Assessment of Alternatives for RMSW Treatment for Valcea County, Romania

STEFAN-ION CIORANU[1]*, MIRCEA GRIGORIU[1], MARCO RAGAZZI[2], ELENA CRISTINA RADA[2], GABRIELA IONESCU[2]
[1] Politechnica University of Bucharest, Faculty of Power Engineering, Department of Energy Production and Use, 313 Splaiul Independenei , 060042, Bucharest, Romania
[2] University of Trento – Department of Civil Environmental and Mechanical Engineering, Via Mesiano 77, 38123 Trento, Italy

This paper presents an analysis of the current and future situation in terms of waste management in Vâlcea County, Romania. Two alternatives for waste landfilling are presented: co-incineration in cement kilns and incineration in a proposed incineration plant. A bio-drying facility is also suggested as an option for residual municipal solid waste pre-treatment before energy recovery. Results regarding population, waste evolution, quantities of generated residual municipal waste and solid recovered fuel are presented. Estimations of lower heating values were performed through indirect methods. Finally, preliminary energy and economical balances were established.

Keywords: waste, incineration, solid recovered fuel, elementary composition, energy balance

On the 1st of January 2007 Romania became a member of the European Union [1]. This recently obtained status involves both rights and obligations derived from the EU treaties and legislations.

In terms of waste management, Landfill Directive 99/31/CE implies major changes, requesting the diversion of biodegradable waste from landfilling with 50% by 2017 [2]. This way, the implementation of selective collection (SC), of materials recycling and waste-to-energy (WtE) technologies is needed. The purpose is to minimize as much as possible the harmful effects on the environment (air, surface water, groundwater, soil) and on human health.

In light of the above this paper presents a study for Vâlcea County, regarding the current and future situation of waste management. The energetic and economical balances are developed considering the EU waste management targets.

Results and discussions

Materials and methods

Vâlcea County is one of the 41 counties, having 2 municipalities, 9 towns and 78 communes, and is located in the south of Romania. The population in this county is about 406,752 inhabitants producing about 149,200 t of municipal solid waste (MSW) per year. Presently, approximately 85% of produced MSW is landfilled [3].

Table 1 shows the values regarding population and MSW generated for the present (year 2013) and future (year 2017) situations [3].SC is implemented in some parts of the county, achieving about 10%. The waste SC is low (about 4%) for the materials with high calorific value (LHV) and only a little part of the food waste (about 15%) is collected in order to be treated in a pilot composting plant [2].

Figure 1 displays the composition of MSW in Vâlcea County. These data are consistent with the MSW composition generated in Romania, where the organic fraction varies between 40 and 50% [2,4-6].

The actual capacity of treating biodegradable fraction and the lack of recycling facilities leads to failure in achieving the targets imposed through European and local legislation. However, the municipality started to implement an Integrated MSW System (ISWMS) in order to comply with the 2017 targets [3]. The SC targets, that must be achieved, are presented in table 2.

Based on the ultimate analysis of each fraction of the generated waste [7-10], an estimation of LHV using indirect methods was performed. In the scientific literature, there can be found several expressions used for its calculation [7,11]:

Table 1
VÂLCEA COUNTY: POPULATION AND MSW

Year	**2013**	**2017**
Inhabitants	399,515	391,741
Sanitation service coverage (%)	100	100
Household waste (t/y)	102,041	102,465
Similar comercial, industrial and institutional waste (t/y)	36,751	37,641
Garden and park waste (t/y)	945	949
Waste from market (t/y)	1,889	1,897
Street cleaning residues (t/y)	5,667	6,792
Total collected MSW (t/y)	**147,293**	**149,744**
Hazardous MSW (t/y)	781	766
Bulky waste (t/y)	1,126	1,404
Total generated MSW (t/y)	**149,200**	**151,913**

Composition of MSW generated in Vâlcea County

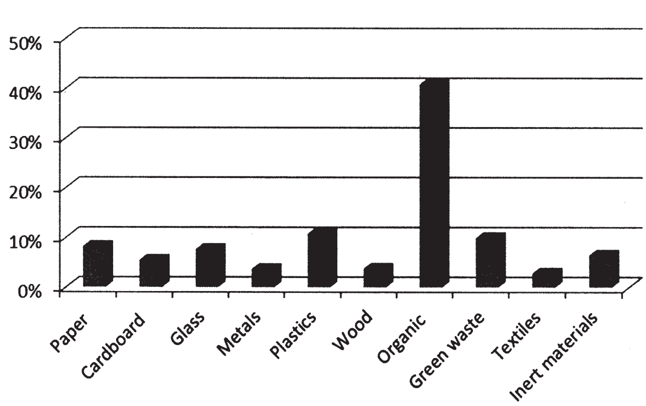

Fig. 1 Composition of MSW – present situation

* email: ionut.cioranu@yahoo.com

Paper and cardboard	Glass	Metals	Plastics	Wood	Food waste	Textiles	Inerts
60%	60%	50%	22.5%	15%	75.5%	0%	0%

Table 2
SC TARGETS

$$LHV = [81C + 342.5\left(H - \frac{O}{8}\right) + 22.5S - 6(W + 9H)] \times 4.18 \quad (1)$$

$$LHV = [81(C-\frac{3}{8}O)+57\frac{3}{8}O+345(H-\frac{O}{16})+25S-6(W+9H)] \times 4.18 \quad (2)$$

$$LHV = \frac{4.18}{100}[8{,}100C + 28{,}690\left(H - \frac{O}{8}\right) + 2{,}210S - 600W] \quad (3)$$

$$LHV = \frac{1}{100}(p_1 \times h_1 + \cdots + p_n \times h_n) - \frac{W}{100} \times 600 \times 4.18 \quad (4)$$

where:

LHV [kJ/kg], C - carbon content (wt%), H - hydrogen content (wt%), O - oxygen content (wt%), S -sulfur content (wt%), W - moisture content (%), p_n - waste fractions (%), h_n - calorific value of waste fraction.

In the present paper two sustainable scenarios are developed for RMSW treatment considering the present and future MSW situation.

In both cases, a bio-drying facility for the RMSW treatment with the possibility of producing solid recovered fuel (SRF) in concordance with CEN/TS 15359, is proposed [12-14]. SRF has advantages both from environmental and economic point of views, for example: improvement of environmental performances concerning CO_2 emissions and the possibility to use as substitute fuel in the existing plants.

For the present situation, only the bio-drying treatment and storage or co-combustion in a cement plant of the obtained products was taken into account [15,16].

For the future situation, the WtE through incineration for energy purposes was considered for the bio-dried material and also for the SRF [17-21], as follows:

- SRF co-incineration in rotary kilns for cement production;
- SRF incineration with energy recovery (thermal and electric energy).

In order to propose an incineration plant for Vâlcea County, the data from the one that will be constructed in Trento were used [22]. The SC in Trentino region arrives to 65%. In table 3, the principal operating parameters of the Trento incinerator plant are presented.

In table 4 the quantities of RMSW generated in Vâlcea County for years 2013 respectively 2017 are displayed.

Based on the obtained RMSW characteristics, the LHV was estimated using equation (4) for the current and near future situations. The LHV of the bio-dried matter and SRF were estimated using a bio-chemical model [12,23,24].

Maximum capacity (t/y)	103,000
Rated thermal load capacity (MW_{th})	60
Waste LHV (interval) (kJ/kg)	6,300-15,800
LHV (kJ/kg)	13,700
Average flow rate effective waste (t/h)	13.2
Maximum flow rate (t/h)	15.53
Minimum net electrical efficiency (%)	23

Table 3
CHARACTERISTICS OF TRENTO INCINERATION PLANT

Waste composition	RMSW 2013	RMSW 2017
Paper and cardboard waste	14.68 %	12.85 %
Glass waste	8.28 %	7.01 %
Metallic waste	3.94 %	4.72 %
Plastic waste	11.62 %	19.15 %
Wood waste	3.73 %	7.45 %
Biodegradable waste	47.27 %	27.04 %
Textile	3.22 %	7.17 %
Inert materials	7.26 %	14.62 %

Table 4
RMSW COMPOSITION

Year	2013	2017
Selective collecting (%)	10.30	55.48
RMSW (t/y)	127,032.19	63,637.24
SRF_BD (t/y)	94,283	52,463
SRF (t/y)	77,397	38,639
Mass loss (%)	25.78	17.56
Post-treatment residues (%)	17.91	26.35

Table 5
SRF, SRF_LIKE QUANTITIES

	LHV (kJ/kg)		SRF class		SRF use	
Year	2013	2017	2013	2017	2013	2017
SRF_RMSW	7,532	10,016	5	4	cement factory	cement factory
SRF_BD	9,923	13,554	5	4	cement factory	incineration
SRF	12,052	18,279	4	3	cement factory	incineration

Table 6
SRF CLASS

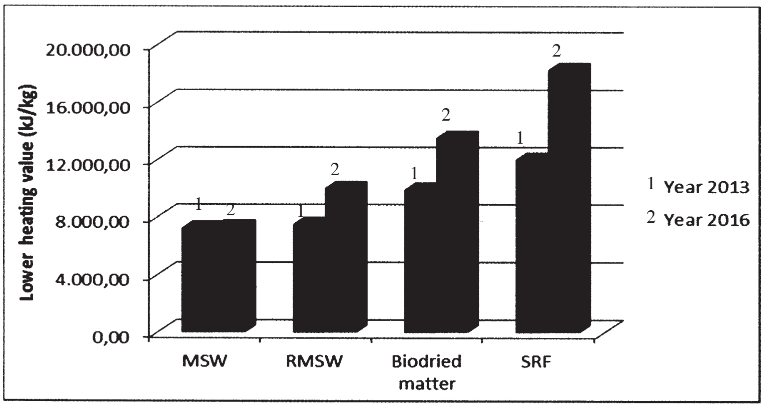

Fig. 2 Lower heating value increas

Table 7
TECHNICAL CHARACTERISTICS OF THE PROPOSED INCINERATION PLANT FOR VÂLCEA COUNTY

Maximum potential	t/y	65,000
Minimum anual disponibility	h	8,640
Waste feed in flow - per hour	t/h	7.5
Waste feed in flow - per second	kg/s	2.1
Waste LHV (interval)	MJ/kg	7.5-18.5
Thermal power	MWth	38
Primary source conversion efficiency	%	0.6
Minimum net electric efficiency	%	0.23
Electric output	MWe	8.8

In table 5 data regarding the MSW, RMSW, SC efficiency, are presented [14, 25]. The bio-dried material (BD), and the RMSW were considered as SRF-like products. The quantities of SRF-like and SRF were determined taking in account the mass loss during the bio-drying process and the not-combustible fraction extracted from the BD [12].

In figure 2 the LHV of all products (MSW, RMSW, BD, SRF) for the present and future situation is reported.

In table 6 the obtained class for the SRF and SRF products, and also the indication for their utilization are reported [25].

Taking into account the obtained results, a bio-drying facility proposed for the case-study will produce about of 50,000 t/y of SRF. The proposed incineration plant will have the technical characteristics exposed in table 7, determined in accordance with the present and future waste generation.

The proposed incineration plant will have two lines (for guaranteeing flexibility to the operations) equipped with moving grate incineration installations.

The quantities of energies recovered through incineration, in form of heat and electricity, for the future situation are presented in table 8 [26,27].

The initial investments, necessary for the construction of the proposed bio-drying facility, and for the incineration plant are presented in tables 9 and 10 [2,28]. The economic figures were estimated based on the current market prices and must be considered as a first approximation.

The preliminary economical balances were determined taking into account the actual market prices in Vâlcea County. The return of investment for the bio-drying facility was calculated depending on the quantity of RMSW diverted from landfilling and its cost. The return of investment for the incineration plant was determined considering the amount of recovered energies and their local value per unit. Also, in the case of produced electric energy, the number of green certificates awarded (GC) and their price were taken in account. The main results are presented in table 11.

The advantages of bio-drying coupled with a cement factory are the low initial investment and the valorisation of existing industrial plants. The advantages of a dedicated combustion plant are: independence from a third party and the possibility to keep direct control on profit.

The use of bio-drying before incineration is not usual as it is an additional cost. The SC of the county can help to increase the LHV of the RMSW in order to limit the choices between SRF production for cement factory and direct incineration of RMSW. That means table 11 should be modified in order to point out that bio-drying with SRF generation can be coupled with an incinerator but additional costs for the fee to be paid to a cement factory must be considered.

Table 8
ENERGY PRODUCED BY THE INCINERATION PLANT IN 2017

Recovered energy	RMSW	SRF_BD	SRF
Thermal energy [GWh/y]	106	119	118
Electric energy [GWh/y]	24	27	27

Table 9
BIO-DRYING FACILITY INVESTMENT AND OPERATING COSTS

Initial investment	
Item	**Price (€)**
Land	480,000
Bio-drying plant and post refinement	900,000
Tank construction	192,000
Improvements	266,400
Excavation/ disposal equipments	48,000
One gummed scoop	110,000
Piping	160,000
Leaching collection system	32,000
Leaching collection tank	11,200
Office building	20,000
Deodorizing installation	24,000
Design and engineering	40,000
Contingency	50,000
Total investment	2,333,600
It follows	
Operating and maintenance	
Item	**Price (€)**
Leaching transport	11,200
Leaching storage	32,000
Deodorizer products	12,800
Fuels	28,800
Electricity	24,000
Maintenance	16,000
Personnel	224,000
Insurance	8,000
Total	356,800

Initial investment		
Object	%	Price (€)
A. Civil works for plant/ and machinery		
Incineratin Installations	50%	22,750,000
Civil and industrial buildings	9%	4,095,000
Technological systems	8%	3,640,000
Equipment for processing high / medium voltage and for the distribution of electrical energy	7%	3,185,000
Installations for the production of electric energy	7%	3,185,000
Finishing of general works in wood, plastic, metal, glass	4%	1,820,000
Structural comp. (steel, metal)	4%	1,820,000
Finishing of general works of a technical nature	3%	1,365,000
Installations for the mobility suspended	2%	910,000
Electromechanical conveyor	2%	910,000
Finishing of general works of nature construction	1%	455,000
Special structures	1%	455,000
Internal electrical, telephone, radio, and television	1%	455,000
Earthworks	0.4%	182,000
Precast reinforced concrete	0.2%	91,000
Green and urban design	0.2%	91,000
Aqueducts, pipelines, irrigation, evacuation	0.2%	91,000
Subtotal chapter A:		45,500,000
B. Security		2,400,000
C. Costs for surveys, inquiries, investigations		480,000
D. Costs for connection to public services/infrastr.works		300,000
E. Design and technical costs		2,580,000
F. Consulting		240,000
Total investment		51,500,000
Operating costs		
Type	**Unit**	**Costs (€/y)**
Administrative staff	30 pers.	1,500,000
Chemicals	2500 t/y	625,000
Maintenance		2,000,000
Slag disposal	12500 t/y	900,000
Dust disposal	2500 t/y	600,000
Other costs (monitoring)		300,000
Total		5,925,000

Table 10
INITIAL INVESTMENT, OPERATION AND MAINTENANCE COSTS FOR THE PROPOSED INCINERATION PLANT

Object	Unit	Quantity
Bio-drying facility		
Produced SRF	t/y	0
Waste diverted from landfilling	t/y	63,637
Price per treated tone of waste	€/t	15
Income	€/y	954,555
Cost	€/y	356,800
Profit	€/y	597,755
Return of investment	Y	4
Incineration plant		
Produced thermal energy	MWth	117,713
Produced electric energy	MWh_e/y	27,074
Electric energy consum for plant functioning	MWh_e/y	2,707
Electric energy for sale	MWh_e/y	24,367
Price of Gcal.	€/Gcal	46
Price of MWh_e	€/MWh_e	115
Green certificate price	€/MWh_e	55
Certificates awarded	GC/MWh_e	1
Income	€/y	8,947,129
Cost	€/y	5,925,000
Profit	€/y	3,022,129
Return of investment	y	17

Table 11
ECONOMICAL BALANCE

Conclusions

This paper presents a case study of Vâlcea County, regarding the present and future situation of waste management. In order to comply with the European legislation, especially Directive 99/31/CE regarding waste landfilling, the municipality is implementing an 'ISWMS in Vâlcea County'. The aim is to minimize as much as possible the quantity of MSW that is landfilled and encourage SC, material recycling, waste-to-energy technologies and waste treatment before disposal through landfill. If the assumed targets are achieved it will mean that major progress was made in terms of waste management in the county.

Because the RMSW has high moisture content a bio-drying process before thermal treatment was considered. This helps to reach the targets regarding the landfilled biodegradable waste, the recyclable material and energy recovery.

Due to the bio-drying process, the LHV of the waste will greatly improve making it suitable for co-incineration in cement kilns, or for incineration with recovery of energy (thermal and electric). This second option can be managed without bio-drying if SC develops according to the targets.

Besides the clear environmental advantages, there are potential financial benefits also.

Nevertheless, it is hard to say that waste bio-drying and thermal treatment are, in our case, the most beneficial solution, even though it is an attractive one. This fact has to be established following a more complex environmental and financial analysis.

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