000	0.0062
	Inorganic emissions to fresh water	0.8413	0.8343	0.0000	0.0002	0.0000	0.0006	0.0000	0.0062
	Sulphuric acid	0.8413	0.8343	0.0000	0.0002	0.0000	0.0006	0.0000	0.0062

Table B.3. Pet bottle production emissions by each scenario for EP - kg Phosphate-Equiv.

Eutrophication Potential (EP) - kg Phosphate-Equiv.									
			PET Bottle Production'						
Scenarios	**Flows**	**Total**	**Electricity grid mix, Turkey'**	**Raw Material**	**Transport of Bottled PET**	**Transport of Landfill**	**EU-28: Plastic waste on landfill**		
2017 Turkey's Landfill	Emissions to air	7406937.7	7227224.9	171343.5	2914.2	0.0002	5455.1		
	Inorganic emissions to air	7406937.7	7227224.9	171343.5	2914.2	0.0002	5455.1		
	Ammonium	2.1	2.1	0.0	0.0	0.0000	0.0		
	Nitrogen oxides	7325529.0	7150585.7	167147.1	2451.5	0.0002	5344.7		
	Nitrous oxide (laughing gas)	81401.6	76637.1	4191.5	462.7	0.0000	110.4		
	Phosphorus	4.9	0.0	4.9	0.0	0.0000	0.0		
	Emissions to fresh water	50240.7	568.6	48712.4	911.5	0.0001	48.1		
	Inorganic emissions to fresh water	50240.7	568.6	48712.4	911.5	0.0001	48.1		
	Phosphate	50240.7	568.6	48712.4	911.5	0.0001	48.1		
2018 Turkey's Landfill	Emissions to air	1703415.5	1523480.0	171555.8	2917.8	0.0002	5461.9		
	Inorganic emissions to air	1703415.5	1523480.0	171555.8	2917.8	0.0002	5461.9		
	Ammonium	1.8	1.8	0.0	0.0	0.0000	0.0		
	Nitrogen oxides	1687901.6	1512741.5	167354.3	2454.5	0.0002	5351.3		
	Nitrous oxide (laughing gas)	15507.2	10736.8	4196.7	463.3	0.0000	110.5		
	Phosphorus	4.9	0.0	4.9	0.0	0.0000	0.0		
	Emissions to fresh water	49856.9	123.3	48772.8	912.7	0.0001	48.2		

	Inorganic emissions to fresh water	49856.9	123.3	48772.8	912.7	0.0001	48.2		
	Phosphate	49856.9	123.3	48772.8	912.7	0.0001	48.2		
			PET Bottle Production'						
	Flows	**Total**	**Electricity grid mix, Turkey'**	**Raw Material**	**Transport of Bottled PET**	**Transport of Landfill**	**EU-28: Plastic waste on landfill**	**Transport of Plastic Wastes**	**PET Recycling'17 GB**
2017 Turkey's Recycling	Emissions to air	7372178.2	7234874.4	82253.6	4025.5	0.0001	2411.6	80.0	48533.1
	Inorganic emissions to air	7372178.2	7234874.4	82253.6	4025.5	0.0001	2411.6	80.0	48533.1
	Ammonia	8954.5	7651.6	8.7	1111.3	0.0000	34.8	22.3	125.8
	Nitrogen oxides	7283532.3	7150585.7	80230.6	2451.5	0.0001	2328.7	48.1	47887.8
	Nitrous oxide (laughing gas)	79688.9	76637.1	2011.9	462.7	0.0000	48.1	9.6	519.6
	Phosphorus	2.4	0.0	2.4	0.0	0.0000	0.0	0.0	0.0
	Emissions to fresh water	36124.8	229.5	2938.8	37.8	0.0000	4577.8	0.7	28340.1
	Inorganic emissions to fresh water	34141.0	568.6	23381.9	911.5	0.0000	21.0	17.9	9240.0
	Phosphate	34141.0	568.6	23381.9	911.5	0.0000	21.0	17.9	9240.0
2018 Turkey's Recycling	Emissions to air	1623058.6	1523480.0	80631.2	2917.8	0.0001	2320.5	58.8	13650.3
	Inorganic emissions to air	1623058.6	1523480.0	80631.2	2917.8	0.0001	2320.5	58.8	13650.3
	Ammonium	1.8	1.8	0.0	0.0	0.0000	0.0	0.0	0.0
	Nitrogen oxides	1609708.1	1512741.5	78656.5	2454.5	0.0001	2273.5	49.0	13533.1
	Nitrous oxide (laughing gas)	13346.4	10736.8	1972.4	463.3	0.0000	47.0	9.8	117.2
	Phosphorus	2.3	0.0	2.3	0.0	0.0000	0.0	0.0	0.0
	Emissions to fresh water	33424.5	123.3	22923.2	912.7	0.0000	20.5	18.2	9426.6

	Inorganic emissions to fresh water	33424.5	123.3	22923.2	912.7	0.0000	20.5	18.2	9426.6
	Phosphate	33424.5	123.3	22923.2	912.7	0.0000	20.5	18.2	9426.6
Scenarios			**PET Bottle Production'**						
	Flows	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Material**	**Transport of Bottled PET**	**Transport of Landfill**	**EU-28: Plastic waste on landfill ts**		
Turkey's Future Landfill	Emissions to air	1227733.8	1078412.9	142366.9	2421.3	0.0002	4532.6		
	Inorganic emissions to air	1227733.8	1078412.9	142366.9	2421.3	0.0002	4532.6		
	Ammonium	2.3	2.3	0.0	0.0	0.0000	0.0		
	Nitrogen oxides	1214957.3	1069599.3	138880.2	2036.9	0.0001	4440.8		
	Nitrous oxide (laughing gas)	12770.1	8811.3	3482.6	384.5	0.0000	91.7		
	Phosphorus	4.1	0.0	4.1	0.0	0.0000	0.0		
	Emissions to fresh water	41860.6	588.7	40474.5	757.4	0.0000	40.0		
	Inorganic emissions to fresh water	41860.6	588.7	40474.5	757.4	0.0000	40.0		
	Phosphate	41860.6	588.7	40474.5	757.4	0.0000	40.0		
			PET Bottle Production'						
	Flows	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Material**	**Transport of Bottled PET**	**Transport of Landfill**	**EU-28: Plastic waste on landfill ts**	**Transport of Plastic Wastes**	**PET Recycling Turkey future**
Turkey's Future Recycling	Emissions to air	10912.8	8813.6	1569.0	384.5	0.0000	37.0	8.4	100.3
	Inorganic emissions to air	10912.8	8813.6	1569.0	384.5	0.0000	37.0	8.4	100.3
	Ammonium	2.3	2.3	0.0	0.0	0.0000	0.0	0.0	0.0
	Nitrogen oxides	1146412.8	1069599.3	62496.1	2036.9	0.0001	1790.3	42.2	10448.0
	Nitrous oxide (laughing gas)	10908.7	8811.3	1567.2	384.5	0.0000	37.0	8.4	100.3
	Phosphorus	1.8	0.0	1.8	0.0	0.0000	0.0	0.0	0.0

	Emissions to fresh water	27712.5	588.7	18213.5	757.4	0.0000	16.1	15.7	8121.1
	Inorganic emissions to fresh water	27712.5	588.7	18213.5	757.4	0.0000	16.1	15.7	8121.1
	Phosphate	27712.5	588.7	18213.5	757.4	0.0000	16.1	15.7	8121.1
			PET Bottle Production'						
	Flows	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Material**	**Transport of Bottled PET**	**Transport of Plastic Wastes**	**PET Recycling Turkey Future**	**Transport of Plastic Wastes for Incineration**	**EU-27: Waste incineration of plastics**
Turkey's Future Incineration Recycling	Emissions to air	1137458.9	1078412.9	64065.1	2421.3	2421.3489	10548.3	50.7	2159.1
	Inorganic emissions to air	1137458.9	1078412.9	64065.1	2421.3	2421.3489	10548.3	50.7	2159.1
	Ammonium	2.3	2.3	0.0	0.0	0.0005	0.0	0.0	0.0
	Nitrogen oxides	1126721.4	1069599.3	62496.1	2036.9	2036.8978	10448.0	42.2	2131.9
	Nitrous oxide (laughing gas)	10733.4	8811.3	1567.2	384.5	384.4506	100.3	8.4	27.2
	Phosphorus	1.8	0.0	1.8	0.0	0.0000	0.0	0.0	0.0
	Emissions to fresh water	27660.0	588.7	18213.5	757.4	757.3850	8121.1	15.7	0.6
	Inorganic emissions to fresh water	27660.0	588.7	18213.5	757.4	757.3850	8121.1	15.7	0.6
	Phosphate	27660.0	588.7	18213.5	757.4	757.3850	8121.1	15.7	0.6
			PET Bottle Production'						
	Flows	**Total**	**Electricity grid mix, Turkey Future**	**Raw Material**	**Transport of Bottled PET**	**Transport of Landfill**	**EU-28: Plastic waste on landfill**	**Transport of Plastic Wastes**	**PET Recycling**
	Emissions to air	466572.4	434759.0	25827.7	976.2	0.0000	736.7	20.4	4252.5
	Inorganic emissions to air	466572.4	434759.0	25827.7	976.2	0.0000	736.7	20.4	4252.5
	Ammonium	0.9	0.9	0.0	0.0	0.0000	0.0	0.0	0.0
	Nitrogen oxides	462172.9	431205.8	25195.1	821.2	0.0000	721.8	17.0	4212.1
	Nitrous oxide (laughing gas)	4397.8	3552.3	631.8	155.0	0.0000	14.9	3.4	40.4

EU	Phosphorus	0.7	0.0	0.7	0.0	0.0000	0.0	0.0	0.0
	Emissions to fresh water	11172.2	237.3	7342.7	305.3	0.0000	6.5	6.3	3274.0
	Inorganic emissions to fresh water	11172.2	237.3	7342.7	305.3	0.0000	6.5	6.3	3274.0
	Phosphate	11172.2	237.3	7342.7	305.3	0.0000	6.5	6.3	3274.0

Table B.4. Pet bottle production emissions by each scenario for ODP - kg R11-Equiv.

Ozone Layer Depletion Potential (ODP) - kg R11-Equiv.									
Scenarios			**PET Bottle Production'**						
	Flows	**Total**	**Electricity grid mix, Turkey'**	**Raw Material**	**Transport of Bottled PET**	**Transport of Landfill**	**EU-28: Plastic waste on landfill**		
2017 Turkey's Landfill	Emissions to air	3219.510149	0.013773958	3219.496308	2.04E-05	1.27E-12	4.67E-05		
	Organic emissions to air (group VOC)	3219.510149	0.013773958	3219.496308	2.04E-05	1.27E-12	4.67E-05		
	Group NMVOC to air	3219.510149	0.013773958	3219.496308	2.04E-05	1.27E-12	4.67E-05		
	Halogenated organic emissions to air	3219.510149	0.013773958	3219.496308	2.04E-05	1.27E-12	4.67E-05		
	Carbon tetrachloride (tetrachloromethane)	0.591765911	0	0.591765911	0	0	0		
	Halon (1211)	1.443778295	0	1.443778295	0	0	0		
	Halon (1301)	2.030649687	2.33E-09	2.030649684	7.95E-11	4.93E-18	7.45E-10		
	Methyl bromide	3215.310128	4.28E-09	3215.310128	1.46E-10	9.06E-18	1.37E-09		
	R 114 (dichlorotetrafluoroethane)	0.133826446	0.013773952	0.119985366	2.04E-05	1.27E-12	4.67E-05		
	Emissions to air	3223.49781	0.01135078	3223.486392	2.05E-05	1.27E-12	4.68E-05		
	Organic emissions to air (group VOC)	3223.49781	0.01135078	3223.486392	2.05E-05	1.27E-12	4.68E-05		
	Group NMVOC to air	3223.49781	0.01135078	3223.486392	2.05E-05	1.27E-12	4.68E-05		

2018 Turkey's Landfill	Halogenated organic emissions to air	3223.49781	0.01135078	3223.486392	2.05E-05	1.27E-12	4.68E-05		
	Carbon tetrachloride (tetrachloromethane)	0.592499317	0	0.592499317	0	0	0		
	Halon (1211)	1.445567642	0	1.445567642	0	0	0		
	Halon (1301)	2.033166378	6.52E-09	2.033166371	7.96E-11	4.94E-18	7.46E-10		
	Methyl bromide	3219.295025	1.20E-08	3219.295025	1.46E-10	9.07E-18	1.37E-09		
	R 114 (dichlorotetrafluoroethane)	0.131552043	0.011350761	0.12013407	2.05E-05	1.27E-12	4.68E-05		
			PET Bottle Production'						
	Flows	**Total**	**Electricity grid mix, Turkey'**	**Raw Material**	**Transport of Bottled PET**	**Transport of Landfill**	**EU-28: Plastic waste on landfill**	**Transport of Plastic Wastes**	**PET Recycling'17 GB**
2017 Turkey's Recycling	Emissions to air	1545.372149	0.013773958	1545.358228	2.04E-05	5.52E-13	2.03E-05	4.00E-07	0.000106605
	Organic emissions to air (group VOC)	1545.372149	0.013773958	1545.358228	2.04E-05	5.52E-13	2.03E-05	4.00E-07	0.000106605
	Group NMVOC to air	1545.372149	0.013773958	1545.358228	2.04E-05	5.52E-13	2.03E-05	4.00E-07	0.000106605
	Halogenated organic emissions to air	1545.372149	0.013773958	1545.358228	2.04E-05	5.52E-13	2.03E-05	4.00E-07	0.000106605
	Carbon tetrachloride (tetrachloromethane)	0.284047637	0	0.284047637	0	0	0	0	0
	Halon (1211)	0.693013581	0	0.693013581	0	0	0	0	0
	Halon (1301)	0.974711851	2.33E-09	0.974711848	7.95E-11	2.15E-18	3.25E-10	1.56E-12	3.72E-10
	Methyl bromide	1543.348862	4.28E-09	1543.348862	1.46E-10	3.95E-18	5.96E-10	2.86E-12	6.83E-10
	R 114 (dichlorotetrafluoroethane)	0.071514709	0.013773952	0.057592976	2.04E-05	5.52E-13	2.03E-05	4.00E-07	0.000106604
2018 Turkey's Recycling	Emissions to air	1515.050089	0.01135078	1515.038604	2.05E-05	5.39E-13	1.99E-05	4.09E-07	9.35E-05
	Organic emissions to air (group VOC)	1515.050089	0.01135078	1515.038604	2.05E-05	5.39E-13	1.99E-05	4.09E-07	9.35E-05
	Group NMVOC to air	1515.050089	0.01135078	1515.038604	2.05E-05	5.39E-13	1.99E-05	4.09E-07	9.35E-05
	Halogenated organic emissions to air	1515.050089	0.01135078	1515.038604	2.05E-05	5.39E-13	1.99E-05	4.09E-07	9.35E-05
	Carbon tetrachloride (tetrachloromethane)	0.278474679	0	0.278474679	0	0	0	0	0
	Halon (1211)	0.679416792	0	0.679416792	0	0	0	0	0

	Halon (1301)	0.955588202	6.52E-09	0.955588194	7.96E-11	2.10E-18	3.17E-10	1.59E-12	4.06E-10
	Methyl bromide	1513.068662	1.20E-08	1513.068662	1.46E-10	3.85E-18	5.82E-10	2.92E-12	7.45E-10
	R 114 (dichlorotetrafluoroethane)	0.067948021	0.011350761	0.056463013	2.05E-05	5.39E-13	1.99E-05	4.09E-07	9.35E-05
			PET Bottle Production'						
	Flows	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Material**	**Transport of Bottled PET**	**Transport of Landfill**	**EU-28: Plastic waste on landfill ts**		
Turkey's Future Landfill	Emissions to air	2675.04037	0.005116307	2675.035198	1.70E-05	1.05E-12	3.88E-05		
	Organic emissions to air (group VOC)	2675.04037	0.005116307	2675.035198	1.70E-05	1.05E-12	3.88E-05		
	Group NMVOC to air	2675.04037	0.005116307	2675.035198	1.70E-05	1.05E-12	3.88E-05		
	Halogenated organic emissions to air	2675.04037	0.005116307	2675.035198	1.70E-05	1.05E-12	3.88E-05		
	Carbon tetrachloride (tetrachloromethane)	0.491690156	0	0.491690156	0	0	0		
	Halon (1211)	1.199615526	0	1.199615526	0	0	0		
	Halon (1301)	1.687239215	3.24E-07	1.687238891	6.61E-11	4.10E-18	6.19E-10		
	Methyl bromide	2671.556959	5.95E-07	2671.556959	1.21E-10	7.53E-18	1.14E-09		
	R 114 (dichlorotetrafluoroethane)	0.104865354	0.005115388	0.09969419	1.70E-05	1.05E-12	3.88E-05		
			PET Bottle Production'						
	Flows	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Material**	**Transport of Bottled PET**	**Transport of Landfill**	**EU-28: Plastic waste on landfill ts**	**Transport of Plastic Wastes**	**PET Recycling Turkey future**
Turkey Recycling Future	Emissions to air	1203.771041	0.005116307	1203.765839	1.70E-05	4.25E-13	1.56E-05	3.52E-07	5.26E-05
	Organic emissions to air (group VOC)	1203.771041	0.005116307	1203.765839	1.70E-05	4.25E-13	1.56E-05	3.52E-07	5.26E-05
	Group NMVOC to air	1203.771041	0.005116307	1203.765839	1.70E-05	4.25E-13	1.56E-05	3.52E-07	5.26E-05
	Halogenated organic emissions to air	1203.771041	0.005116307	1203.765839	1.70E-05	4.25E-13	1.56E-05	3.52E-07	5.26E-05
	Carbon tetrachloride (tetrachloromethane)	0.22126057	0	0.22126057	0	0	0	0	0
	Halon (1211)	0.539826987	0	0.539826987	0	0	0	0	0

	Halon (1301)	0.759257828	3.24E-07	0.759257501	6.61E-11	1.65E-18	2.49E-10	1.37E-12	2.42E-09
	Methyl bromide	1202.200632	5.95E-07	1202.200631	1.21E-10	3.03E-18	4.58E-10	2.52E-12	4.44E-09
	R 114 (dichlorotetrafluoroethane)	0.050063327	0.005115388	0.044862385	1.70E-05	4.25E-13	1.56E-05	3.52E-07	5.26E-05
			PET Bottle Production'						
	Flows	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Material**	**Transport of Bottled PET**	**Transport of Plastic Wastes**	**PET Recycling Turkey Future**	**Transport of Plastic Wastes for Incineration**	**EU-27: Waste incineration of plastics**
Turkey Future Incineration Recycling	Emissions to air	1203.892574	0.005116307	1203.765839	1.70E-05	3.52E-07	5.26E-05	2.38E-07	0.121587962
	Organic emissions to air (group VOC)	1203.892574	0.005116307	1203.765839	1.70E-05	3.52E-07	5.26E-05	2.38E-07	0.121587962
	Group NMVOC to air	1203.892574	0.005116307	1203.765839	1.70E-05	3.52E-07	5.26E-05	2.38E-07	0.121587962
	Halogenated organic emissions to air	1203.892574	0.005116307	1203.765839	1.70E-05	3.52E-07	5.26E-05	2.38E-07	0.121587962
	Carbon tetrachloride (tetrachloromethane)	0.22126057	0	0.22126057	0	0	0	0	0
	Halon (1211)	0.539826987	0	0.539826987	0	0	0	0	0
	Halon (1301)	0.759494613	3.24E-07	0.759257501	6.61E-11	1.37E-12	2.42E-09	9.25E-13	0.000236785
	Methyl bromide	1202.200632	5.95E-07	1202.200631	1.21E-10	2.52E-12	4.44E-09	1.70E-12	0
	R 114 (dichlorotetrafluoroethane)	0.17135962	0.005115388	0.044862385	1.70E-05	3.52E-07	5.26E-05	2.38E-07	0.121351176
			PET Bottle Production'						
	Flows	**Total**	**Electricity grid mix, Turkey Future**	**Raw Material**	**Transport of Bottled PET**	**Transport of Landfill**	**EU-28: Plastic waste on landfill**	**Transport of Plastic Wastes**	**PET Recycling**
EU	Emissions to air	485.2967356	0.002062624	485.2946385	6.84E-06	1.71E-13	6.31E-06	1.42E-07	2.12E-05
	Organic emissions to air (group VOC)	485.2967356	0.002062624	485.2946385	6.84E-06	1.71E-13	6.31E-06	1.42E-07	2.12E-05
	Group NMVOC to air	485.2967356	0.002062624	485.2946385	6.84E-06	1.71E-13	6.31E-06	1.42E-07	2.12E-05
	Halogenated organic emissions to air	485.2967356	0.002062624	485.2946385	6.84E-06	1.71E-13	6.31E-06	1.42E-07	2.12E-05
	Carbon tetrachloride (tetrachloromethane)	0.089200545	0	0.089200545	0	0	0	0	0
	Halon (1211)	0.217629653	0	0.217629653	0	0	0	0	0

	Halon (1301)	0.306092548	1.31E-07	0.306092416	2.66E-11	6.66E-19	1.01E-10	5.52E-13	9.75E-10
	Methyl bromide	484.6636299	2.40E-07	484.6636297	4.89E-11	1.22E-18	1.85E-10	1.01E-12	1.79E-09
	R 114 (dichlorotetrafluoroethane)	0.020182882	0.002062253	0.018086138	6.84E-06	1.71E-13	6.31E-06	1.42E-07	2.12E-05

Table B.5. Pet bottle production emissions by each scenario for POCP - kg Ethene-Equiv.

Photochemical Ozone Creation Potential (POCP) - kg Ethene-Equiv.									
			PET Bottle Production'						
Scenarios	**Flows**	**Total**	**Electricity grid mix, Turkey'**	**Raw Material**	**Transport of Bottled PET**	**Transport of Landfill**	**EU-28: Plastic waste on landfill**		
2017 Turkey's Landfill	Emissions to air	26673889.8	26301395.2	357265.5	8207.6	0.0007	7021.5		
	Inorganic emissions to air	25454677.2	25306984.5	140769.4	3371.9	0.0003	3551.4		
	Carbon monoxide	181217.3	144225.1	34368.7	1698.7	0.0002	924.9		
	Nitrogen oxides	1577806.2	1540126.2	36000.9	528.0	0.0000	1151.2		
	Sulphur dioxide	23695653.6	23622633.2	70399.8	1145.2	0.0001	1475.4		
	Organic emissions to air (group VOC)	1219212.6	994410.7	216496.1	4835.7	0.0004	3470.1		
	Group NMVOC to air	1082425.8	867779.5	207463.6	4361.6	0.0004	2821.0		
	Methane	136786.8	126631.2	9032.5	474.1	0.0000	649.1		
2018 Turkey's Landfill	Emissions to air	2536350.9	2163394.7	357708.3	8217.8	0.0007	7030.2		
	Inorganic emissions to air	2066076.9	1918201.1	140943.8	3376.1	0.0003	3555.8		
	Carbon monoxide	68214.3	31176.2	34411.3	1700.8	0.0002	926.0		
	Nitrogen oxides	363548.0	325821.2	36045.5	528.7	0.0000	1152.6		
	Sulphur dioxide	1634314.5	1561203.7	70487.0	1146.6	0.0001	1477.2		
	Organic emissions to air (group VOC)	470274.1	245193.6	216764.4	4841.7	0.0004	3474.4		

	Group NMVOC to air	414188.6	199276.3	207720.8	4367.0	0.0004	2824.5		
	Methane	56085.5	45917.2	9043.7	474.7	0.0000	649.9		
			PET Bottle Production'						
	Flows	**Total**	**Electricity grid mix, Turkey'**	**Raw Material**	**Transport of Bottled PET**	**Transport of Landfill**	**EU-28: Plastic waste on landfill**	**Transport of Plastic Wastes**	**PET Recycling'17 GB**
2017 Turkey's Recycling	Emissions to air	26649274.2	26301395.2	171487.4	8207.6	0.0003	3059.3	217.0	164907.6
	Inorganic emissions to air	25536508.1	25306984.5	67569.3	3371.9	0.0001	1547.4	80.6	156954.4
	Carbon monoxide	164060.3	144225.1	16497.0	1698.7	0.0001	403.0	47.8	1188.8
	Nitrogen oxides	1568760.8	1540126.2	17280.4	528.0	0.0000	501.6	10.3	10314.3
	Sulphur dioxide	23803687.0	23622633.2	33791.9	1145.2	0.0000	642.8	22.5	145451.4
	Organic emissions to air (group VOC)	1112766.1	994410.7	103918.1	4835.7	0.0002	1511.9	136.4	7953.2
	Group NMVOC to air	979938.8	867779.5	99582.5	4361.6	0.0002	1229.1	127.1	6859.0
	Methane	132827.2	126631.2	4335.6	474.1	0.0000	282.8	9.3	1094.2
2018 Turkey's Recycling	Emissions to air	2359975.3	2163394.7	168122.9	8217.8	0.0003	2986.8	221.5	17031.7
	Inorganic emissions to air	2003025.5	1918201.1	66243.6	3376.1	0.0001	1510.7	82.3	13611.7
	Carbon monoxide	49997.1	31176.2	16173.3	1700.8	0.0001	393.4	48.8	504.6
	Nitrogen oxides	346706.4	325821.2	16941.4	528.7	0.0000	489.7	10.6	2914.8
	Sulphur dioxide	1606322.0	1561203.7	33128.9	1146.6	0.0000	627.6	22.9	10192.3
	Organic emissions to air (group VOC)	356949.8	245193.6	101879.3	4841.7	0.0002	1476.1	139.2	3420.0
	Group NMVOC to air	305411.2	199276.3	97628.8	4367.0	0.0002	1200.0	129.7	2809.4
	Methane	51538.7	45917.2	4250.5	474.7	0.0000	276.1	9.5	610.6
			PET Bottle Production'						
	Flows	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Material**	**Transport of Bottled PET**	**Transport of Landfill**	**EU-28: Plastic waste on landfill ts**		
	Emissions to air	1837032.3	1527531.7	296847.0	6819.6	0.0006	5834.1		

Turkey's Future Landfill	Inorganic emissions to air	1471886.8	1349171.0	116963.3	2801.7	0.0002	2950.8		
	Carbon monoxide	67419.2	36682.8	28556.5	1411.5	0.0001	768.5		
	Nitrogen oxides	261683.1	230375.2	29912.7	438.7	0.0000	956.5		
	Sulphur dioxide	1142784.5	1082112.9	58494.2	951.5	0.0001	1225.9		
	Organic emissions to air (group VOC)	365145.5	178360.7	179883.7	4017.9	0.0004	2883.2		
	Group NMVOC to air	324950.5	146603.9	172378.7	3624.0	0.0003	2343.9		
	Methane	40194.9	31756.7	7505.0	393.9	0.0000	539.3		
			PET Bottle Production'						
	Flows	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Material**	**Transport of Bottled PET**	**Transport of Landfill**	**EU-28: Plastic waste on landfill ts**	**Transport of Plastic Wastes**	**PET Recycling Turkey future**
Turkey's Future Recycling	Emissions to air	1683403.4	1527531.7	133581.1	6819.6	0.0002	2352.0	190.7	12928.3
	Inorganic emissions to air	1416012.8	1349171.0	52633.5	2801.7	0.0001	1189.6	70.8	10146.2
	Carbon monoxide	51801.2	36682.8	12850.4	1411.5	0.0001	309.8	42.0	504.7
	Nitrogen oxides	246919.7	230375.2	13460.7	438.7	0.0000	385.6	9.1	2250.3
	Sulphur dioxide	1117291.9	1082112.9	26322.4	951.5	0.0000	494.2	19.7	7391.1
	Organic emissions to air (group VOC)	267390.6	178360.7	80947.6	4017.9	0.0001	1162.4	119.9	2782.1
	Group NMVOC to air	231152.5	146603.9	77570.4	3624.0	0.0001	944.9	111.7	2297.5
	Methane	36238.1	31756.7	3377.2	393.9	0.0000	217.4	8.2	484.6
			PET Bottle Production'						
	Flows	**Total**	**Electricity grid mix, Turkey, Future**	**Raw Material**	**Transport of Bottled PET**	**Transport of Plastic Wastes**	**PET Recycling Turkey Future**	**Transport of Plastic Wastes for Incineration**	**EU-27: Waste incineration of plastics**
	Emissions to air	1651652.0	1527531.7	133581.1	6819.6	190.7229	12928.3	128.8	1761.3
	Inorganic emissions to air	1388459.3	1349171.0	52633.5	2801.7	70.8497	10146.2	47.9	1377.7

Turkey's Future Incineration Recycling	Carbon monoxide	51597.8	36682.8	12850.4	1411.5	42.0246	504.7	28.4	626.7
	Nitrogen oxides	242678.4	230375.2	13460.7	438.7	9.0952	2250.3	6.1	459.2
	Sulphur dioxide	1094183.0	1082112.9	26322.4	951.5	19.7298	7391.1	13.3	291.8
	Organic emissions to air (group VOC)	263192.7	178360.7	80947.6	4017.9	119.8732	2782.1	81.0	383.6
	Group NMVOC to air	227810.2	146603.9	77570.4	3624.0	111.6716	2297.5	75.4	342.8
	Methane	35382.5	31756.7	3377.2	393.9	8.2016	484.6	5.5	40.8
			PET Bottle Production'						
	Flows	**Total**	**Electricity grid mix, Turkey Future**	**Raw Material**	**Transport of Bottled PET**	**Transport of Landfill**	**EU-28: Plastic waste on landfill**	**Transport of Plastic Wastes**	**PET Recycling**
EU	Emissions to air	678659.1	615819.9	53852.8	2749.3	0.0001	948.2	76.9	5212.0
	Inorganic emissions to air	570861.4	543914.3	21219.0	1129.5	0.0000	479.6	28.6	4090.4
	Carbon monoxide	20883.5	14788.6	5180.6	569.0	0.0000	124.9	16.9	203.5
	Nitrogen oxides	99544.9	92875.1	5426.6	176.9	0.0000	155.5	3.7	907.2
	Sulphur dioxide	450432.9	436250.6	10611.8	383.6	0.0000	199.2	8.0	2979.7
	Organic emissions to air (group VOC)	107797.7	71905.6	32633.8	1619.8	0.0001	468.6	48.3	1121.6
	Group NMVOC to air	93188.4	59102.9	31272.3	1461.0	0.0001	381.0	45.0	926.2
	Methane	14609.3	12802.6	1361.5	158.8	0.0000	87.7	3.3	195.4