A techno economic assessment of waste management scenarios in Attica -Greece

A. Mitsikas*, K. Aravossis
[1] *National Technical University of Athens, School of Mechanical Engineering, Section of Industrial Management & Operational Research, 15780, Zografou, Athens, Greece*
** Corresponding author: almits@central.ntua.gr*

Abstract

Almost half the population of Greece lives in Attica. As a result, a significant amount of municipal solid waste is produced in this region. As a first step in waste management, the habitants dispose waste into bins. There are (blue) bins for mixed recyclable waste, bins for recyclable waste streams (glass, paper) and (green) bins for mixed solid waste. Subsequently, waste is transferred to treatment or disposal facilities. The treatment methods that are widely used include recycling, composting and landfilling. However treatment facilities are inadequate for an ecologically proper management, while the participation of the population at the separation at source is low. As a result, in Attica, about 80% of the produced quantity of two million tons per year is deposited in landfills. According to the National Waste Management Plan and the legislation of European Union (Directive 2008/98/EC), household waste should be recycled and recovered up 50 % by 2020 (at country level). Furthermore landfilling should be reduced (Directive 99/31 EC): The biodegradable municipal waste that heads to landfills must be reduced to 35% of the total amount of biodegradable waste produced in 1995. In order to the region of Attica to positively contribute to these goals, the waste management situation must be significantly improved, by increasing recycling and composting. Incineration or other methods can be examined, in order to reduce landfilling and increase the recovery of materials or energy from waste. The design parameters, such as the treatment methods, the amount of waste that can be processed per year etc. can be assessed with economic, environmental and social criteria. The techno-economic analysis can take place with methods such as cost-benefit analysis and multicriteria analysis.

Four different scenarios for the waste management in Attica are evaluated. The scenarios are based on Regional Waste Management Plan (PESDA) and its revision. The first scenario is the implementation of PESDA. According to this scenario, a separation at source program and appropriate equipment must be established. The construction of four centers for mechanical sorting of recyclable materials, three composting plants for separately collected organic waste and four treatment plants for mixed waste are also proposed. According to the second scenario, special bins for printed paper must be installed additionally to the existing bins. The construction of three large composting plants and some (about ten) smaller is also suggested. Based on this scenario, a large amount of households are participating in home composting program. The third scenario is based on the proposition of the Administrative region of Attica for the review of PESDA. Three large composting plants and some smaller are suggested. For mixed waste, three or four new mechanical sorting plants and composting are planned, and additionally the upgrade of an existing plant is suggested. The fourth scenario, takes into account, in addition to the separation at source program and the construction of mechanical sorting and composting plants, the installation of an incineration plant.

Keywords: *solid waste management, recycling, waste management in Attica, economic evaluation of waste management*

ISBN: 978-618-5271-24-4

1. INTRODUCTION

1.1 Solid waste management hierarchy

Solid waste effective management is essential in order to avoid environmental, social and economic impacts (air/ water pollution, solid contamination, etc). According to the waste management hierarchy, waste must be prevented, recycled or composted. If these options aren't feasible, then waste- to- energy treatment and landfilling in modern landfills with methane recovery should be used (http://www.seas.columbia.edu/earth/wtert/faq.html, Directive 2008/98/EC).

1.2 National and European legislation

According to the National Waste Management Plan and the legislation of European Union (Directive 2008/98/EC), household waste should be recycled and recovered up to a percentage of 50 % by 2020 (at country level). Furthermore landfilling should be reduced, according to the Directive 99/31 EC: The biodegradable municipal waste that heading to landfills must be reduced to 35% of the total amount of biodegradable municipal waste produced in 1995. Moreover, there are additional recycling goals for packaging waste and other streams of waste. In Greece, according to the law 4042/2012 (article 41), up to 2020, at least 40% of the total weight of biodegradable waste must be collected separately.

1.3 The region of Attica

The administrative region of Attica is in central Greece. The area is 3.808 km^2, about 2.9% of entire country. In 2011, there were 3.827.624 inhabitants (a slight increase compared to 2001). Attica is the most densely populated area in Greece (1005 inhabitants /km^2). It is divided in 8 regional units and 66 municipalities. About 45% of the Greek Gross domestic product is produced in Attica (ESDNA, 2016).

2. TECHNOECONOMIC EVALUATION OF FOUR WASTE MANAGEMENT SCENARIOS

In Attica, as well as all over Greece, the municipalities are responsible for municipal solid waste management. Habitants throw solid waste in bins. In most cases, there are (green) bins for mixed solid waste, and (blue) bins for mixed recyclable materials (mainly packaging waste and paper). There are also some additional bins for recyclable streams (paper, glass). Waste is collected with garbage trucks and moved to treatment areas. Four different scenarios for the waste management in Attica are evaluated. Each scenario includes new waste treatment plants, equipment such as waste bins and other actions such as awareness campaigns. For the comparison, there is also a fifth scenario, the do-nothing solution.

2.1 Municipal solid waste management in Attica

A significant amount of municipal solid waste is produced in Attica. In 2014, about 1872157 tonnes of waste produced (EDSNA, 2015, page 70). It is estimated that this amount will be increased up to 1,893,617 tonnes per year for 2020 (EDSNA, 2016). Treatment methods are mainly recycling, composting and landfilling. The existing waste treatment plants are two sorting centers of recyclable materials (SCRM) with total capacity 140.000 tonnes / year and one mechanical sorting and composting plant with capacity 260.000 t/ year.

ISBN: 978-618-5271-24-4

However, treatment facilities are inadequate for an ecologically proper management, while the participation of the population at the separation at source is low. As a result, about 80% of the produced quantity is deposited in landfills.

2.2 Description of scenarios and economic data

2.2.1 Assumptions and waste management data

The efficiency rate of sorting centers of recyclable materials and alternative waste management systems is 0.7-0.73, depending on the waste bins, awareness campaigns etc that each scenario suggests. The efficiency rate of mechanical and biological treatment plants and the amount of each recyclable material as a rate to the total recovered materials is based to the Regional Waste Management Plan- PESDA (EDSNA, 2016, page 128). The recycling and recovery rate for mechanical and biological treatment (MBT) plants are presented to the next table.

Table 1. Recycling and recovery rate for mechanical and biological treatment plants

Waste stream	Recycling rate	Recovery (RDF and compost) rate	Total recovery
Glass	0	0	0
Paper/ carton	0.15	0.40	0.55
Metals	0.90		0.90
Plastic	0.25	0.35	0.60
Wood	0	0.10	0.1
Other recoverable materials	0.15	0	0.15
Organic	0	0.65	0.65
Other	0	0	0

Incineration plants in all scenarios are working 8000 hours per year, and the electric power is sold for 85€/MWh. The average heating value of RDF is assumed 14.5MJ/ kg. The residue for landfill (ash etc.) is about 30% of the incoming quantity. The cost of treatment plants is based mainly on the average value from four functions taken by literature (Tsilemou, Panagiotakopoulos, 2007, Komilis, 2014, Varela, 2011, Economopoulos, 2009), with small adjustment. The adjustment is made in order to fit the values of reviewed PESDA. In the evaluation of all scenarios there is an extra cost of 1,500,000 -2,000,000 € at the end of the tenth year for additional equipment requirement (purchase of new bins in order to replace some worn out bins, new garbage trucks to replace the older ones etc.). In all scenarios, there is also a smaller income (about 50% and 80% of the calculated income) for the first two years, in order to measure smaller amount of separation at source for the first years, additional equipment costs, etc.

The price of recyclable materials is the lower of two sources (http://ec. europa .eu/eurostat/statistics-explained/index.php/Recycling_%E2 %80%93_secondary_ material_ price_indicator, ESDI, 2014). An extra income of 45€/t of waste that treated in plants is calculated. There is also a cost of 45€ for each tonne of treatment plant residue (cost of disposal). The existing facilities are not taken into account for the economic evaluation. On the other hand, the amount that treated in these plants is counted for the rates of recycling,

ISBN: 978-618-5271-24-4

composting, landfilling etc. Tax is not included in economic assessment. In some scenarios there is also the construction of large and local transfer stations and new landfills. These expenses are not calculated in the economic assessment.

2.2.2 Scenario description, suggested facilities and economic data

Scenario S1

The first scenario (S1) is the implementation of the existing PESDA (2006). According to this scenario, a separation at source program and appropriate equipment should be established. Four centers for mechanical sorting of recyclable materials should be constructed. Two of them have already been constructed, so two sorting centers are taken into account for economic evaluation. The capacity and economic data for the sorting centers are presented below. In all the tables, net cash flow includes also an income of 45€/t of treated waste and a cost of 45€/t of residue.

Table 2 Economic data (investment cost etc.) and capacity of recycling schemes of the scenario S1

Unit	Capacity (t/year)	investment cost (€)	Operational cost (€)	Income (recyclable materials)	Cash flow
SCRM 1 (Exists)	100000				
SCRM 2 (Exists)	40000				
SCRM 3	72500	8,482,500.00	2,320,000.00	4,135,467.64 €	4,099,217.64 €
SCRM 4	72,500	8,482,500.00	2,320,000.00	4,135,467.64 €	4,099,217.64 €
Total	285000	16,965,000.00	4,640,000.00	8,270,935.28 €	8,198,435.28 €

Based on the scenario, a significant amount of waste is treated in mechanical and biological treatment facilities. More specifically, four new MBT plants are proposed, with total capacity more than 1 million tonnes. The plants are considered as mechanical sorting plants with aerobic composting. The capacity and data about incomes and cost are presented in the next table.

Table 3 Capacity and economic data for Mechanical sorting and composting plants (Mechanical and biological treatment plants) of the scenario S1. In 5th column, income from the sale of recyclable materials and compost)

Unit/ AWMS	Capacity (t/year)	investment cost (€)	Operational cost (€)	Income	Cash flow
MBT Plant 1	127,000	25,527,000.00	5,145,222.92	1,166,422.22 €	- 1,036,859.73 €
MBT plant 2	700,000	128,800,000.00	27,699,973.23	6,429,098.83 €	- 5,055,451.72 €
MBT Plant 3	400,000	72,000,000.00	15,828,556.13	3,673,770.76 €	- 2,888,829.55 €
MBT Plant 4	127,000	25,527,000.00	5,145,222.92	1,166,422.22 €	- 1,036,859.73 €
Total	1,354,000	251,854,000.00	53,818,975.21	12,435,714.02 €	- 10,018,000.74 €

Three (new) composting plants for separately collected organic waste are also proposed. The capacity and economic data are presented in the next table.

Table 4. Economic data and Capacity of proposed composting plants of the scenario S1

Unit	Capacity (t/ year)	investment cost (€)	Operational cost (€)	Income (compost)	Cash flow
Composting plant 1	40000	9,880,000.00	400,000.00	210,000.00 €	1,322,000.00 €
Composting plant 2	40000	9,880,000.00	400,000.00	210,000.00 €	1,322,000.00 €
Composting plant 3	80000	16,640,000.00	1,120,000.00	420,000.00 €	2,324,000.00 €
Total	160000	36,400,000.00	1,920,000.00	840,000.00 €	4,968,000.00 €

The scenario S1 includes also 19-29 recycling spots /schemes (estimated cost 11 million €), a separation at source program (estimated cost 30million €). A waste- to- energy unit for energy recovery from the produced RDF is also calculated. The capacity is assumed 100,000 tonnes/year. The initial cost is 53.9 million €. The operational cost is estimated 3.5 million € /year and the income from the sale of electric power is estimated 9,586,111.11 €/year.

The total investment cost of scenario S1 is 400,119,000.00 €. The total income is 104,460,563.35 €. It includes the total income from different products that are recovered (compost from separately collected organic waste, compost like output/ compost from MBT, recyclable materials) and sold in market. The total cost includes operational cost and an extra fee of 45€/tone of waste that is landfilled and it is estimated 88,880,110.96 €.

Scenario S2

The second scenario (S2), is based on a proposal of four Non-government/ environmental organizations. According to this scenario, recycling bins for paper must be installed additionally to the existing bins. New sorting centers of recyclable materials should be created. Other alternative waste management systems (AWMS) for specific recyclable materials such as packaging waste and printed paper are also proposed. The capacity, the costs and the income for recyclable material systems and sorting centers are presented to the following table.

Table 5. Economic data and capacity of recycling facilities of the scenario S2

Unit/ AWMS	Capacity (t/ year)	investment cost (€)	Operational cost (€)	Income (recyclables)	Cash flow
SCRM 1 -Exists)	100,000	- €	- €		
SCRM 2 -Exists)	40,000	- €	- €		
SCRM 3	120,000	13,800,000.00	3,222,151.92	7,063,745.05 €	7,654,472.91 €
SCRM 4	120,000	13,800,000.00	3,222,151.92	7,063,745.05 €	7,654,472.91 €
SCRM 5	120,000	13,800,000.00	3,222,151.92	7,063,745.05 €	7,654,472.91 €
AWMS	320,000	29,440,000.00	10,240,000.00	18,940,993.10 €	18,924,993.10 €
Total	820,000	70,840,000.00	19,906,455.76	40,132,228.26 €	41,888,411.81 €

ISBN: 978-618-5271-24-4

In this scenario, new mechanical and biological treatment plants are not proposed. The organic stream of municipal waste is separated at source and processed (composted) in three closed composting plants. About 10 smaller (open) composting units are also proposed. The capacity and economic data about the composting units are presented in the next table.

Table 6 Capacity and economic data for composting plants of the scenario S2

Unit	Capacity (t/year)	investment cost (€)	Operational cost (€)	Income (compost)	Cash flow
Composting plant 1	180,000	40,140,000.00	3,222,151.92	941,384.94 €	3,953,816.74 €
Composting plant 2	180,000	40,140,000.00	3,222,151.92	941,384.94 €	3,953,816.74 €
Composting plant 3	180,000	40,140,000.00	3,222,151.92	941,384.94 €	3,953,816.74 €
Small units	180,000	27,000,000.00	2,331,048.42	941,384.94 €	5,388,308.07 €
Total	720,000	147,420,000.00	13,627,667.67	3,765,539.75 €	17,249,758.28 €

Based on this scenario, a large amount of households are participating in home composting program (estimated cost 10 million €). There is also about 25 recycling spots/schemes (estimated cost 36 million €), separation at source of organic waste (7 million €), an awareness/ informational campaign (20 million €), etc. The total investment cost of the scenario S2 is 329,260,000.00 €.

Scenario S3

The third scenario (S3) is based on the proposition of the Administrative region of Attica for the review of PESDA. As in the previous scenario, sorting centers of recyclable materials and other alternative waste management systems (AWMS) for specific recyclable materials are proposed. These and the existing facilities are presented below.

Table 7 Economic data and capacity of recycling facilities of the scenario S3

Unit/ AWMS	Capacity (t/year)	investment cost (€)	Operational cost (€)	Income (€)	Cash flow
SCRM 1 (Exists)	100000				
SCRM 2 (Exists)	40000				
SCRM 3	120000	13,800,000.00	3,224,720.77	7,116,696.04	7.816.574,85 €
SCRM 4	120000	13,800,000.00	3,224,720.77	7,116,696.04	7.816.574,85 €
SCRM 5	120000	13,800,000.00	3,224,720.77	7,116,696.04	7.816.574,85 €
AWMS	345000	31,740,000.00	10,669,446.50	20,460,501.12	20,752,865.02 €
Total	845000	73,140,000.00	20,343,608.81	41,810,589.24	44,202,589.56 €

For organic waste, this scenario suggests the construction of six large units, some smaller and the modification of the existing MBT plant

ISBN: 978-618-5271-24-4

Table 8 Economic data and capacity of composting plants of scenario S3

Unit	Capacity (tones/ year)	investment cost (€)	Operational cost(€)	Income (compost and recyclables)	Cash flow
Central Sector 1	50000	11,650,000.00	749,833.65	246,039.17 €	1,267,687.52 €
Central Sector 2	50000	11,650,000.00	749,833.65	246,039.17 €	1,267,687.52 €
Piraeus	70000	15,050,000.00	984,156.67	344,454.83 €	1,840,372.97 €
South Attica	45000	10,800,000.00	717,028.43	221,435.25 €	1,098,740.62 €
NE Attica	20000	5,860,000.00	393,662.67	98,415.67 €	413,345.80 €
West Attica	50000	11,650,000.00	749,833.65	246,039.17 €	1,267,687.52 €
Small units	20000	3,300,000.00	393,662.67	98,415.67 €	413,345.80 €
Ano Liosia (conversion)	70000				
Total	375000	69,960,000.00	4,738,011.38	1,500,838.92 €	7,568,867.74 €

For mixed waste, three or four new mechanical sorting and composting plants are proposed. Additionally, the upgrade of the existing plant is suggested.

Table 9 Capacity and economic data for mechanical and biological treatment plants according to scenario S3

Unit	Capacity (t/ year)	investment cost (€)	Operational cost(€)	Income	Cash flow
Central Sector 1	130000	26,130,000.00	5,467,900.62 €	928,562.15 €	2,449,969.89
Central Sector 2	130000	26,130,000.00	5,467,900.62 €	928,562.15 €	2,449,969.89
South Attica	150000	29,550,000.00	6,162,392.47 €	1,071,417.87 €	2,826,888.33
Piraeus	170000	32,980,000.00	6,984,044.79 €	1,214,273.59 €	3,037,520.00
NE Attica	60000	13,080,000.00	2,875,783.15 €	428,567.15 €	1,424,202.59
Ano Liosia (extension)	90000	14,004,000.00	3,609,401.30 €	642,850.72 €	1,520,064.64
Ano Liosia (existing)	190000			-	
Total	920000	141,874,000.00 €	30,567,422.95 €	5,214,233.63 €	13,708,615.34

The scenario S3 also includes the construction of recycling spots/ schemes, an awareness campaign, home composting program, technical support etc. The total cost of these actions is estimated at 85,250,000.00 €. The total investment cost of this scenario is 370.224.000,00 €.

S4- Scenario with incineration plant

The fourth scenario (S4) is similar to S3. In addition to the separation at source program and the construction of mechanical sorting and composting plants, the scenario takes into account the construction of an incineration plant. The separately collected recyclable and organic waste is at about 75% of the S3. The waste management facilities are presented below

ISBN: 978-618-5271-24-4

Table 10. Recycling and composting facilities (with indicative position) of scenario S4

Unit/ AWMS	Capacity (t/ year)	investment cost (€)	Operational cost (€)	Income	Cash flow
SC 1 (Exists)	100000				
SC 2 (Exists)	40000				
SCRM 3	120000	13,800,000.00	3,205,464.60	7,062,178.02 €	7,756,695.35 €
SCRM 4	120000	13,800,000.00	3,205,464.60	7,062,178.02 €	7,756,695.35 €
SCRM 5	120000	13,800,000.00	3,205,464.60	7,062,178.02 €	7,756,695.35 €
AWMS	135000	12,424,000.00 €	4,273,952.79	7,944,950.27 €	8,058,477.14 €
Total recycling	635000	53,360,000.00 €	13,890,436.58	29,131,484.32€	31,328,563.18 €
Central Sector 1	50000	11,650,000.00	784,331.38	257,358.73 €	1,326,010.23 €
Central Sector 2	20000	5,860,000.00	411,773.97	102,943.49 €	432,362.67 €
Piraeus	50000	11,650,000.00	784,331.38	257,358.73 €	1,326,010.23 €
NE Attica	50000	11,650,000.00	784,331.38	257,358.73 €	1,326,010.23 €
Small units	18000	2,970,000.00	370,596.58	92,649.14 €	389,126.40 €
Ano Liosia (conversion)	70000				
Total composting	258000	43,780,000.00	3,135,364.68	967,668.84 €	4,799,519.78 €

Table 11. Capacity and economic data for mechanical sorting and composting plants of scenario S4

Unit	Capacity (tones/ year)	investment cost (€)	Operational cost(€)	Income	Cash flow
Central Sector 1	120000	24,360,000.00	5,042,763.02	1,486,232,07 €	387,239.23 €
Central Sector 2	120000	24,360,000.00	5,042,763.02	1,486,232,07 €	387,239.23 €
Piraeus	120000	24,360,000.00	5,042,763.02	1,486,232,07 €	387,239.23 €
South Attica	130000	26,130,000.00	5,462,993.27	1,610,084,74 €	419,509,23 €
Ano Liosia (extension)	90000	14,004,000.00	3,606,161.93	1,114,674,05 €	466,399.81 €
Total	580000	113,214,000.00	24,197,444.26	967,668.84 €	2,047,566,91 €

The capacity of incineration plant is 315,000 t/y. The operational cost is estimated 12.247 million € /year and the income from the sale of electric power is estimated 30,196,250 €/year. Recycling spots and other actions are assumed similar to the previous scenario. The total cost is 76,251,285.19 € and the income 142,410,212.35 €. The total investment cost of this scenario is 500,254,000.00 €.

Scenario S0 -Do nothing solution

The fifth scenario presents the current state without any additional actions such as construction of waste management facilities. It is used for comparison reasons. In the current situation, in addition with the existing treatment plants, about 30.000 tonnes of recyclable materials are transferred in sorting centers outside of Attica. The rest amount, about 1.437.617 tonnes, is landfilled without treatment. Only this amount of waste is taken into account, since the existing plants aren't calculated in the economic evaluation. The estimated disposal cost is 64.692.765,00 €. This amount will probably be increased, because a new tax of 35€/tonne will be added in untreated waste that going into landfills. In this case, there is an extra cost of 50.316.595,00 € per year and the total cost is 115.009.360,00 €/year.

2.3 Evaluation of four scenarios

2.3.1 Economic evaluation

The economic evaluation of the five scenarios is presented in the next table (NPV= Net Present Value, IRR= Internal rate of return, do- nothing scenario without the cost 35€/t of new tax)

Table 12 Values from economic evaluation in the presented scenarios

Scenario	Do nothing	S1	S2	S3	S4
NPV	- 742,439,714€	- 276,435,822 €	209,078,018 €	58,491,121 €	165,110,866 €
IRR		-3.54%	12,03%	7,59%	9,33%
Cash flow	-64,692,765 €	15,505,512 €	53,460,460 €	44,875,448 €	66,158,927 €
Initial cost	- €	400,119,000 €	329,260,000 €	370,224,000 €	500,254,000 €
Initial cost (€/tonne)	- €	211.30 €	173.88 €	195.51 €	264.18 €
Operational cost (€/tonne)	34.16 €	46.94 €	31.41 €	45.44 €	40.27 €
Income (€/tonne)	- €	55.12 €	59.64 €	69.13 €	75.21 €
Total cost (€/tonne)	34.16 €	57.50 €	40.11 €	55.21 €	53.48 €
Total cost	64,692,765 €	88,880,111 €	59,481,166 €	86,036,970 €	76,251,285 €

2.3.2 Environmental evaluation

An environmental evaluation of scenarios is presented in the next table. Note that the row landfilling includes residue from incineration plant in scenarios S1 and S4 and all the amount that enters in the incineration plants is counted in recovery.

Table 13 Recycling, composting, recovery and landfilling in four scenarios

Scenario	Do nothing	S1	S2	S3	S4
Recycling	8.88%	24.53%	34.78%	38.67%	32.10%
Composting	4.30%	30.61%	38.19%	34.44%	32.67%
Recovery	15.12%	65.75%	74.44%	77.18%	81.39%
Landfilling	84.88%	35.83%	25.56%	22.82%	23.60%

ISBN: 978-618-5271-24-4

3. CONCLUSIONS

All the proposed scenarios are better in terms of economic and environmental assessment that the do- nothing solution. The scenario S2 (proposal of four environmental organizations) has the higher net present value, but supposes that a large amount of waste is separated at source. This maybe is not feasible due to there is already a low participation in separation at source. The scenario S1 doesn't require high participation, but the targets from European legislation aren't achieved and probably the cost will be increased due to a fine. Furthermore, the mechanical treatment plants that are suggested have very large capacity and there is a risk of malfunction. In addition, the social acceptance is low. The scenario S4 has the higher recovery rate due to the combination of recycling, composting and incineration. But to achieve this recovery rate requires larger initial cost (about 130 million € more than S3). Furthermore, incineration plants haven't social acceptance and it is possible an increasing of cost in order to reduce environmental and social impacts. Scenario S3 has the greater rate of recycling and the lower rate of landfilling from all other scenarios.

Note that the evaluation is based on literature data and several assumptions. It may needs further analysis in order to create more accurate results, in case that more accurate data are available etc. For example, if recycling rate in MBT plants is increased, scenarios S1 and S3 have the most significant improvement (0.7% and 0.2% in IRR for an increase 10% in recycling rate).

REFERENCES

1. http://www.seas.columbia.edu/earth/wtert/faq.html (accessed February 13, 2017)
2. Official Journal of the European Union *directive 2008/98/EC of the European parliament and of the council of 19 November 2008 on waste and repealing certain directives* (Text with EEA relevance), 22.11.2008 , L 312/3
3. Official Journal of the European Communities, *Council Directive 1999/31/EC, of 26 April 1999 on the landfill waste*, 16.7.1999, L 182/1
4. 2nd degree union of municipalities of Attica (EDSNA), 2016, *Strategic study of environmental impacts of 2nd revision of the regional waste management planning in Attica* (in Greek)
5. 2nd degree union of municipalities of Attica (EDSNA), 2015 *Study for 2nd revision of the regional waste management planning in Attica* (in Greek)
6. Komilis D, 2014. *Full cost accounting on existing and future municipal solid waste management facilities in Greece, Global NEST Journal, Vol 16, No 4, pp 787-796*
7. Economopoulos A., 2009.*Technoeconomic aspects of alternative municipal solid waste treatment methods. Elsevier (Article in Press)*
8. Varela Evangelia, 2011. *Evaluation of technologies of municipal solid waste mechanical and biological treatment* (Diploma thesis in Greek). *National Technical University of Athens, Athens*
9. Tsilemou K., Panagiotakopoulos D, 2007. *Economic Assessment of Mechanical-Biological Treatment Facilities* , Environmental Research, Engineering and Management, 2007.No.1(39), P. 55-63
10. http://ec.europa.eu/eurostat/statistics-explained/index.php/Recycling_%E2% 80%93_secondary _material_price_indicator
11. Environmental and Sustainable Development Institute –ESDI, 2014, http://slideplayer.gr /slide/2295879/ (in Greek), accessed 10/12/2017

ISBN: 978-618-5271-24-4