# Mechanical – Biological Treatment Experiences in Greece: Problems, Trends and Perspectives

**Triantafyllia Haritopoulou[1], Katia Lasaridi[2]**

[1]Municipality of Athens Development Agency, Athens, Greece
[2]Department of Geography, Harokopio University, Athens, Greece

**Erfahrungen mit der MBA in Griechenland: Probleme, Trends und Perspektiven**

**Abstract**

Today, three years before the first – extended – deadline of the EU landfill directive, Greece still relies on landfills for the disposal of over 85% of its waste, while waste production continues to grow at about 3% annually. The 2006 estimate for Municipal Solid Waste (MSW) production is 5.3 million tons, while the Biodegradable Municipal Waste (BMW – putrescibles and paper) content is approximately 67%. Currently Greece has no incineration capacity, neither source separation of BMW (with the exception of paper recycling), while installed Mechanical-Biological Treatment (MBT) capacity rises to about 500,000t. There are three MBT plants in the country, while a few more are under different stages of planning. Experiences from the design and operation of these plants are discussed along with the institutional framework and the status of the market for MBT products, and the prospects of Greece for meeting the landfill directive targets are explored.

**Keywords**

Mechanical-biological treatment, Greece, landfill directive, biodegradable municipal waste (BMW), Kalamata plant, Chania plant, Ano Liossia plant, AMCAR, DEDISA

# 1 Current status of MSW management in Greece

## 1.1 Legislative and Institutional Framework

Greece is a full member of the European Union and therefore has to adjust its legislative framework to comply with the European legislation. In most environmental issues, including waste management, the drive to implement new stricter laws stems from the EU. To a large extent, European legislation is incorporated well to the national law and the legislative framework for waste management can be considered sufficient and well elaborated. Problems usually arise at the level of implementation.

The Ministry of Environment, Physical Planning, and Public Works (MEPPPW; ΥΠΕΧΩΔΕ in Greek) is charged with environmental protection and provides coordination and advice on the main environmental policy areas. Also, the Ministry of the Interior has particularly important responsibilities regarding solid wastes and local solid waste management (SWM), as part of its role in supervising local authorities. The first Waste Framework Directive (75/442/EEC) was adopted in 1975 and established gen-

eral rules for the management of waste. It was amended in 1991 by Directive 91/156/EEC, and has been incorporated into Greek Legislation, through three Joint Ministerial Decisions (JMDs), which: defined the terms and measures for SWM (69728/824); provided detailed technical specifications for SWM facilities (114218/97), equipment and procedures; and outlined the general directions of SWM policy in Greece (113944/97).

In 2000, the National Plan for SWM became a legal text, as a JMD, which sets the priorities and gives directions for the sustainable management of solid wastes of the country. In 2002, MEPPPW initiated the update of the National Plan, aiming at: the redrafting of the Prefectural Waste Strategies according to the Regional Strategies that where developed for promoting integrated SWM; the elaboration of integrated SWM systems for the 13 Regions of Greece; the management of Uncontrolled Waste Disposal Sites (UWDSs) and their gradual elimination and restoration; and the development of modern sanitary landfills, covering the entire country by the end of 2008. During the period of 2002 – 2003, MEPPPW focused also on the transposition of the EU Legislation on waste management into the National Legal System and, thus, issued new JMDs, including JMD 29407/3508/2002 on measures and terms for sanitary disposal (harmonization with the EU Directive 99/31/EC) and JMD 50910/2727/2003 on measures and terms for SWM.

The application field of Law 2939/2001 (harmonization with the EU Directive 94/62/EEC) on “Packaging and the Alternative Management of Packaging and other Materials” extends to packaging wastes, end-of-life vehicles, waste batteries and accumulators, catalysts, used tyres, wastes from electrical and electronic equipment, oils and waste oils, and demolition and construction wastes. This law obligates the economic actors to organize or participate in systems of alternative waste management, in order to achieve specific quantitative recycling and recovery targets. During 2004-2005 the establishment and the operation of individual Recycling Systems for different waste types (tyres, electrical supplies, batteries etc) were introduced by Presidential Decrees.

Regarding the diversion of BMW from landfilling, seven years after the adoption of the EU landfill directive (99/31/EEC) Greece still relies on landfills for the disposal of over 85% of its waste. Making use of the four years extension allowed to countries heavily relying on landfills, Greece may use this method for no more than 75, 50 and 35% of the quantity of BMW generated in 1995, by the year 2010, 2013 and 2020 respectively. The directive also sets stringent standards on the design, construction, operation and aftercare of landfills and introduces a compulsory framework for the calculation of landfill costs and charges, based on full cost accounting, including the costs for restoration and monitoring after the end of the useful life of the landfill. These provisions are also de-

fined in the Ministerial decree 29407/3508 (JMD 1572B/2002) which transposed, practically through an exact translation, the directive into national law.

The implementation of the landfill directive and the corresponding national legislation will require major changes in the entire waste management sector in Greece, from the introduction of new technologies and stringent operation regimes for landfills to the calculation of costs and charges to the public and the structure, organisation and operation of the waste management authorities. In short, the whole philosophy on which the Greek waste management system was built needs to be upgraded to meet demanding targets, criteria and standards, while keeping cost increases to a minimum. In this context MBT – technologies can play an important role, as they are: relatively flexible to accommodate for a still developing waste management system; may be economically feasible in a wide range of scales and have generally a good level of public acceptance.

## 1.2 Production and management of MSW

MSW quantities in Greece grew from $3.9 \times 10^6$ tonnes in 1997 (the first year for which relatively reliable data exist) to $4.6 \times 10^6$ tonnes in 2001, at a rate of 3.4% annually and their 2006 production is estimated at $5.3 \times 10^6$ tonnes (LALAS ET AL., 2007). The BMW content is estimated at 67%, comprising of 47% putrescibles (dropping in urban areas) and 20% paper, with an increasing tendency (Figure 1). Data illustrating the temporal and geographical variation of waste composition in the country, according to the few studies carried out up to now, are summarised in Figure 2. The lack of accurate waste data is a basic problem complicating any SWM planning in the country.

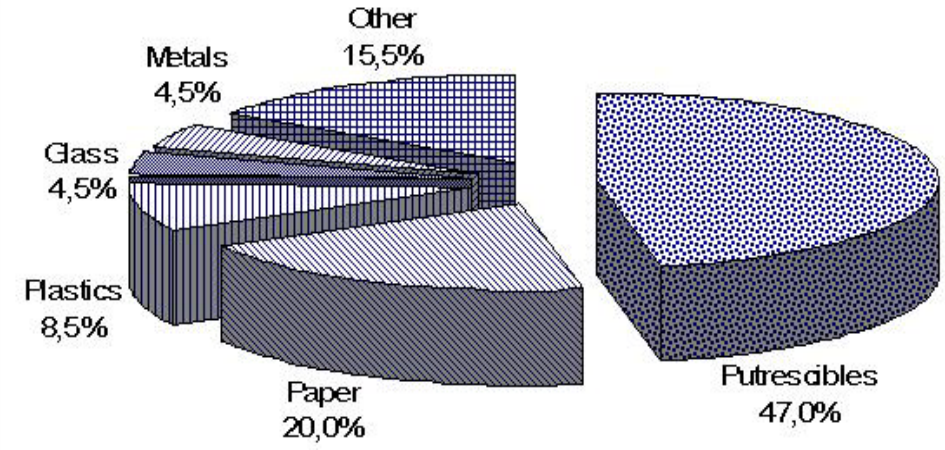


**Figure 1** Average Greek MSW composition (JMD 50910/2727/2003).

From Figure 2 a decreasing tendency with time for the putrescible fraction can be observed, which is coupled by an increasing trend for paper and plastics. However, this does not necessarily mean that the overall quantity of putrescibles is decreasing.

An important progress is being made in the area of packaging recovery, which currently consists solely of materials recycling. A collective system, the Hellenic Recovery and Recycling Corporation (HERRCO S.A.) has been approved, which, in collaboration with the local authorities, is developing a network of material recycling facilities (MRFs) to treat the dry-recyclables collected through a two streams source separation system

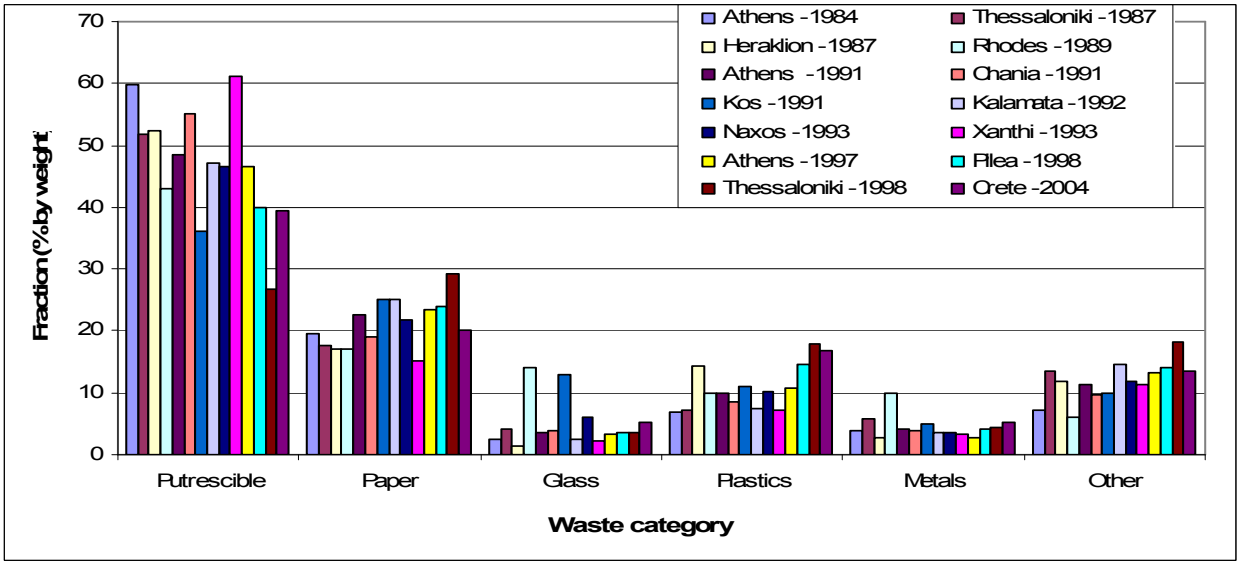


**Figure 2** Geographical and temporal variation of MSW composition in Greece (Source: GIDARAKOS ET AL., 2006, PAPACHRISTOU ET AL., 2002, JMD 50910/2727/2003).

(blue bin type). Table 1 presents the geographic expansion of the HERRCO packaging collection system, along with the population served and the material quantities recovered. The quantity recovered includes both packaging and printed paper, part of which contributes towards the achievement of the BMW landfill diversion targets. In addition, it is estimated that a large fraction of paper and cardboard is currently being recycled, through different formal and informal activities and the commercial sector, amounting to 230,000 t/yr, or 25% of this waste stream (JMD 50910/2727/2003). At the administrative level, the establishment of the National Organisation for the Alternative Management of Packaging and Other Products (EOEDSAP), under the auspices of MEPPPW, is under way. EOEDSAP is expected to greatly contribute to the formulation and implementation of the national strategy for the prevention and recycling of waste, along the lines of the relevant EU Thematic Strategy, approved last December.

Currently Greece has no incineration capacity, neither source separation of biowaste. The country relies heavily on landfilling for the disposal of about 86% of its waste, the rest being recycled by both the formal and informal sector (8%) and MBT treated in the Ano Liossia plant, in Athens and the Chania plant, in Crete (6%).

**Table 1** The development of the HERRCO source separation and recycling network for packaging waste (*Source:* www.herrco.gr).

| Municipalities / Cities | Population served | Quantity recovered (t/yr) | Status of development |
|---|---|---|---|
| Athens-Patra-Zante-Chania-Pieria | 730,000 | 19,250 | Operating |
| West Thessaly-Kalamata-Corfu-Lamia-Heraclio-Thessaloniki | 965,000 | 22,400 | Ready to operate |
| Thermi-Elefsina | - | - | Under preparation |

In the last decade large investments have being made on waste management infrastructure: in the period 2000-2006 alone, over **300 million €** from the EU Cohesion Fund has been spent in the sector. However, the vast majority was spent on increasing landfill capacity, to replace uncontrolled dumps and exhausted landfills.

Summarizing the actual waste management situation, there exist **43 landfills** while **19 new** ones, with a total capacity of 2,192,000 tonnes per year, are under different stages of planning and construction (LALAS ET AL., 2007). Many of the existing landfills do not conform to the specifications of the landfill directive with respect to their operational regime, while none applies full cost accounting systems for the calculation of the gate fees, thus resulting to considerably lower costs for the landfill users. A recent survey of landfill charges in Greece showed that they vary from **8 to 35 €/tonne**, with the majority lying in the range of 8-12 €/tonne, while real costs are moderately estimated at about 30-35 €/tonne (LALAS ET AL., 2007).

To complete the picture, it should be noticed that a substantial budget of 80 million euro has been recently dedicated to the restoration of dumping sites, which should be completely phased out by the year 2008.

# 2 MBT experiences in Greece

## 2.1 Overview of MBT implementation

Following the main legislative guidelines as described above, Greece's waste management strategy moved since the early 80's towards mechanical – biological treatment in urban areas, mainly due to social constraints, such as public acceptance, and real or perceived difficulties in the implementation of source separation. Thus, three MBT plants of different capacities have been constructed in the country, while another five are at different stages of the planning procedure:

- The Kalamata plant (32,000 t/yr capacity), in Peloponnesus, was the first to operate in 1997, was forced to close at the beginning of 2003 by court decision due to poor environmental performance and is planned to re-open soon after an upgrade of its equipment and operational conditions.
- The Ano Liossia plant in Athens is one of the biggest MBT facilities in Europe, with a nominal capacity of 438,000 t/yr (350,000 t/yr real) and began full scale operation (about 300,000 t/yr) in summer 2006.
- The Chania plant, in Chania, Crete, with a capacity of 70,000 t/yr, uses similar technology with the Ano Liosia facility and is still under trial operation, gradually expanding to cover its capacity.

In total, the installed MBT capacity rises to about **500,000 tons** mixed MSW, which, if fully operational, will be able to divert from landfilling about 310,000 tonnes of BMW, contributing to about 10% diversion (LASARIDI, 2006). There are also five facilities underway, at different stages of the planning procedure to be developed until 2010. Some, such as the NW Thessaloniki plant, are well matured while others are still characterised by a high uncertainty level:

- The NW Thessaloniki treatment facility, of 450,000 t/y capacity, to include MBT and a solid refuse fuel (SRF) WtE plant, aspiring to operate in three years.
- The West Thessaloniki treatment facility, of 140,000 t/y capacity.
- The Patras treatment facility, of 120,000 t/y capacity.
- The Heraklion, Crete, treatment facility, of 70,000 t/y capacity.
- The Hemathia treatment facility, in Central Macedonia, of 50,000 t/y capacity.

Provided that these facilities are constructed on time, the installed MBT capacity of Greece will reach 1,300,000 t/y, achieving thus the 2010 landfill diversion target. However, an intensive further development strategy will be required to achieve the more demanding target of 2013 (LALAS ET AL., 2007).

## 2.2 Waste management plan and the role of MBT in Attica

The Region of Attica, with 4.5 million inhabitants, generates over 58% of the annual MSW produced in Greece. This amounts to about 7,735 tons daily (2.8 t/y), or a unit production rate of 1.7 kg/ca/d. This value is much higher compared to MSW generation in other areas of Greece, which ranges from 0.6 to 1.4 kg/ca/d, and the highest values are recorded in the continental part of Athens-Piraeus Prefecture, where many commercial activities are located.

To facilitate integrated, sustainable waste management in this large Region, the Association of Communities & Municipalities of the Attica Region (ACMAR) was established

in 1970, with responsibilities for the overall waste management (recycling, treatment, disposal), apart from collection and transport, which remains a major task of each local authority (LA). AMCAR has undertaken all the activities to implement an integrated SWM system, including the construction and operation of one of the largest MBT facilities in Europe, the Ano Liossia plant, and siting and development of sanitary landfills, with a remarkable delay though, mostly due to intense public opposition and some bureaucratic difficulties. Currently, ACMAR manages the waste of 87 LA which are its members (73 municipalities and 14 communities). ACMAR collects directly, from the Ministry of Interiors, **6%** of the income of each LA-member in order to manage its MSW, independently of their quantity. 70% of this amount constitutes the compensation of the Municipalities where the landfill is located. In 1997, (ACMAR) initiated the construction of the MBT next to the then existing uncontrolled landfill at Ano Liosia.

## 2.3 The Ano Liossia MBT plant - Athens

The MBT facility in Attica is located at the eastern part of the region in a 131.915 $m^2$ area, with buildings covering 40% of the total area. A joint-venture of companies undertook the design and construction of the facility. The construction of the MBT plant lasted approximately 6 years (1997 – 2003), and the costs of the entire project reached the amount of **56 million €,** exceeding the initial estimate of 45 million €. The MBT plant is one of the biggest and most modern plants of its kind worldwide, having a nominal capacity of 438,000 tons of commingled MSW per year. On an annual basis it is designed to accept also 40,000 tons of yard wastes or similar material for the control of the porosity of the organic fraction; and 85,000 tons of processed sludge from Psyttalia Wastewater Treatment Plant.

The collected MSW are brought into the facility by waste collection and transfer trucks, and are fed to three parallel lines, each consisting of a trommel drum, where the compostable portion is separated from the recyclable solids, followed by mechanical sorting equipment (see Figure 3). The compostable products of the three lines are fed into a single composting unit. The unit has a rotating drum reactor with 12-14 hours retention time for size reduction and pre-treatment of the organic fraction while composting is carried out in 48 aerated channels where mechanical turning is also provided.

According to the initial planning, the recycling plant would operate 10 hours per day, 6 days per week and process about **1.200 tons** of waste daily, which accounts to almost **1/5** of the totally municipal solid waste produced in the Attica Region. Its process philosophy is determined by the combination of ecological principles of recycling natural organic matter back to the soil and the need to take full advantage of the non-organic recycling products, either through thermal utilization with negligible environmental impact or through the re-introduction of materials back to the market and the production

cycle. The projected final marketable products of the waste processing were approximately:

- 360 tons per day of compost products, to be derived from processing of the compostable fraction of MSW, yard wastes, and processed sludge.
- 350 tons per day of Refuse Derived Fuel (SRF) of 8% moisture (calorific value of 10 megajoules per kilogram), which represents the most refined fuel form that can be obtained from mixed MSW.
- 33 – 40 tons per day of ferrous and 5 tons per day of aluminum products were projected to be recovered for recycling.

The useless side-products, estimated to exceed 330 tons daily, were to be directed to the adjacent sanitary landfill after their mechanical compaction, thus saving valuable space and increasing the landfill's life.

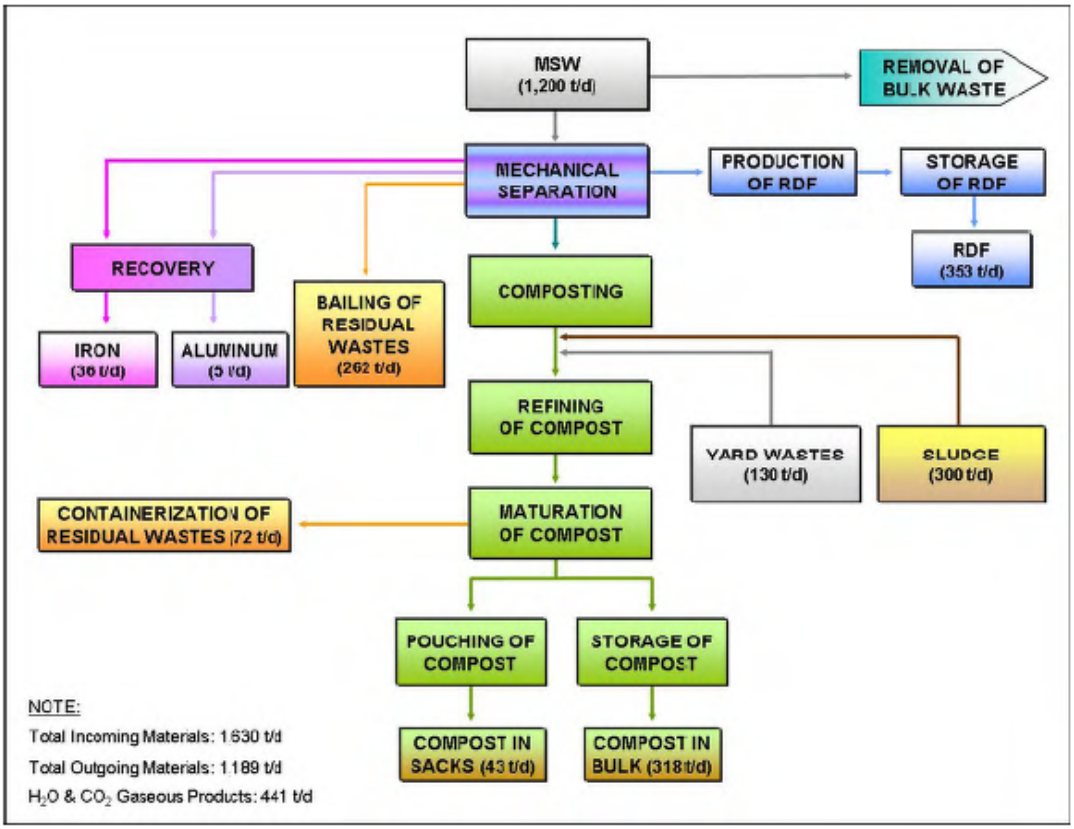


Figure 4.41 Schematic process diagram of MRCF (based on Reference 52).

**Figure 3**: Schematic process diagram of the facility (Source: Columbus, 2006)

The plant started operating the last week of July 2004. Until January 2005, only two of the three modules of mechanical sorting operated. The total amount of waste processed was **200 tons daily** (**16.7%** of the planned capacity), resulting in the production of approximately **38 tons** of compost, **30 tons of SRF**, 750 kilograms of ferrous metals and 375 kilograms of aluminum. At that time, 100 tons of waste and 30 tons of SRF ended

to Ano Liossia sanitary landfill daily. The only recyclable products were the ferrous and aluminum metals. In addition, five compost turners, as well as the refining unit at the plant were in operation. By March 2006, the facility remains under trial operation, some five years after its planned opening date and so far it did not reach its targets towards recycling.

## 2.4 The Chania MBT plant - Crete

In the western part of Crete, in the Perfecture of Chania, a new Mechanical-Biological Treatment plant was designed and started its operation in 2005. The plant serves a population of 150.000 inhabitants and 70.000 “bed-equivalents” from 8 neighbouring municipalities, which have established an Association called DEDISA in 1994. The plant was designed and constructed by one of the companies, which have constructed the Ano Liossia facility and is built in a 235.000 $m^2$ area, where also the landfill is located. The total cost of the plant accounted to **23 million €** and was funded by the 3rd CSF.

The process is the same as described above and the first operation data from the trial period are presented. It should be considered, that the MBT plant also operates as a sorting unit for the separately collected recyclable materials. In the pilot period from the first year (2006) the following MSW quantities were treated: **83.493 tons** MSW, of which **68.810 tons** were directly diverted to the sanitary landfill, **9.079 tons** (**1/7** of the planned capacity) to the mechanical treatment and **5.604 tons** recyclable material from the recycling program. The daily input to the plant in 2007 is 264 tons of waste, of which 203 tons (73,8%) was disposed to the landfill, whereas 60 tons are treated in the mechanical sorting unit and 45 tons are composted.

**Figure 4** An aerial photograph of the MBT plant and the landfill (DEDISA, 2006).

The composting is carried out together with chopped green cut under controlled conditions (aeration, humidity). The compost material that is produced is of relatively good quality (low content of plastic material, high organic content, high N concentration, heavy metal concentration below the EU limits). The compost-like material could be distributed as cover material for the restoration of dumping sites, whereas the SRF is still diverted to the landfill. Some discussions with the cement industry are going, in order to deliver the SRF material for incineration to such facilities at a low cost.

The first financial data show that the facility has an annual turnover of **10 million €,** of which the cofunded sum will be 1,5 mil. €, while 1 million € is expected to come from the sale of the recycled materials. The final gate fee for the landfill could thus be kept as low as **34€/ton**. It must be pointed out that in all cost calculations the main investment costs have not been taken into account, since the plants have been co-financed by the EU and / or national funds. Thus, no final financial evaluation on their viable operation can be extracted from the data available until now.

# 3 Discussion

The conflict experienced in Greece between adequate legal and legislative arrangements, mainly driven by EU directives and regulations, and weak capabilities of policy implementation and enforcement is a typical scenario experienced in countries with less developed waste management systems and environmental policy in general. It is increasingly becoming apparent that MSW is not just a technical problem accepting better of worse engineering solutions, but a management problem of considerable dimensions, requiring a complex interaction of political, economic and technical approaches in combination with changes in public consumption attitudes and behaviour. The above described situation in conjunction with the level of existing waste management infrastructure described above and the delays experienced in the waste management sector cast doubts on the country's ability to meet the agreed BMW diversion targets.

Similar challenges will be likely faced by many of the new member states, which also rely heavily on landfilling, and have to solve much more pressing problems not only in waste management but regarding all aspects of environmental protection. Moreover, the new states will have to secure relatively higher national funds, as the European Structural Fund is no longer as generous as it has been when the Mediterranean countries joined the EU. As the economies of these countries are still struggling to adapt to the new regime and achieve some convergence with the EU average, local funds will be scarce and the implementation of expensive waste management options even more difficult.

As described above, sufficient financial and technical data are not yet available, to allow an informed evaluation of the operation of MBT in Greece, which would allow a good prediction of the prospects and limitations of the technology in assisting the country to meet its landfill diversion obligation. Costs mentioned by the operating authorities for the existing MBTs are low compared to the European experience, at around 35€/t. However, this does not include any capital costs, as facilities have been built with public funds, nor any expenses for the products disposal, as currently the SRF is being stored. The latter is of particular importance, as the European experiences show that the main challenge of MBT is finding viable markets for its products and securing long-term off-take contracts.

The extrapolation of the limited local experience indicates that in some areas at least (e.g. Crete) sufficient outlets may be available for the compost-like output (CLO), at a positive price, as land reclamation /restoration material and top soil in restorations of old dump sites, quarries and possibly landscaping. Top soil is an expensive commodity in Greece and local soils are very poor in organic matter, while the CLO produced complies with the – lenient – national legislation regarding heavy metals. Therefore, although its agricultural application is not likely, other bulk outputs seem possible.

The situation is more complicated regarding the SRF produced. Greece has an extensive cement industry, which could absorb all the SRF currently produced and a large part of the total production, if MBT was widely adopted. However, no contract has been signed yet and informal information on the likely conditions and cost for the off-take varies. It seems that negotiations are still hard and none of the players is willing to fully open its cards. Some of the new MBT projects that are in a fairly advanced stage of planning foresee a specially built WtE plant to utilise the SRF in house.

The national legislative framework does not set any specific landfill acceptance criteria, nor any techniques for residual biodegradability measurement, making it still unclear how landfilling of MBT treated waste would contribute to the achievement of the landfill directive BMW diversion targets. If relevant EU legislation is adopted, it will level the field across Europe, largely determining the role and prospects of MBT. Otherwise, it seems likely that a national approach will adopt relatively lax criteria, recognising the contribution of MBT to landfill diversion even if the treated outputs are used as daily landfill cover (which often entails lower costs compared to other outlets).

The aforementioned remarks along with the overall state of MSW management in Greece, briefly described by: a considerable lack of infrastructure (still over 1000 uncontrolled dumping sites, which should be closed by 2008); limited landfill capacity in many areas; low costs of current waste disposal methods, making sharp price increases difficult to be accepted by the public; wide public opposition to incineration; need of compli-

ance with EU landfill directive; and limited EU funding in the coming period, indicate that MBT may have substantial perspectives for further development in Greece.

# 4 Acknowledgements

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**Author's addresses**

Dr. Triantafyllia Haritopoulou
Municipality of Athens Development Agency
5 Favierou & Mayer Str.
GR – 10138 Athens, Greece
Telephone: +30 210 2125900
E-mail: ax2u022@minagric.gr

Assist. Professor Dr. Katia Lasaridi
Department of Geography, Harokopio University
70 El. Venizelou, Kallithea
GR-176 71 Athens, Greece
Telephone: +30 210 9549164
Email: klasaridi@hua.gr
Website: www.hua.gr