THE IMPACT FROM THE IMPLEMENTATION OF "WASTE TO ENERGY" TO THE ECONOMY. A MACROECONOMIC APPROACH FOR THE TRADE BALANCE OF GREECE

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Presented at the 4th International Conference on Environmental Management, Engineering, Planning and Economics (CEMEPE), June 24 to 28, 2013, Mykonos, Greece

ABSTRACT

Waste to Energy (WTE) is a proven method for waste treatment. A significant number of studies and reports presenting the positive impact of WTE facilities in the waste management have proven the complementary character with recycling, while the greener cities of the world consider WTE to be an important parameter in achieving this distinguishes. There are also economic studies investigating the investment and operational costs, while they examine also the gate fee always as a basic parameter, for the economic viability and public acceptance. This work examines the contribution of WTE to economic growth, through the contribution to the trade balance deficit decrease of Greece. A potential investment in such a sector will lead to a decrease in the trade balance and, hence, a significantly positive impact will occur on the GDP. Given that Greece suffers from multiple deficits (fiscal, external, etc), it becomes clear that the devotion in waste management is likely to offer considerable effects in the growth rate, especially through the reduction of energy imports.

KEYWORDS:
waste to energy (WTE); greenhouse gasses emission reduction; trade balance; gross domestic product (GDP); investment;

1. INTRODUCTION

The European Union promotes through legislation the reduction of the amount of wastes land-filled by means of recycling, composting and energy recovery [1, 2]. Accordingly, the member states are gradually adopting waste management methods that are recovering energy and materials from municipal solid wastes (MSW) and non-hazardous industrial wastes [1, 3-5]. Waste to Energy (WTE) is a method for waste treatment of proven efficiency. In the EU 450 facilities and globally more than 800 operate successfully while, at least, 100 additional ones are under construction or design [4]. Based on these facts, a significant number of studies and reports presenting the positive impact of WTE facilities, in waste management, have proven the complementary character with recycling [3-5]. The greener cities of the world consider WTE as an important parameter in achieving this distinguish. Other studies present the contribution of WTE in the energy mix and the renewable power generation percentage, as well as the greenhouse gas reduction potential. There are also economic studies investigating the investment and operational costs, while they examine also the gate fee always as a basic parameter, for the economic viability and public acceptance. Thus, these studies for the economics of WTE focus only in the investment, from the investors' point of view [3-8].

This work examines the contribution of WTE to economic growth, through the contribution to the trade balance deficit decrease of Greece. A potential investment in such a sector will lead to a decrease in the trade balance and, hence, a significantly positive impact will occur on the GDP. Given that Greece suffers from multiple deficits (fiscal, external, etc), it becomes absolutely clear that the devotion in waste management is likely to offer considerable effects in the growth rate, especially through the reduction of oil, electricity, or other types of energy imports. Moreover, the positive outcome on the unemployment cannot be ignored. Furthermore, the country can benefit also from the reduced greenhouse gasses emissions and the transactions in the respective financial markets. Consequently, public revenue is likely to achieve a serious increase. To sum up, from the macro-economic point of view, besides the environmental and social ones, it is worth taking such conclusions seriously into account.

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2. MUNICIPAL SOLID WASTE PRODUCTION AND MANAGEMENT IN GREECE

MSW production in Greece has increased appreciably over the years, as everywhere in the world. It is estimated that the annual MSW generation in Greece has exceeded 450 kg/capita. A constant increase over the past years is observed and is estimated to continue in the foreseeable future. A large fraction of the MSW tonnage is generated in the Regions of Attica (39%) and Central Macedonia (16%), where the largest cities, Athens and Thessaloniki, are situated. Figure 1 presents the mean composition of MSW in Athens and Thessaloniki, while Fig. 2 presents the municipal waste generation (kg/capita) in Greece from 1997-2007 [3, 6, 9].

The composition of MSW in Greece is similar to the European average, with the only difference of higher organic fraction and moisture content, up to 40%. The MSW management methodologies in Greece are land-filling (82%), recycling (17%) and composting (1%). At present, there is no WTE facility in Greece, while some mechanical treatment units, producing RDF or SRF, are operating or are under construction [1, 9, 11]. From November of 2006, the Mechanical Biological Treatment and Composting (MBTC) Plant at Ano Liosia (Attica) had produced 220000 t per year of RDF (27.4% moisture and 0.4% Cl content), very similar to MSW. The production of this fuel had justified the investment of the MBTC facility and was projected to be financially better than the conventional approach of mass-burning of solid wastes. Nevertheless, this fuel has not yet been used in cement production or power generation, even though the utilization potential is quite high [1, 9, 11, 12]

3. POWER GENERATION POTENTIAL FROM WASTE COMBUSTION IN GREECE

WTE facilities can combust either as-received MSW (stoker or "mass burn" technology) or pre-processed "refuse-derived" fuels (RDF or SRF). The latter have higher calorific values and can be used both in dedicated WTE

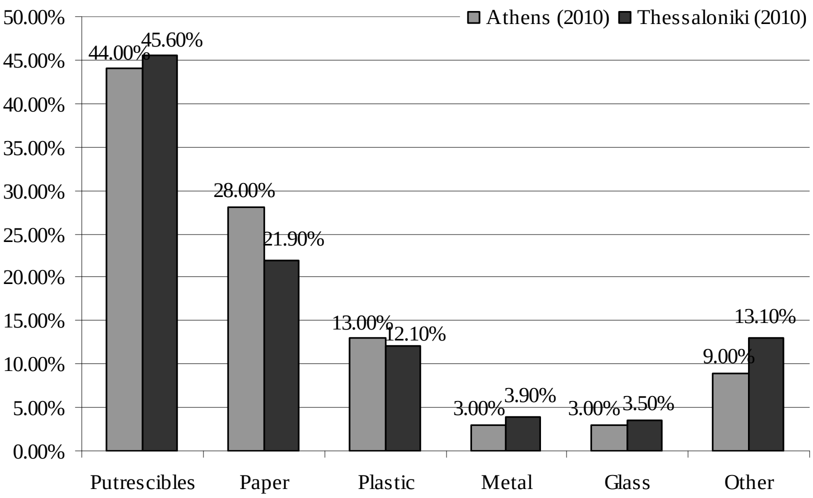

FIGURE 1 - Mean composition of MSW in Athens (2010) and Thessaloniki (2010) [3, 6, 9]

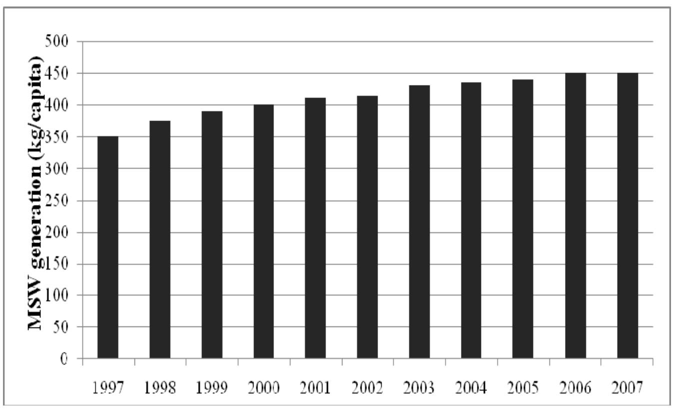

FIGURE 2 - Municipal waste generation (kg/capita) in Greece from 1997-2007 [3, 6, 9].

plants and as fuel substitutes in cement kilns and coal-fired power plants [1, 3-5]. The direct combustion of "as-received" MSW (mass burn) is widely used throughout the developed world, and it is less costly to implement than the combination of an RDF generating facility (e.g., like the MBTC facility at Ano Liossia) followed by an RDF-dedicated power plant. However, the RDF option offers advantages in cases where the RDF can be co-combusted with lignite in existing industrial plants equipped with Air Pollution Control systems that can meet the EU standards for volatile metals, dioxins, and particulate matter. Another possibility is the implementation of distributed small RDF/SRF plants that reduce the weight of MSW processed, and produce a higher calorific value fuel that can then be transported easier to a regional WTE facility. The advantage of such a configuration would be that a few WTE facilities, strategically located across Greece, might be less costly to implement than many small WTE plants [7, 10, 11, 13-18].

In the case of co-combustion and co-gasification of SRF with lignite, significant research has been conducted already [16-18]. Some of these studies have indicated that the SRF quantities to-be-produced in Western Macedonia can be utilised by the Kardia Power Plants, by substituting 2-3% of lignite in one of the 3x300 MW units. The same scenario has been proposed for the SRF production in Peloponnese, by using the Megalopolis III Thermal Power Station where a new desulphurization unit, under construction, is projected to reduce current emissions substantially [11, 16-18].

The basic scenario under examination was proposed by Psomopoulos and Themelis [11], and it can be summarised in Table 1. Implementation of this scenario will reduce the GHG emissions of the Power Generation Sector in Greece and reduce the nation's dependence on imported fossil fuels, thus supporting the efforts for economic growth of Greece. These additional benefits to the ones already mentioned prove that the use of MSW and RDF/SRF for energy production will provide significant benefits not only to the environment but also to the economy and Power Generation Sector in Greece. The potential benefits are huge: Over 1.5 billion kWh_e/y, almost 2.5% of the total electricity production of Greece in 2006, will be generated, and over 128000 t of lignite will be saved annually. In addition, the CO_2 emissions can be highly reduced, over 3000 kt CO_2/y [3-5, 8, 11, 14, 16, 17, 19-22].

The steam used for electricity production from the steam generators in power stations presents low enthalpy for extended heating systems, if it comes from a dedicated electricity production plant [23]. But even then, the existing low enthalpy in the steam can be utilised for small scale domestic / residential type heating [23]. A fast approximation of the quantities of thermal energy that can be utilised, based on the plant sizes proposed by Psomopoulos and Themelis in [11], and considering the data from typical power plants using fossil fuels [23] for steam generators, is summarised in Table 2.

TABLE 1 - Potential for electricity production and lignite savings in Greece by WTE (mass-burn and RDF/SRF utilisation) [11, 21, 22].

Region	Electricity Production / Lignite Savings	Remarks
Attica	$650x10^6$ kWh_e/y 84 MW_e	Scenario with WTE facilities of at least 1Mt/y capacity for mixed streams of MSW and RDF/SRF
Central Macedonia	$325x10^6$ kWh_e/y 38 MW_e	Scenario with WTE facility with 0.5Mt/y capacity for mixed streams of MSW and RDF/SRF
Crete	$70x10^6$ kWh_e/y 5 MW_e	1 dedicated RDF/SRF utilization plant of at least 105 Kt/y capacity
Western Macedonia	$20x10^3$t/y	Co-combustion / co-gasification on existing coaled fired power plants
Peloponnese	$76x10^3$t/y	Co-combustion / co-gasification on existing coaled fired power plants
Epirus	$32x10^3$t/y	Proposal for MBT Plants in Epirus and co-combustion/co-gasification on existing coaled fired power plants in Western Macedonia
Western Greece	$130x10^6$ kWh_e/y 15 MW_e	Proposal for 1 WTE facility with 0,2Mt/y capacity for mixed streams of MSW and RDF/SRF produced locally
Central Greece Thessaly	$195x10^6$ kWh_e/y 20 MW_e	Proposal for 1 WTE facility with 0.3 Mt/y capacity for mixed streams of MSW and RDF/SRF produced locally in the Regions
Eastern Macedonia – Thrace	$130x10^6$ kWh_e/y 15MW_e	Proposal for 1 WTE facility with 0,2Mt/y capacity for mixed streams of MSW and RDF/SRF produced locally

TABLE 2 - Potential for use of the low enthalpy steam after electricity production for district heating in Greece from the proposed WTE (mass-burn and RDF/SRF utilisation) facilities [11, 21-23].

Region	District heating potential	Remarks
Attica	$16x10^6$ kWh_{th}/y	Scenario using the low enthalpy steam from the steam turbine generator in domestic type mainly heating
Central Macedonia	$8x10^6$ kWh_{th}/y	Scenario using the low enthalpy steam from the steam turbine generator in domestic type mainly heating
Western Greece	$3x10^6$ kWh_{th}/y	Scenario using the low enthalpy steam from the steam turbine generator in domestic type mainly heating
Central Greece Thessaly	$5x10^6$ kWh_{th}/y	Scenario using the low enthalpy steam from the steam turbine generator in domestic type mainly heating
Eastern Macedonia – Thrace	$3x10^6$ kWh_{th}/y	Scenario using the low enthalpy steam from the steam turbine generator in domestic type mainly heating

4. ENERGY DEPENDANCY AND TRADE BALANCE OF GREECE

4.1 Energy dependency of Hellenic market

Greece had an energy import dependency of 72% in 2006, which is above the EU-average of 54%. Crude oil and petroleum products accounted for 81% of imports, while natural gas accounted for just 11%. Overall, the Hellenic energy system relies on fossil fuels for 93% of its gross energy consumption. The considerable expansion in use of lignite for power generation starting in the 1970s was itself a response to growing energy import dependence. With a Mediterranean climate, a large tourist industry, and a rather complicated geography, the Hellenic energy system has evolved along rather different dimensions compared to other Member states. The lack of electricity grid connections in islands and some outlying areas has presented technical challenges in the power sector. Final energy consumption is dominated by electricity and oil, which together accounted for 90% of the total in 2006. Transport and households accounted for 65% of final energy consumption. Gas has been entering the market in recent years and is, thus far, directed mainly to the power sector [24]. The electricity demand in Greece is covered by utilization of existing lignite, imported natural gas and diesel oil, renewable that include wind, solar and hydropower, and also some direct imports of electricity. Table 3 present these basic figures [25]. In this table, it is shown that a significant part, almost 37%, of the electricity consumption in Greece is covered by imported fuels. Here, it must be noticed that the Hellenic lignite presents low calorific values, and there are imports of coal to improve the quality of the fuel. These imports were estimated to be 0.6 Mt with an average cost for 2012 of 95 €/MWh [26, 27]. The imports cover a not negligible part of the consumption while they are followed by specific power capacity provided to the Hellenic transmission and distribution network given by third countries to Greece. This power corresponds to several MW of electricity imported in addition to the energy. In 2008, this amount of power was between 100 MW and 275 MW with an average of 173 MW with accosting 22066.8 €/MW. The cost of the imported energy during this period was varying between 1.57 €/MWh to 35.78 €/MWh depending on the month and requested energy beyond the signed imported quantities, with an average in price of 15.50€/MWh. Main countries from which Greece is importing electricity are mainly Bulgaria and FYROM, Italy and Turkey [28].

Considering the existing conditions in Greece, even thought the residential heating oil demand was reduced in recent years, the need for heat in residual sector and sanitary hot water remains at the same levels. Following the results presented there is a potential for $35000MWh_{th}/y$. Based on the fact that this energy is coming from low enthalpy steam, the utilisation is limited. Thus, it could be used only for small-scale district heating applications and production of sanitary hot water, or heating of water in swimming pools, replacing common diesel oil used in such applications. Considering that 1 MWh equals 0.086 to_e or 103.2 L of oil equivalent, then, this energy could be equal to 3010 to_e or 3612000 L, thus mainly reducing the oil consumption on the residential sector [24].

TABLE 3 - Fuels percentage used in the electricity mix of Greece [23].

	Year Sept 2011 – Aug 2012	Year 2009 (62.509 GWh)	
Lignite Power Station	47.10%	51.42%	32142 GWh
Oil Power Stations	8.13%	11.16%	6976 GWh
Natural Gas	24.72%	15.79%	9870 GWh
Hydropower	6.16%	8.34%	5213 GWh
RES	9.88%	5.94%	3713 GWh
Interconnections	4.02%	7.35%	4594 GWh

4.2 The Hellenic economy problems and trade balance

One of the biggest problems of the troubled Greek economy is the huge trade deficit, and the current account. Simply put, this means that Greece for many years introduced more value (and volume) of these goods exported. In particular, as revealed by the data, from 2000 onwards, there is a rapid increase in the deficit, culminating in 2008, a year before the outbreak of the financial crisis in the country. Indicative, according to Bank of Greece, it ranged from 21.93 billion or 16% of GDP in 2000 to 27.56 billion in 2005 or 14.3% of GDP in 2005, and 44.05 billion or 18.9% of GDP in 2008, before scaling started rapidly from next year to 30.8, 28.3 and 27.23 billion in the years 2009, 2010 and 2011, respectively, primarily due to the decrease in imports due to the Great Depression, but also due to the small increase in exports. In terms of strict notation, the following equation is the national accounting identity [29-31]:

$$NX = Y - C - I - G \quad (1)$$

where Y is GDP (Gross Domestic Product) of the country, C is the cost for private consumption, I is the cost for private investment, G is the cost of public expenditure, and NX represents net exports, i.e. exports minus imports, and is an alternative notation of the trade balance [29].

As noted, this was (and still is) a strong negative aspect for Greece, putting downward effect on GDP of the country. The trade balance is equal to the difference between domestic production (Y), from domestic expenditures (C + I + G). The last relation shows a reality, which was noted when it was already too late for Greece, that state-level economics are similar with households: when the country spends more than its income, it is forced to request external loans. Therefore, the trade deficit corresponds directly to foreign dept of the country [29].

Considering the data presented previously and in literature, the investments in WTE facilities will directly affect the energy imports in both electricity and fuels [3-5, 11, 15, 19]. But this reduction in imports of energy products will directly affect the trade balance by reducing the domestic expenditures. In particular, the produced RDF/SRF could be easily substitute 128 Kt of the imported hard coal, as it is experimentally proven that it can replace a part of the lignite used in existing power stations [15-18], corresponding to a reduction of 12.16 M€ annually [11, 26, 27]. The electricity imports can be reduced by 1.5 million MWh [11] corresponding to a reduction of 23.25 M€ annually [28], and in that amount, if the reduction of the power capacity demand is also included which corresponds to 170 MW, there is a potential for additional 3.75 M€ annually [28]. The utilization of low enthalpy heat that remains after electricity production in WTE facilities used for district heating, a common practice in newest facilities, is included in these calculations considering them as reduction to diesel oil imports only, resulting on 2.52 M€. The calculation performed considering 697.53 €/1000 L excluding taxes [32]. The entire values amount almost to 42 M€ annually, which is added to the balance of goods. According to the Hellenic Statistical Authority, the deficit of goods for the year 2012 was equal to 23.5 billion €, while the overall trade deficit was 9.74 billion €, or 5% of the GDP [30]. The 42 M€ mentioned before corresponds to 0.4% of the trade deficit of the country, a size small but not negligible. Table 4 summarizes these amounts. This will be the result of the reduced imports of oil and, consequently, of natural gas for central heating, sanitary hot water and swimming pools heating [1, 3-5, 7, 8, 11].

If it is considered that these calculations do not include the metals recovered from the bottom ash, and the bottom ash itself, which are tradable goods, the imports could be reduced further, since these raw materials can be used in the metallurgic and construction sectors, or can be exported, increasing the exports of the country. Table 5 provides a rough estimation of ferrous and non-ferrous materials that could be recovered by the facilities proposed by Psomopoulos and Themelis [8] considering the Spain's report on WTE plants in the country published by CEWEP [33].

Therefore, the reduction of the negative impact (deficit) of the trade balance will foster the product level, and it will cause economic growth. In particular, the improvement in the trade balance (reduction of the deficit or increase the surplus) will cause positive change in GDP (dY/Y)> 0. This qualitative positive effect is certain, but the exact figures cannot be easily estimated. The contribution of the energy recovery is being extended to other areas of direct economic interest. In particular, WTE will lead

TABLE 4 - Basic costs of energy goods, GDP and trade balance.

		Unit	Costs reductions
Coal imports		M€	12.16
Electricity	Power Capacity	M€	3.75
	Energy	M€	23.25
Heating gas oil		M€	2.52
Total		M€	**41.68**
Trade deficit		M€	9744.00
Total	(% of trade deficit)	%	0.43
GDP		M€	194769.00
Trade deficit	(% of GDP)	%	5.003
Trade deficit including WTE	(% of GDP)	%	4.981

TABLE 5 - An estimation of potential quantities from metals recovery in the proposed WTE plants in Greece [11, 33].

Region	MSW Processed	Ferrous metals	Non-Ferrous metals
Attica	700kt/y of MSW and 300kt/y RDF/SRF	14.0kt	14.0kt
Central Macedonia	350kt/y of MSW and 150kt/y RDF/SRF	7.0kt	7.0t
Western Greece	140kt/y of MSW and 60kt/y RDF/SRF	2.8kt	2.9kt
Central Greece Thessaly	210kt/y of MSW and 90kt/y RDF/SRF	4.2kt	4.3kt
Eastern Macedonia – Thrace	140kt/y of MSW and 60kt/y RDF/SRF	2.8kt	2.9kt

to the closure of several illegal dumps for which Greece is paying substantial fines. The new processing units will require manpower for staffing creating jobs directly and indirectly through the services required related to the operation of the facilities, which would reduce unemployment. The energy recovery from wastes will lead to lower greenhouse gasses emissions [1, 3, 5, 19-22]; thus, the country can sell carbon credits, a source of revenue for many countries. The construction of WTE facilities will be an 'alternative' investment which will stimulate the economic environment in Greece at this critical sector, and enhance positive expectations which are formed gradually on the Greek economy. Finally, a highly important factor is the savings due to land preservation that the WTE facilities present in comparison to land-filling [8].

5. CONCLUSIONS

This work examined the contribution of WTE implementation to economic growth, through the contribution to the trade balance deficit decrease of Greece. A potential investment in such a sector will lead to a decrease in the trade balance and, hence, a significantly positive impact will occur on the Gross Domestic Product. Given that Greece suffers from multiple deficits (fiscal, external, etc), it becomes absolutely clear that the devotion in waste management is likely to offer considerable effects in the growth rate, especially through the reduction of oil, electricity, or other types of energy imports. Moreover, the positive outcome on the unemployment cannot be ignored. Furthermore, the country can benefit also from the reduced greenhouse gasses emissions and the transactions in the respective financial markets. The implementation of such investments will also contribute to the reduction of unemployment (with direct hiring staff, and indirect, through the services required related to the operation of the facilities). Furthermore, these facilities support the land preservation as they require significant smaller areas than landfills. Consequently, public revenue is likely to achieve a serious increase. To sum up, from the macro-economic point of view, besides the environmental and social ones, it is worth taking such conclusions seriously into account.

The authors have declared no conflict of interest.

REFERENCES

[1] European Environmental Agency (2007). Europe's Environment, The 4th Assessment, Copenhagen.

[2] EU (1999). Directive 1999/31/EC on the landfill of waste.

[3] Profu AB, Energy from waste - An international perspective, RAPPORT U2009:05, ISSN 1103-4092, http://www.cewep.eu/media/www.cewep.eu/org/med_463/403_U2009-05.pdf (accessed on March 2013)

[4] Themelis, N.J., Barriga, M.E.D., Estevez, P., and Velasco, M.G., WTE Guidebook for Latin America and the Caribbean, WTE Guidebook, EEC/IDB, July 2013 http://www.seas.columbia.edu/earth/wtert/files/WTEGuidebook_IDB.pdf (accessed on July 2013)

[5] CEWEP, Interactive presentation on Waste-to-Energy, http://www.cewep.eu/whatiswastetoenergy/index.html (accessed on March 2013)

[6] HSWMA, Hellenic Solid Waste Management Association, Municipal Solid Waste Management in greece (in Greek) http://www.eedsa.gr/Contents.aspx?CatId=97 (accessed on March 2013)

[7] Murphy J.D., and McKeogh E. (2004). Technical, economic and environmental analysis of energy production from municipal solid waste. Renewable Energy, 29, 1043–1057.

[8] Psomopoulos, C.S., Bourka, A. and Themelis, N.J. (2009). Waste to energy: A review of the status and benefits in U.S.A.. Waste Management, 29, 1718 -1723.

[9] Euroconsultants, (2010). Balkwaste : Establishment of Waste Network for sustainable solid waste management planning and promotion of integrated decision tools in the Balkan Region, LIFE07/ENV/RO/686.

[10] EU (2001). Directive 2001/80/EC on the limitations of emissions of certain pollutants into the air from large combustion plants.

[11] Psomopoulos, C.S. and Themelis, N.J. (2009). Potential for energy generation in Greece by mass burning and by pre-processing (RDF/SRF) of solid wastes, Proc. 2nd Int. Conf. Envir. Manag. Eng. Plan. Econ. (CEMEPE), 21-25 June, Mykonos, Greece, 1121-1125.

[12] Theochari Ch., Aravossis K., Varelidis P., Diavatis I., Ziogas, Ch. Iatrou, S., Bourka A., Economopoulos A., Papagrigoriou S., Pantelaras P. and Frantzis, I. (2006). Solid waste management in Greece, The Attica case. Technical Chamber of Greece, Athens, November.

[13] EU (2000). Directive 2000/76/EC on the incineration of waste.

[14] Otoma S., Mori Y., Terazono A., Aso T. and Sameshima R. (1997). Estimation of energy recovery and reduction of CO_2 emissions in municipal solid waste power generation. Resources, Conservation and Recycling, 20, 95–117.

[15] Garg A., Smith R., Hill D., Simms N. and Pollard S. (2007). Wastes as co-fuels: the policy framework for solid recovered fuel (SRF) in Europe, with UK implications. Env. Sci Technol. 41(14), 4868-74.

[16] Grammelis P., Kakaras E. and Skodras G. (2003). Thermal exploitation of wastes with lignite for energy production. J. Air Waste Manag. Assoc., 53 (11), 1301-11.

[17] Kakaras E., Grammelis P., Agraniotis M., Derichs W., Schiffer H.-P., Maier J., Hilber T., Glorius T. and Becker U. (2005). Solid Recovered Fuels as Coal Substitute in the Electricity Generation Sector. Thermal Sci. J., 9, 17-30.

[18] Koukouzas N., Katsiadakis A., Karlopoulos E. and Kakaras E. (2008). Co-gasification of solid waste and lignite – A case study for Western Macedonia. Waste Management, 28, 1263–1275.

[19] EU Directive 2001/77/EC of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market.

[20] Psomopoulos, C.S., Stavroulakis, C., Stavropoulos, V. and Themelis, N.J. (2013). Greenhouse gasses emission reduction potential in Greece by implementing WTE facilities in strategically selected urban areas. Fresenius Environmental Bulletin, 22 (7a), 2042 – 2047.

[21] Perkoulidis G., Papageorgiou A., Karagiannidis A. and Kalogirou S. (2010), Integrated assessment of a new waste-to-energy facility in central Greece in the context of regional perspectives, Waste Management 30, 1395-1406

[22] Papageorgiou A., Karagiannidis A., Barton J.R. and Kalogirou E. (2009), Municipal solid waste management scenarios for Attica and their greenhouse gas emission impact, Waste Management and Research 27, 928-937.

[23] Spliethoff, H. (2010). Power Generation from Solid Fuels, Springer-Verlag Berlin Heidelberg, ISBN 978978-3-642-02856-4

[24] Eurostat (2009), Panorama of energy: energy statistics to support EU policies and solutions, http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-GH-09-001/EN/KS-GH-09-001-EN.PDF

[25] Price bills for domestic users of Hellenic Electricity Distribution Network Operator SA (Authors Bills)

[26] Eurocoal, Country Profiles: Greece, http://www.euracoal.be/pages/layout1sp.php?idpage=73 (accessed on March 2013)

[27] EUROCOAL (2012) EURACOAL Market Report 2/2012, January 2013, http://www.euracoal.be/pages/medien.php?idpage=1285 (accessed on March 2013)

[28] Regulatory Authority for Energy (RAE) (2009), National Report to the European Commission, Athens

[29] Obstfeld, M. and Rogoff, K. (1996). Foundations of International Macroeconomics, the MIT Press.

[30] Bank of Greece, (2012). The Governor's Annual Report on the Greek economy.

[31] Hellenic Statistical Authority (2013), The Greek Economy, April 2013.

[32] European Commission - Energy Policy, Consumer prices of petroleum products net of duties and taxes, http://ec.europa.eu/energy/observatory/oil/doc/prices/bulletin_without_taxes/2013_10_28_without_taxes_1677.pdf (accessed on October 2013)

[33] CEWEP, Country Report 2010-2011 Spain http://www.cewep.eu/media/www.cewep.eu/org/med_734/1080_spain_2012.pdf (accessed on October 2013)

Received: November 05, 2013
Revised: March 19, 2014
Accepted: April 02, 2014

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FEB/ Vol 23/ No 11/ 2014 – pages 2735 - 2741