# Overview of the Waste Management Situation and Planning in Greece

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Waste management has been recognized as one of the most pressing problems in Greece suffering of a low level of organization and relying predominantly on semi-controlled landfills until the end of the previous century [9]. Nevertheless improvements have been made during the last twenty years making the solid waste management in Greece a well-structured, organized and environmentally responsible activity with specific goals, mostly in the urban areas [4]. However, there is a big need of changing the waste management model. The development of efficient use of resources is the mean of realizing this vision. The transformation of the economy towards a resource-efficient direction will lead to increased competitiveness and new sources of growth and jobs through cost reduction through improved efficiency, commercialization of innovations and better management of resources throughout the duration of cycle life. This will require policies that take into account the interdependence between the economy, well-being and natural capital and seeks to remove barriers to improved resource efficiency, while providing a fair, flexible, predictable and coherent basis business [3].

## 1. Waste management in Greece

Greece is a European country situated in the southeastern part of it, with estimated population 10.955.000 inhabitants in 2016. Administratively, Greece consists of 13 peripheries, with total land area of 131,957 km$^2$. The MSW generation in Greece

in 2001 was 4,529,585 tons, and it developed to 5,006,435 tons in 2011. A change from 416 to 457 kg per capita. During the financial crisis, a twenty percent decrease in MSW generation is estimated. Focusing on the Attica region, where Athens, the capital of Greece, is placed, the MSW generation reaches the quantity of 6,000 tons daily, which equals to 2.0 million tons of MSW per annum.

In general, the waste management in Greece depends mainly on sanitary landfill sites. According to the European Union, uncontrolled disposal sites (dumps) are illegal and have to shut down. In Greece most of illegal dumping sites have shut down and a few of them are in restoration process – they are estimated around fifty around Greece. Earlier data (2011) suggested that 109 illegal dumpsites were in operation despite the ruling of European Court of Justice of 2005 (case c-502/03) which dictated that by the end of 2008 all illegal dumping sites should have been closed and rehabilitated. The deadline was extended for Greece, until the 1st January of 2011.

The only exceptions are the five Mechanical and Biological Treatment (MBT) plants located in Athens, Kalamata – not in operation in 2016, – Chania, Heraklio and Kefalonia. On the other hand the products of these plants, such as RDF and compost, have no responding market and as a result in the most cases they are just disposed to landfill. 29 Mechanical Recycling Facilities are also operating, covering around 87 percent of Greek territory.

All the above have driven Greece almost to the bottom of the European's sustainable waste management gradation. These facts are loudly verified by Eurostat, whose statistics for the year of 2014 for Greece, give 81 percent landfill, 19 percent recycling and composting. In the following diagram the statistics by Eurostat for the waste management across Europe on 2014 are presented.

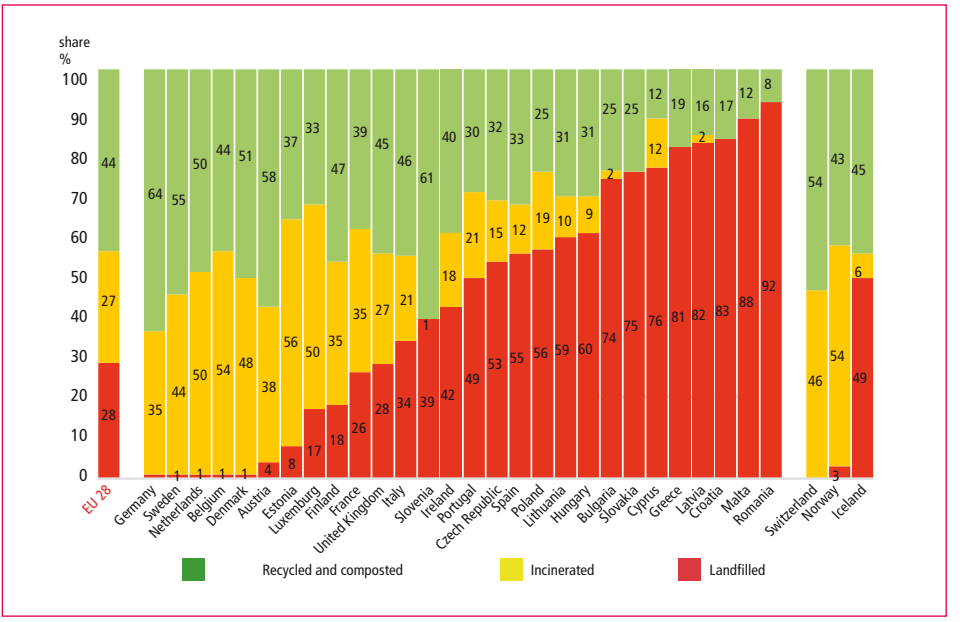


Figure 1: Municipal waste management across Europe for 2014

Source: Eurostat, 2016

The composition of Municipal Solid Waste (MSW) in Greece across the thirteen peripheries of the country is presented in the following chart.

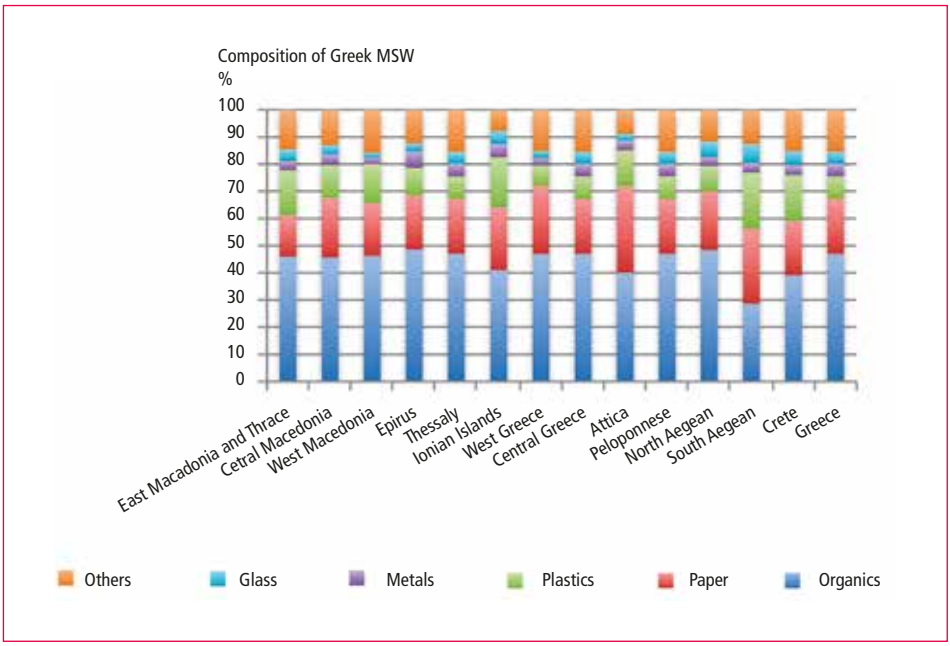


Figure 2: Composition of Greek Municipal Solid Waste

The legal framework that designates the direction of waste management in Greece follows closely the development of European waste management and the corresponding directives.

In the following chapters, methods and results of MSW management in Greece are analyzed.

## 1.1. Recycling and special waste streams

### 1.1.1. Packaging waste

In today's society, one of the most important material flow is the packaging. The packaging materials have a relatively high environmental impact. About forty percent of municipal solid waste in Europe can be attributed to packaging waste. As income levels increase and lifestyle changes, the packaging waste is expected to increase in developing countries.

As consumption patterns change over time and with economic developments, packaging waste composition also differ. In recent decades, plastics have a growing share in the packaging market because of their versatility. Plastics are relatively easy to take shape, and may be more or less adapted to the various functions of the packaging.

In industrialized countries, the plastics are a growing part of packaging waste, despite their low weight. Moreover, national traditions around the product packaging, can influence the composition of packaging and therefore packaging waste [12].

In the largest part of the country, the collection and transportation of municipal packaging waste is made by municipalities with the *bucket blue* system, which is the most widespread, according to which citizens can deposit all waste packaging in blue bucket without further screening. Then, the packaging waste is shipped with purpose such vehicles Recycling Sorting (MRFs), where it is sorted and recovered per material – paper/cardboard, liquid packaging cardboard, plastic packs of different types, glass packaging, aluminum, tin. Then they get promoted to merchants and utilizers for recycling or recovery. On a much smaller scale collection of household packaging waste is possible through Recycling Centers (RCs), where citizens individually reject glass, metal and plastic packaging. Then, the separated thereby waste is collected, they are checked and screened when necessary, then forward again through merchants for recycling or recovery [5].

| Packaging waste generation | | Packaging waste recycling | | Packaging waste recycling rate |
|---|---|---|---|---|
| tn | | tn | | % |
| 2003 | 1,014,000 | 2003 | 336,000 | 33.14 |
| 2004 | 1,038,000 | 2004 | 381,000 | 36.71 |
| 2005 | 1,061,005 | 2005 | 444,000 | 41.85 |
| 2006 | 1,056,000 | 2006 | 451,500 | 42.76 |
| 2007 | 1,050,000 | 2007 | 504,000 | 48.00 |
| 2008 | 1,050,000 | 2008 | 460,163 | 43.83 |
| 2009 | 1,008,000 | 2009 | 527,400 | 52.32 |
| 2010 | 927,400 | 2010 | 545,634 | 58.83 |
| 2011 | 870,420 | 2011 | 540,630 | 62.11 |
| 2012 | 773,370 | 2012 | 453,260 | 58.61 |

Table 1:

Packaging waste generation and recycling in Greece

Source: Eurostat, 2012

It is well noted that despite the decrease in the generation of packaging waste due to the economic crisis, the development of Recycling Sorting Plants (29 today) and the operation of the System of Alternative Management has enabled quantitative constant recycling of packaging waste, which has increased recycling rates and has put Greece over the objectives of Directive 2004/12/EC the last measured years (2010 to 2012)

### 1.1.2. Waste electric and electronic equipment

Recycling of waste electrical and electronic equipment (WEEE) has particular importance both for the recovery of materials and for the management of hazardous substances involved in most devices. The uncontrolled disposal of waste electrical and electronic equipment (WEEE) has negative impacts on the environment and humans, because of their high content of heavy metals and other hazardous substances.

In line with the report of EOAN, the separate collection of four kilograms per inhabitant per year was achieved for the years 2008, 2009, 2010. In the following years, the rapid reduction in disposal of electrical and electronic equipment market due to the economic crisis and the practices diverting part of WEEE outside the organized collection network – transport – treatment significantly affected the amount of collected WEEE [5].

Table 2: Total WEEE recovered, reused and recycled in Greece during 2012

| Category | Recovery | | Reuse – Recycling | |
|---|---|---|---|---|
| | Weight | Rate | Weight | Rate |
| | tn | % | tn | % |
| 1. Large household appliances | 28,559 | 88.07 | 28,559 | 88.07 |
| 2. Small household appliances | 1,766 | 81.66 | 1,766 | 81.66 |
| 3. IT and telecommunications equipment | 7,475 | 94.66 | 7,475 | 94.66 |
| 4. Consumer equipment | 7,033 | 87.06 | 7,033 | 87.06 |
| 5. Lighting equipment (except 5.a) | 180 | 84.98 | 180 | 84.98 |
| 5.a. Lamps | N/a | N/a | 65 | 93.11 |
| 6. Electrical and electronic tools | 59 | 93.72 | 59 | 93.72 |
| 7. Toys, leisure and sports equipment | 168 | 63.13 | 168 | 63.13 |
| 8. Medical devices | 127 | 93.92 | 127 | 93.92 |
| 9. Monitoring and control instruments | 46 | 91.76 | 46 | 91.76 |
| 10. Automatic dispensers | 120 | 90.81 | 120 | 90.81 |
| **Total WEEE** | **45,533** | **88.44** | **45,598** | **88.31** |

Source: EOAN (Hellenic National Recycling Organization): Annual reports. 2014; available in print and also at: http://www.eoan.gr/en/ (accessed June 2016)

### 1.1.3. Batteries and accumulators

In the European Union every year are produced and ultimately dumped approximately 160,000 tons of portable batteries. This amounts to 410 gr per inhabitant and year. Car batteries used each year is estimated at 110,000 tons, with a rate of about 80 to 95 percent recycled (Eurostat, 2014).

The alternative management of waste batteries includes the collection and transport, storage and recycling, in recycling processing plants which have the envisaged by law licensing. Besides the Pb-acid batteries with available treatment/recycling facilities in Greece, the other types are exported to appropriate facilities abroad for processing. Recycling Pb-acid battery plants operating in Greece is estimated to have an installed capacity of about 70,000 tn per year [5].

Regarding portable batteries, the *AFIS* system has managed to achieve and exceed the collection target of 25 percent set by the European Union. More specifically, the collection rates for portable batteries were calculated according to Annex I of Directive 2006/66/EC, for the period 2009-12 and are presented in Table 3.

Table 3: Batteries recycling in Greece

| Year | Rate |
|---|---|
| | % |
| 2009 | 31.6 |
| 2010 | 34.9 |
| 2011 | 32.8 |
| 2012 | 35.7 |

Source: EOAN (Hellenic National Recycling Organization): Annual reports. 2014; available in print and also at: http://www.eoan.gr/en/ (accessed June 2016)

Table 4: Accumulators generation in Greece

| Year | Total generation |
|---|---|
| | tn |
| 2004 | 78,955 |
| 2006 | 43,060 |
| 2008 | 41,908 |
| 2010 | 45,845 |
| 2012 | 48,756 |

Source: Eurostat, 2014

As for the overall production of waste batteries and accumulators in Greece, Table 4 presents the data submitted to Eurostat by the Hellenic Recycling Organization.

## 1.1.4. End-of-life vehicles

The ELV management is regulated by Presidential Decree 116/2004 issued in line with Directive 2000/53/EC. As life cycle end vehicle are considered vehicles (M1) which are intended for transport of persons and with maximum outside the driver's seat to eight seats as well as vehicles (N1) intended for the carriage of goods and having a maximum weight up to 3.5 tons. The geographical coverage of the alternative management system covers all the country, while population coverage is hundred percent of the total population. Until 30/06/2014 the system had 110 processing centers (dismantling ELVs) and 21 collection points [5].

| Waste | Quantity | Rate |
|---|---|---|
| | kg | % |
| Mineral oil | 294,691 | 0.38 |
| Batteries | 923,597 | 1.18 |
| Tires | 2,419,907 | 3.09 |
| Freon liquid | 14,242 | 0.02 |
| Radiator liquid | 188,448 | 0.24 |
| Freon | 2,051 | 0.00 |
| Oil filter | 16,309 | 0.02 |
| Brake pads | 4,517 | 0.01 |
| Catalysts | 160,176 | 0.20 |
| Metals – scrap | 56,314,622 | 71.80 |
| Dismantling spare parts | 15,254,543 | 19.45 |
| Crystals | 300,187 | 0.38 |
| Plastics | 398,698 | 0.51 |
| Other | 2,141,209 | 2.72 |
| Total ELVs depolluted | 78,433,197 | 100.00 |

Table 5:

ELVs depolluted in Greece in 2012

Source: EOAN (Hellenic National Recycling Organization): Annual reports. 2014; available in print and also at: http://www.eoan.gr/en/ (accessed June 2016)

### 1.1.5. Tires

Based on the principle of *extended producer responsibility*, all tire importers and vehicle importers participate in the alternative management system. The year 2012 in Greece, were recorded 34,403 tons of used tires of whom 38.7 percent followed mechanical granulation, 12.1 percent energy recovery (domestic – co-incineration), 30.6 percent was exported abroad shredded and 18.6 percent were exported to energy recovery. Summarizing the above that 38.7 percent was processed to produce final products and 61.3 percent to produce energy in Greece and abroad [5].

### 1.1.6. Waste oil and lubricants

The Waste Oils and Lubricants is one of the two designated hazardous waste of special waste management. These materials are dangerous to public health and the environment because they contain large concentrations of toxic and carcinogenic substances such as heavy metals, poly-chlorinated hydrocarbons, poly-aromatic compounds etc. In recent years it is estimated that in the EU were consumed about 5.8 million tons of lubricating oils. During their use, the oils lose their properties, thus are discarded as waste and replaced with new oils. In Greece it is estimated that 60 percent of lubricating oil [5] available in the market is a waste and therefore subject of alternative management.

## 1.2. Waste to energy and planning

Waste-to-Energy is an established and well proven worldwide option for municipal solid waste treatment, motivated both by necessity to minimize the environmental impacts of landfilling and the aim to increase the share of renewable energy [1; 10]. European Directive 2008/98/EC [8] classifies Waste-to-Energy as energy recovery operation of the conceptual hierarchy of the waste management options, when R1 criterion for energy efficiency is fulfilled [1]. Directives 2008/98/EC and 2000/76/EU & 2010/75/EC form a common ground from Waste-to-Energy motivation

### 1.2.1. The case of Attica

In Attica region (capital of Greece) the daily production of Municipal Solid Waste (MSW) is estimated at 6,000 tons. This means 2 million tons per year, from which 85 to 90 percent is deposited in one Sanitary Landfill, which is almost overcapacity. The European Union Legislation for Sanitary Landfills (1999/31/EC), imposes the decrease of biodegradable waste which are deposit to sanitary landfills, so WTE methods of MSW represent almost the only integrated solution to such problems. The Greek legislation for the incineration of wastes is the Joint Ministry Decision 22912/1117/2005& 36060/1155/E.103.2013 – in harmonization with the European Union directives for Incineration of Waste 2000/76/EC & 2010/75/EC.

For the Attica Region, the Greek Waste-to-Energy Research and Technology Council *SYNERGIA* has suggested the following tree scenarios [13], through which all the difficulties on the waste management in Attica will be overcome.

- Two plants of 400,000 tpa, which is a medium capacity plant. Whether two plants of such capacity may constructed in opposite directions of the Attica Region, the residuals of recycling would be managed by the most environmental friendly method, producing electricity and increasing the lifetime of the landfills.
- One plant of 700,000 tpa, which is a large capacity plant, according to the global reference. This kind of plant might be constructed at a site where already waste management facilities exist. Such a place in Attica might be at Ano Liossia Municipality, where the main landfill of Attica and a MBT plant exist.
- One co-incineration plant of 700,000 tpa MSW and 300,000 tpa RDF, which is a large capacity plant and also implementing state-of-the-art techniques. This proposal is based on the previous one and also provides a treatment method for the already produced RDF of Attica, which otherwise would be landfilled.

In the following table the power production of the three scenarios for Attica are presented.

Table 6: Scenarios examined for the case of Attica

| Capacity (tpa) | Unit | 400,000 tn MSW | 700,000 tn MSW | 700,000 tn MSW and 300,000 tn RDF |
|---|---|---|---|---|
| Lower heating value | MJ/kg | 9 | 9 | 10.8 |
| Gross power | MW | 32.93 | 57.63 | 98.73 |
| Net power | MW | 27.99 | 48.98 | 83.92 |
| R1 | | 0.6972 | 0.6972 | 0.6979 |
| Net electrical energy | MWh/year | 223,929.08 | 391,875.90 | 671,387.41 |
| Numb. of residents served | | 141,530 | 247,677 | 424,336 |

Surce: WTERT Greece, SYNERGIA, 2009, www.wtert.gr

## 1.2.2. The Hellinikon opportunity

Hellinikon located 7 km South of Athens was the International Airport of Athens for sixty years until 2001. After its closure a small part in the Northwest was redeveloped for venues of the 2004 Summer Olympic Games. Since 2012 investment plans took place and investors were attracted to develop the site commercially and also create a large municipal park (biggest in Europe). By decision of the Interministerial Committee for Restructuring and Privatisation, the shares of Hellinikon SA were transferred to Hellenic Republic Asset Development Fund (HRADF). HRADF is charged with designing and carrying out the site development process.

Since this investment is the first big one in Greece within the last eight years (crisis period), the authors propose that scenarios like the three above mentioned for Attica, could be taken into consideration for this large project development.

Two excellent examples supporting the idea are the Maresme Integrated Waste Management Center and the Palm Beach Renewable Energy Facility.

Figure 3: The Hellinikon development area

## 2. Conclusions

The waste management plan in Greece has to be changed rapidly in order to be conformed to the European directives. Many efforts should be made in order to inform and persuade the society and the policy makers of Greece that modern waste to energy technology is the demanded step after recycling and composting at the source, in order to be severed by the landfill sites and the illegal dumps.

The research conducted on the existent MSW management system in Greece led to the conclusion that it has several assets and numerous liabilities. Currently, the MSW generated in Greece are mainly transferred either directly or indirectly through Waste Transfer Stations (WTSs), to sanitary landfills; also, some are disposed at illegal Uncontrolled Waste Disposal Sites (UWDSs). To alleviate this situation, the construction of Integrated Waste Management Facilities (IWMFs) has been planned, but not yet implemented.

WtE is a well proven means of environmentally sound treatment of solid wastes that also generates renewable electricity and heat. Controlled combustion of as received MSW allied with stringent Air Pollution Control (APC) technologies can consistently and reliably process not only untreated MSW, but also post recycling/composting waste residues in an environmentally safe method with minimal impact on the environment. Additionally, the volume of waste to be landfilled is reduced by ninety percent, resulting in alleviation of traffic congestion and the reduction of air pollution caused by trucks. Finally, the electrical and thermal energy produced by the processing of waste is a major source of profit and also can be used for the operation and for cooling/heating of the WTE plant and/or neighboring facilities. For all these reasons, WTE is considered to be a long-term efficient solution to the waste problem situated in Greece.

To sum up, the integration of WtE in Greece‘s Regional Plan for SWM will lead not only to compliance of the Region with the EU targets (Directive 2008/98/EC) towards Sustainable Development, but also to the final solution of the MSW problem of the Region with the simultaneously production of renewable energy – reducing GHGs comparing with fossil fuels, Directive 20-20-20 and the Greek Laws 3851.2010, 4012/2012.

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