Feasibility analysis of MSW mass burning in the Region of East Macedonia and Thrace in Greece

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Abstract

Municipal Solid Waste (MSW) treatment is a top priority, in Greece. Among other alternatives, MSW mass-burning is a proved and wide-spread solution. In this context, the present work conducts a preliminary techno-economic feasibility study for a single MSW mass burning to electricity plant for the total MSW potential of the Region of Eastern Macedonia and Thrace (EMT). For an installed capacity of 400,000 tons of MSW, the available to grid electrical energy was estimated at approximately 260 GWh per year (overall plant efficiency 20.5 % LHV). The investment for such a plant was estimated at 192 M€. Taking into account that 37.9 % of the MSW LHV can be attributed to their renewable fractions, the price of the generated electricity was calculated at 53.19 €/MWh$_e$. Under these conditions, the economic feasibility of such an investment depends crucially on the imposed gate-fees. Thus, in the gate fee range of 50 – 110 €/tn the Internal Rate of Return (IRR) increases from 5 to above 15 %, whereas the corresponding Pay Out Time periods decrease from 11 to about 4 years.

Keywords: municipal solid waste, mass burning to electricity, economic feasibility

Introduction

MSW mass-burning with simultaneous electricity generation (or electricity/heat co-generation) is a widespread waste treatment practice, with more than 800 such plants being in operation worldwide and almost 500 of them in EU-27. In 2009, about 20 % of EU's MSW were incinerated, a share that exceeded 50 % in Denmark, 40 % in Sweden and 30 % in Germany, France, Netherlands and other north and central European countries, where at least 100 of these plants have been installed within the past decade (WTERT 2013). Despite their high initial investment costs, which requisite a minimum capacity to obtain economic feasibility, mass-burning solutions can reduce MSW volume by up to 90 % and generate partially renewable electricity (Tabasová et al. 2014; Achillas et al. 2013).

In this context, the purpose of this paper is to evaluate the techno-economic feasibility of a single MSW mass burning to electricity plant in the Region of East~~ern~~ Macedonia and Thrace (EMT) in Greece, an option that might lead to a potential solution regarding MSW treatment in this region.

Methodology

The evaluation of the techno-economic feasibility was based on a commercially available technology and plant design, which has already been applied for MSW capacities of several hundred thousand tons per year, and has been proven as among the most efficient ones; e.g. the 400.000 tn yr^{-1} MSW mass burning, co-generation plant (30 MWe / 45.7 MWth) in Brescia, Italy (http://wteplants.com/plant/brescia). Recent data regarding the qualitative/quantitative and the elemental analysis of the MSW (Komilis et al. 2012) were used for the thermodynamic analysis of the aforementioned commercially available and applied plant design. The nominal capacity of the plant was estimated according to the official data of MSW generation in Greece and in EMT region, as well as the evolution of MSW production during the past decade. The basic economic features for the installation/operation of such a plant were taken from the literature (Tsilemou and Panagiotakopoulos 2006).

Evolution of MSW generation in EMT region, Greece

Eurostat (2014) has reported the evolution of MSW generation in Greece. Unfortunately, the specific MSW generation rate of EMT region in Greece was only available for 2008, through the local Regional Planning for Waste Treatment (DIAAMATH 2013). Thus, the methodology adopted herein was to assume the MSW generation in the EMT region follows the same trend as the total MSW generation rate of the country. The recorded MSW production in Greece, from 2002 to 2011, is presented in Table 1 along with the proportionally calculated production in the EMT region.

Table 1. MSW generation in Greece (Eurostat 2013) during 2002 – 2011, and extrapolations to the end of the life time of the plant (EMT data (DIAAMATH 2013). Numbers in parentheses are estimations for EMT in Mtn yr^{-1}.

2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
4.64	4.71	4.781	4.853	4.927	5.002	5.077 0.277	5.154 (0.281*)	5.892 (0.322)	5.607 (0.306)
2012[1]	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
5.715 (0.312)	5.834 (0.318)	5.952 (0.325)	6.071 (0.331)	6.190 (0.338)	6.308 (0.344)	6.427 (0.351)	6.546 (0.357)	6.665 (0.364)	6.783 (0.370)
2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
6.902 (0.377)	7.021 (0.383)	7.139 (0.390)	7.258 (0.396)	7.377 (0.403)	7.496 (0.409)	7.614 (0.416)	7.733 (0.422)	7.852 (0.429)	7.971 (0.435)
2032	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	*2039*	*2040*	*2041*
8.089 (0.4420	8.208 (0.448)	8.327 (0.455)	8.445 (0.461)	8.564 (0.468)	8.683 (0.474)	8.802 (0.480)			

1 values beyond 2012 are linear extrapolations of the 2002 – 2011 data

* values in parenthesis are calculated values, regarding proportional variation of MSW generation in EMT and in the whole country

MSW composition in the EMT region

MSW composition for EMT Region (Table 2) used in this study was taken from DIAAMATH (2013). Elemental composition and calorific value of the MSW (Table 3) were calculated according to Komilis et al. (2012).

Table 2: Composition of MSW in EMT (DIAAMATH 2013; Komilis et al. 2012).

	% w (wet)	% Moisture	% w (dry)
Fermentable materials	45.80	71.20	20.27
Paper-Cardboard	15.30	5.93	22.12
Plastic	16.50	0.44	25.25
Leather-Wood-Fabric-Tires (LWFT)	5.20	10.50	7.15
Diapers-sanitary napkins-toilet paper (DSNTP)	6.20	5.93	8.96
Metal	3.40	2.50	5.10
Glass	4.30	2.00	6.48
Inert materials	2.00	8.00	2.83
Other	1.30	8.00	1.84
Total	100.00	34.94	100.00

The Higher Heating Values (HHV) of the MSW and of their components, were calculated by their elemental compositions (dry weight), through the correlation (Komilis et al. 2012):

$$HHV = 350{,}26C + 1241.74H - 146.13O$$

in which HHV is expressed in kJ kg^{-1} and C, H, and O denote the weight percentage of carbon, hydrogen and oxygen in the dry matter. The HHV and LHV of the supplementary diesel fuel was taken equal to 46.546 and 43.400 MJ kg^{-1}, respectively.

Table 3: Elemental composition and heating value of EMT's MSW, computed according to Komilis et al. 2012.

	%w (dry)						kJ/kg		
	C	**H**	**O**	**N**	**S**	**ash**	**HHV[1]**	**HHV[2]**	**LHV[2]**
Fermentable	48.00	7.66	32.70	5.75	0.52	5.37	20.761	5.979	3.756
Paper-Cardboard	39.40	5.99	42.20	0.11	0.00	12.30	14.427	13.572	12.189
Plastic	74.90	11.10	5.78	0.14	0.05	8.04	37.948	37.780	35.341
LWFT	60.63	7.65	21.38	4.20	0.16	5.99	26.619	23.824	22.063
DSNTP	39.40	5.99	42.20	0.11	0.00	12.30	14.427	13.572	12.189
Metal	4.50	0.60	4.30	0.10	0.00	90.50	1.619	1.579	1.389
Glass	0.50	0.10	0.40	0.10	0.00	98.90	233	228	158
Inert materials	26.30	3.00	2.00	0.50	0.20	68.00	12.215	11.238	10.436
Other	26.30	3.00	2.00	0.50	0.20	68.00	12.215	11.238	10.436
Total	46.72	6.94	23.07	1.57	0.14	21.56	20.847	13.563	11.718

1 dry basis 2 wet basis

Design parameters of the MSW-mass-burning-to-electricity-plant

The examined Waste-to-Energy (WTE) plant, utilizes a "moving griddle" burner and sustains an operation temperature above 850 ºC (effluent gasses at 130 ºC), using, on average, 1 kg of diesel per ton of MSW, as a supplementary fuel. This burner is able to operate on 5 – 15 MJ kg^{-1} LHV of supplied fuel, and obtains these temperatures with 60 % air excess. The schematic diagram of the steam turbine system is shown in Figure 1. Based on the operation pressures provided by the plant designer, the boxes in Figure 1 denote the temperatures and the specific enthalpies of steam, in the process streamlines. The cogeneration heat exchangers (CHE1-3) were not taken into account (i.e. valves 3-5 were considered closed), since the cogeneration option was not considered for application (WTERT 2013).

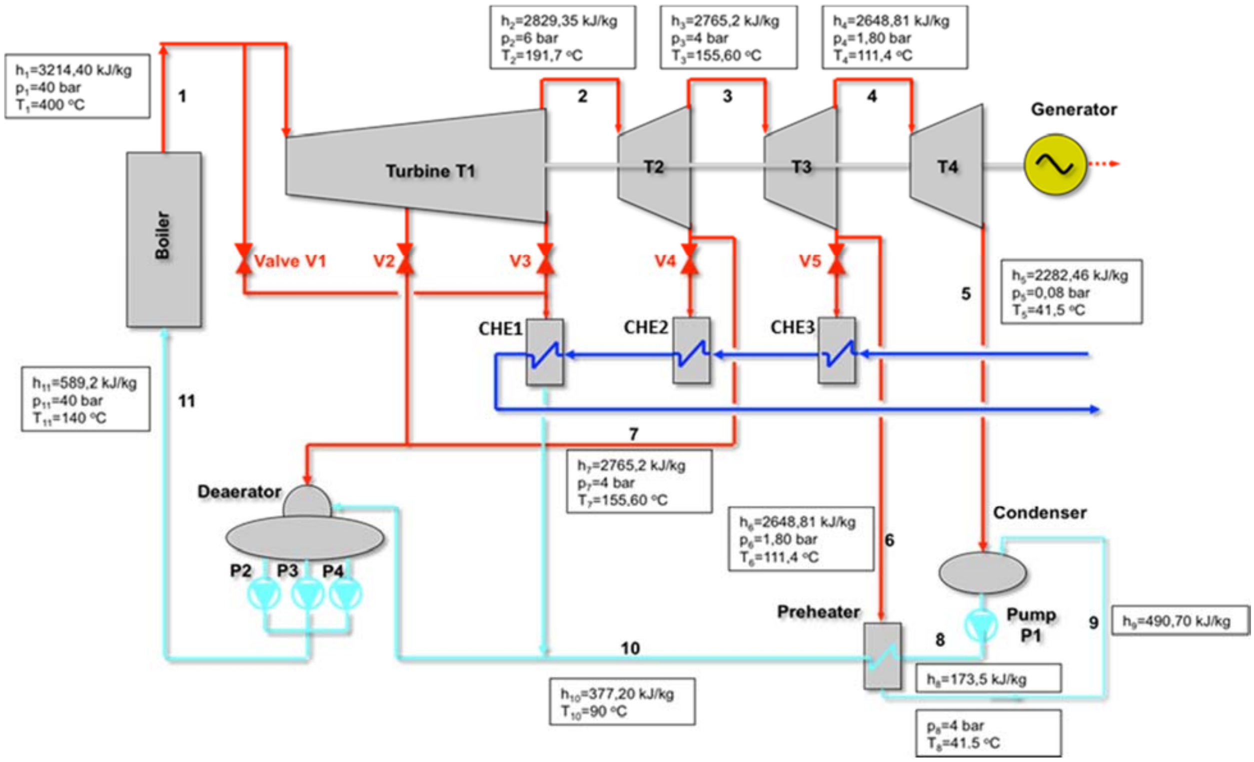

Figure 1: The steam turbine flow diagram of the examined MSW mass burning to electricity plant.

<u>Cost elements</u>

Initial (fixed) costs and annual operating costs of MSW mass-burning-to-electricity plants exhibit a considerable heterogeneity, around Europe. The investment (I) and operating cost (OC) functions used herein was estimated according to the correlations $I = 5000 \times C^{0.8}$ and $OC = 700 \times C^{-0.3}$ (I in €, OC in € tn^{-1} of wet

MSW and C the nominal plant capacity in tn yr^{-1}), which were proposed in literature for WTE solutions in the range of 20 – 600 ktn yr^{-1} (Tsilemou and Panagiotakopoulos 2006). These correlations refer to 2003, and they were inflated to 2013 using an average annual inflation of 2.7 %.

Results and discussion

Based on the maximum calculated production of MSW, in 2010 (0.322 Mtn yr^{-1} – Table 1), the design load of the plant was set at 0.4 Mtn yr^{-1}, increased by a safety factor of about 20 % with respect to the aforementioned maximum. Taking into account the maintenance shut down periods and according to empirical estimations, the annual operating time of the plant was set at 8,000 hr yr^{-1}. Thus, its nominal capacity corresponded to 50 tn hr^{-1}. As shown in Table 1, the projected EMT generation of MSW is expected to reach the nominal plant capacity by the year 2025, i.e. 12 years after its start up and 13 years before the end of its assumed lifetime (25 years, up to 2038). This means that for almost half of its life time the plant will operate at partial load, whereas for the rest of its life time a portion (up to 20 %, in 2038) of the generated MSW will not be treated by the plant, provided that the actual evolution of MSW generation will follow our projections.

According to the elemental analysis of the raw material (Table 3), the amount of O_2 required for stoichiometric combustion of 1wet kg of MSW was 32.55 kmoles kg^{-1}. The corresponding amount of air, for the stoichiometric combustion of 1wkg MSW was calculated, considering the composition of air as 72.01% N_2, 20.69% O_2, 1.26 % H_2O and 0.03% CO_2. As a result, the required stoichiometric air was estimated to be 157.334 moles of air per wet kg of MWS. The excessive air used for such facilities, as the studied plant, is generally around 60 %. Therefore, the air supply to the combustor was set at 251.734 moles of air per wet kg of MWS. The calculated exhaust gas composition is shown in Table 4 (for NO_2, the data was taken from data referring to similar existing mass burning plants – at units of the same technology, CO at the outlet is of the order of 40 ppb and thus CO was neglected (WTERT 2013)).

Table 4: Exhaust gas composition in excessive air conditions 60% (mol kg^{-1} of MSW) and the calculated losses due to exhaust gas sensible heat (L_{ESH}, kJ wkg^{-1} of MSW).

Product	mol wkg^{-1} MSW	a	b	c	d	L_{ESH}
CO_2	25.383	22.26	5.98E-02	-3.50E-05	7.47E-09	10.47
H_2O	44.920	32.24	1.92E-03	1.06E-05	-3.60E-09	160.88
O_2	24.823	25.48	1.52E-02	-7.16E-06	1.31E-09	78.25
N_2	197.105	28.9	-1.57E-03	8.08E-06	-2.87E-09	605.67
NO_2	0.054	22.9	5.72E-02	-3.52E-05	7.87E-09	0.22
SO_2	0.028	25.78	5.80E-02	-3.81E-05	8.61E-09	0.12
Total	292.312					949.83

The energy losses of the combustor were primarily attributed to i) the exhaust gas sensible heat at vent temperature (130 ^{o}C), ii) the latent heat of the steam content the exhaust gas and iii) the sensible heat of the ash removed from the bottom of the burner at approximately 425 ^{o}C (WTERT 2013). The exhaust gas sensible heat losses (L_{ESH}) were calculated by the integration of the heat capacities (c_p, kJ mol^{-1} K^{-1}) analytical expressions ($cp = a + b\times T + c\times T^2 + d\times T^3$) to the exhaust gas temperature. The corresponding coefficients and the calculated energy losses due to exhaust gas sensible heat are also presented in Table 4. The total losses due to the exhaust gas sensible heat were found equal to 949.83 kJ kg^{-1}, i.e. the 8.1 % of the LHV of the wet MSW at the inlet (Table 3).

The specific latent heat of water condensation was taken equal to 40,7 kJ mol^{-1}, and the corresponding latent heat losses, for the calculated exhaust gas composition, was found equal to 1828.22 kJ $kg^{-1}$of wet MSW, i.e the 15.6 % of the MSW's LHV at the the burner's inlet. Considering the specific heat capacity of ash equal to 1,047 kJ kg^{-1} $^{o}C^{-1}$ and an ash outgoing temperature of 425 ^{o}C, the heat losses due to ash removal was 58.74 kJ kg^{-1} of wet MSW, i.e the 0.5 % of the MSW's LHV at the the burner's inlet. Heat losses due to unburned carbon and radiation were considered negligible. Thus, the total calculated heat losses were 2830,79 kj kg^{-1} of wet MSW, and the useful heat, also taking into account the 1 kg of diesel per wet tn of MSW, was 10772.89 kJ kg^{-1} (129.30 MJ s^{-1}). The boiler efficiency was calculated at 10772,89/13609,68 = 79.16 %, whereas 13609,68 is the total HHV at the inlet, i.e. the sum of the HHV of the MSW (13563.15 MJ tn^{-1} wet, Table 3) and the HHV of the auxiliary diesel fuel (46536 MJ tn^{-1} of diesel × 10^{-3} tn of diesel per tn of wet MSW = 46.54 MJ tn^{-1} MSW wet).

The electricity (E_{gross}) produced by the turbine-generator unit of the examined technology, is equal to the sum of energy generated in the four turbines, multiplied by the generator efficiency n_G, which, in this case is approximately equal to 98% (WTERT 2013). According to the mass and energy balances and the thermodynamic analysis of the steam-turbine unit of Figure 1, the net electrical power output was found equal to 41.39 MW, for full load operation of the plant at its nominal capacity. According to data regarding similar units already in operation, 19 % of the net electrical power output is consumed within the power plant and for its own electricity needs (WTERT 2013). Thus, the electrical energy available to grid was 33.52 MW and the overall efficiency 20.53 %, with respect to the LHV of the MSW and the auxiliary diesel fuel.

In order to discriminate which of MSW treatment units can be considered as energy recovery ones, Directive EU2008/98 induced the R_1 coefficient:

$$R_1 = \frac{E_P - E_F - E_I}{0.97 \times (E_F + E_W)} \quad (1)$$

in which E_P is equal to 2.6 times the produced electricity (including the electricity consumed by the plant itself, i.e. the total 41.39 MW for 8,000 hr yr^{-1}) plus 1.1 times the produced heat (which in this case is zero, since the cogeneration option was taken into account), Ef is the fossil LHV induced to the system (in this case through the combustion of the auxiliary diesel, i.e. 43.4 MJ kg^{-1} regarding 1 kg of diesel per tn of wet MSW) , Ew the LHV of the wet MSW, i.e. 400 ktn per yr multiplied by 11718 Mj tn^{-1} and Ei all other (except Ef and Ew) energy supplied to the system, mainly for the electrical energy consumption during the maintenance shut-down period, and for this specific technology is considered equal to the 2 % of the generated electricity, all E_P, E_F, E_I and E_W expressed in GJ yr^{-1}. The coefficient 0.97 refers to losses through radiation and ash removal. Thus, the R1 coefficient, for full load plant operation at is nominal capacity, was:

$$\mathbf{R_1 = \frac{3,099,440 - 17,360 - 23,841}{0.97 \times (3,099,440 + 4,687,017)} = 0.67}$$

a value above the limit that is set by the European Union (0.65), indicating that this specific MSW mass burning to electricity plant, with the specific technology and the measured composition of the local MSW, can be characterized as an energy recovery unit, even without the cogeneration option.

The initial investment cost (I) and the operational cost (OC), which were calculated according to literature (Tsilemou and Panagiotakopoulos 2006), for 2003, were found equal to:

$$I = 5000 \times C^{0.8} = 5,000 \times (400,000)^{0.8} = 151.57 \times 10^6 €$$

$$OC = 700 \times C^{-0.3} = 700 \times (400{,}000)^{-0.3} = 14.60 \text{ €/tn of wet MSW}$$

Taking into account an average annual inflation of 2.7 %, the same costs are expected to have been nominally increased in 2013 to:

$$I_{2013} = IC_{2003}(1.027)^{(2013\text{-}2003)} = 197.8\text{x}10^{6}\text{€}$$

$$OC_{2013} = OC_{2003}(1.027)^{(2013\text{-}2003)} = 19.06 \text{ €/tn MSW}$$

The revenues for the proposed WTE plant are expected from the electricity trade and from the gate fees. According to law 3851/2010, the price at which a WTE plant can sell the electricity it produces depends upon the fraction of this electricity which can be considered as renewable. This renewable fraction can be sold at 87.85 € MWh^{-1}, while the rest (the fossil fraction) at the “System Marginal Price” (SMP). SMP is defined as the instant lowest selling price formed by the electricity bid between electricity suppliers and consumers. The SMP is configured by the price and quantity of electricity that power plants are offering, as well as the hourly load demand. For 2013, the monthly average SMP varied between 62.81 € MWh^{-1} in December and 32.30 € MWh^{-1}, in June, forming a year average of 41.47 € MWh^{-1} (LAGIE 2014). Despite its expected variations, the SMP for the analysis herein was considered equal to 32 € MWh^{-1}, i.e. slightly below the minimum of 2013.

The renewable (biodegradable) fraction of the total MSW was regarded to include the fermentable materials (food waste), the paper/cardboard and, by assumption, the 75 %ww of the TWRL fraction (Table 2). The estimation of the renewable LHV of the local MSWs, i.e. the energy content of the aforementioned renewable components, was calculated according to wet mass fractions, from Table 2, and the specific LHV values of the corresponding wet fractions, from Table 3:

$$\frac{(45.8\times 3,756+15.30\times 12,189+0.75\times 5.20\times 220.53)}{100}=4,445\,kJ/kg$$

and corresponds to the 4,445/11,761 = 37.8 % of the LHV at the inlet (including the LHV of the auxiliary diesel fuel at a portion of 1 kg of diesel per ton of wet MSW). Thus, by considering the selling price of the electricity derived from the MSW renewable fraction at 87. 85 €/kWh and the SMP at 32.00 €, the selling price of the electricity generated by the power plant was calculated at 37.8% x 87.85 + 62.2% x 32 = 53.19 € MWh^{-1}.

Gate Fees for MSW mass-burning WTE plants, in EU, can vary significantly, from below 70 to above 130 € tn^{-1}, depending on the various parameters, the plant's nominal capacity among them (EUNOMIA 2001). Based on the aforementioned correlations for the investment costs, the annual operation costs and the the calculated selling electricity price, and taking into account that such an investment can be subsidized by up to 40 %, Table 5 presents the preliminary feasibility analysis of the examined WTE plant, for gate fees set at 90 € tn^{-1}. This table shows that, for 90 € tn^{-1} gate fees, the Pay Out Time (POT) of the analyzed investment is of the order of 5 years, in case POT is calculated on annual net profits (POT on EBTD further drops to about 2.5 years). The corresponding Internal Rates of Return, were calculated at 13.3 % (on annual net profits) or 24.1 % (on Earnings Before Taxes and Depreciation – EBTD), denoting that such an investment could be economically sound and viable, for imposed gate fees, within the range of values currently applied in EU-27.

In this context, Figure 2 presents the variation of the Internal Rate of Return of a WTE mass-burning plant for the whole potential of MSW of the EMT region, on the variation of the imposed gate fees, between 50 and 110 € tn^{-1}. Selecting POT on net-profits as the economic sustainability criterion of intimate sense,

Table 5: Preliminary feasibility analysis of the proposed WTE plant for gate fees at 90 € tn^{-1} of wet MSW

Initial investment(10^6€)	197,843.79		
Subsidy (10^3 €/year)	79,137.52		
Equity capitals(10^3 €/ year)	118,706.28		
Operating cost (10^3 €/ year)	7,625.08		
Depreciation (10^3 €/ year)	11,870.63		
Electricity revenues (10^3 €/ year)	14,266.30	**IRR on EBTD**	24.10%
Gate fees (10^3 €/ year)	36,000.00	**IRR on net profit**	13.32%
EBTD* (10^3 €/ year)	42,641.21	**POT on EBTD**	2.78
Net profit (10^3 €/ year)	22,770.23	**POT on net profit**	5.21

* Earnings Before Taxes and Depreciation

Figure 2 shows that POT on net profits can still be below 6 years (a limit that can be considered to denote an investment opportunity, in the Greek economic environment), for imposed gate fees as low as 80 € tn^{-1}. For this last gate fee value, the IRR of the investment is still above 10 % (if calculated on net profits, and exceeds 20 % if calculated on EBTD).

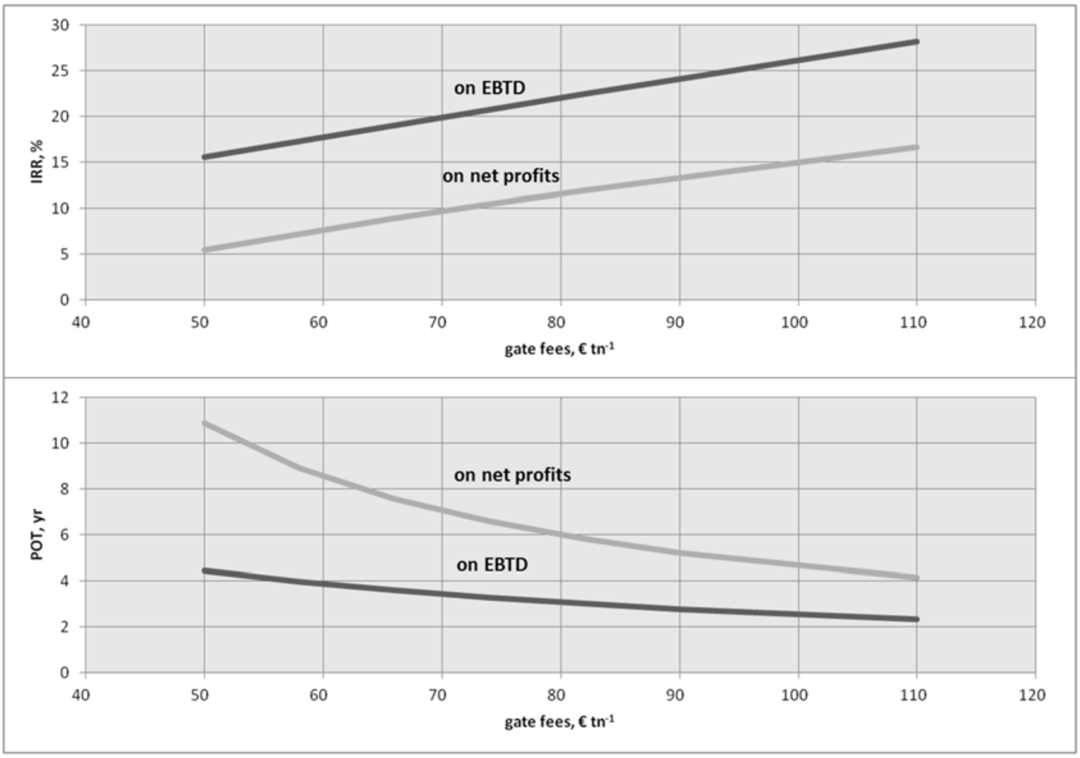

Figure 2: IRR and POT dependence on gate fees, within the gate fee range from 50 to 110 €/tn MSW.

Figure 3 provides an elementary sensitivity analysis of the economic feasibility results of Table 5. Among the three selected parameters (investment costs as calculated by the aforementioned correlations, annual operating costs, still as calculated by the aforementioned correlations and SMP), the economic sustainability of the examined WTE plant in EMT, is more sensitive against the actual height of the initial investment. In this context, Figure 3a shows that if the initial investment of the plant is 20 % higher than the one considered in Table 5, then the required gate fees in order for the investment to obtain 5 years POT on net profits, should be raised to 115 € tn^{-1}, i.e. be almost 30 % compared to 90 € tn^{-1} gate fees assumed in Table 5. Nevertheless, it should be stated at this point that even this value of imposed gate fees is still within the European range for mass-burning WTE plants.

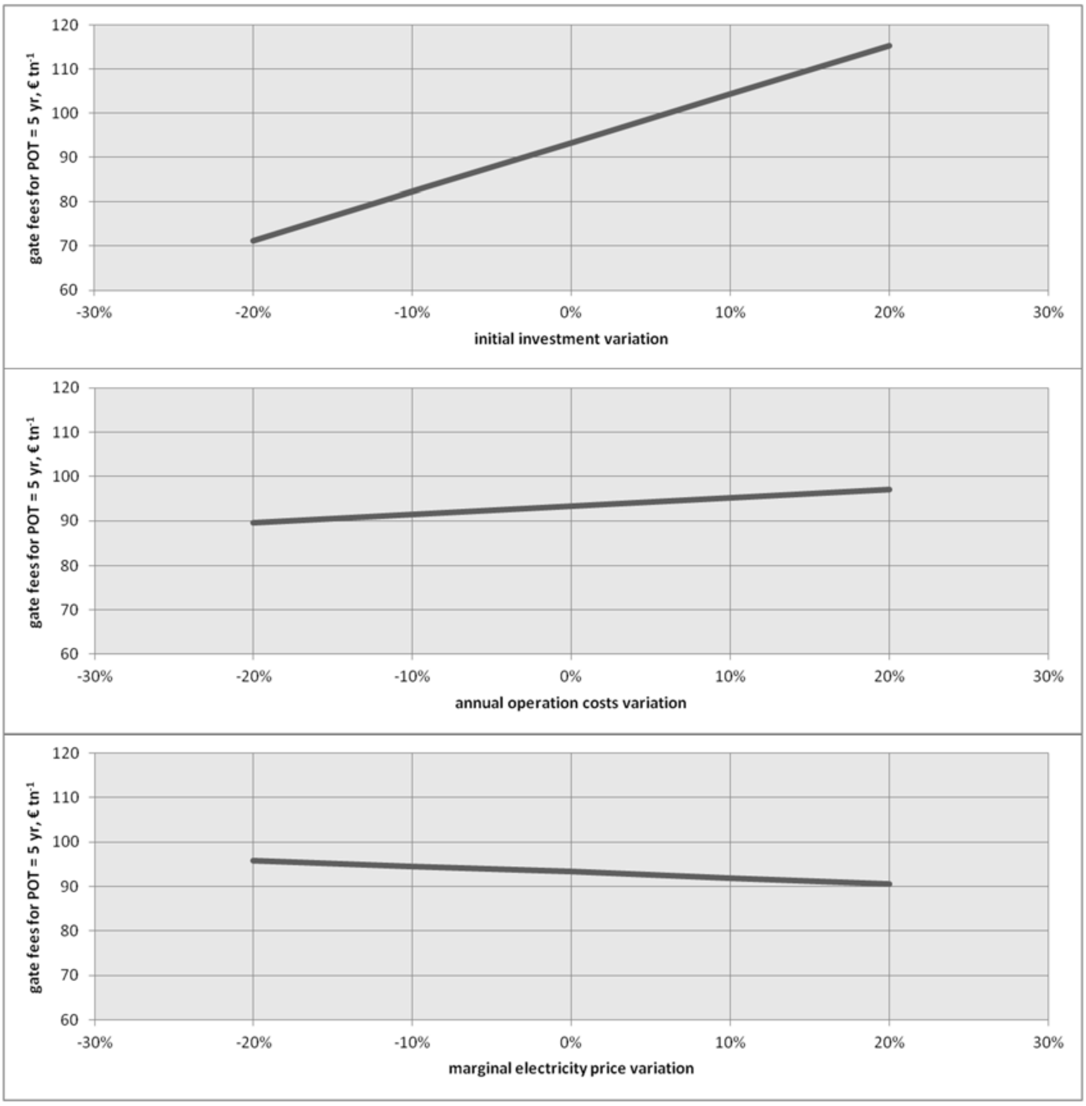

Figure 3: Gate fee variation, in order the POT on net profits to be equal to 5 years, in case (a) the initial investment cost, (b) the annual operation cost and (c) the marginal electricity price varies by ± 20 %, with respect to the corresponding values used for the feasibility analysis of Table 5.

On the other hand, the described investment appears to be much less sensitive to the variation of annual operation costs and on the SNP. Thus the increase of the annual operation costs by 20 %, compared to the value used for the calculations of Table 5, the required gates fees for POT equal to 5 years, do not have to be increased by more than 5 %, whereas the decrease of SNP by 20 % (i.e. to 25.6 € MWh-1) can be counterbalanced by a less than 5 % increase at the imposed gate fees, so that the investment could still achieve POTs of the order of 5 years. For the latest it should be mentioned that the SNP assumed for the year 2013 was lower than the lowest monthly average recorded in this year. It should also be noticed that the recorded SNP values tended to constantly increase in 2013, reaching the historically higher value of 65.11 € MWh^{-1}, in January 2014. Assuming this value for our analysis, the required gate fees for POT = 5 years drops to 75 € tn^{-1}, quite closed to the minimum recorded values in EU-27.

Conclusions

The work attempted a preliminary techno-economic feasibility study of a potential plant for the mass burning of the total potential of MSW in the region of EMT, to generate solely electricity (the option of heat cogeneration was not examined). The total production of MSW in EMT was measured in 2008 and it was found equal to 0.277 Mtn yr^{-1} of wet MSW. Correlating this measured value with the MSW in the whole country, and linearly projecting the latest to 2038 (the end of the assumed 25 yr lifetime of such a plant installed in 2013), a rough picture of the escalation of MSW potential in EMT, was achieved (Table1). According to this escalation, setting the nominal capacity of a potential WTE mass burning plant at 0.4 Mtn yr^{-1} of wet MSW (50tn yr^{-1}, for 8000 hours annual operation), the plant is expected to operate at ± 20 % of its nominal capacity, in the range of its total lifetime.

The performed analysis and the techno-economic feasibility assessment were based on an actual plant technology and design, which is commercially available and already applied for MSW capacities comparable to that of EMT (in Brescia, Italy, for example). Based on the recorded fractionalization of the EMT MSW (Table 2), the elemental analysis of those fractions (Table 3) and bibliographic correlations for the estimation of HHV (Komilis et al. 2012), a thermodynamic analysis of the full load operation of the plant was performed. According to this analysis, the nominal electrical power output of the plant would be 32.5 MW (in agreement with the similar Brescia plant, which operates since 1998) and the total annual electricity production, at full load, would be about 260 GWh. The overall efficiency of the plant was of the order of 20.5 % (on the LHV of the MSW and the auxiliary diesel fuel, the latest at a portion of 1 kg of diesel per 1 ton of wet MSW), and the R1 coefficient was calculated at 0.67 and above the limit for energy recovery set by EU Directive 2008/98. Still based on the aforementioned fractionalization and elemental composition of the local MSW, the renewable fraction of the LHV at the inlet of the plant was calculated at 37.9 % of the total LHV of MSW and the auxiliary diesel fuel. Thus, and according to the Greek Law 3851/2010, the price at which this specific potential plant could sell its electrical production could be 53.2 € MWh^{-1}, in case the average marginal system price of electricity is 32 € MWh^{-1}.

Moreover, based on correlations found in literature (Tsilemou and Panagiotakopoulos 2006) and inflating those correlations to 2013, the initial investment cost of such a plant is expected to of the order of 190 M€ and the annual operation costs of about 20 € tn^{-1} of wet MSW. According to these correlations and the calculated selling price for electricity, the POT of such an investment is expected to be of the order of 6 years, for 40 % initial investment subsidization and 90 € tn^{-1} of wet MSW gate fees. This gate fee value lies within the range of gate fee values currently applied in EU-27 and clearly allows the economic viability of a MSW mass burning to electricity solution in EMT. Finally, the gate fees required for economic viability (assumed at 5 years POT, calculated on net profits) were found sensitive on the actual height of the initial investment, whereas the expected considerable increase of MSP in the forthcoming years further enforces the prospects of this viability, enen at gate fees as low as 75 € tn^{-1} (which would be among the lowest gate fees for mass burning in EU-27)

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