Energy Conversion and Management 77 (2014) 709–720

Contents lists available at ScienceDirect

Energy Conversion and Management

journal homepage: www.elsevier.com/locate/enconman

Strategic municipal solid waste management: A quantitative model for Italian regions

Federica Cucchiella *, Idiano D'Adamo, Massimo Gastaldi

Department of Industrial and Information Engineering and Economics, University of L'Aquila, Via Giovanni Gronchi 18, Zona Industriale Pile, 67100 L'Aquila, Italy

ARTICLE INFO

Article history:
Received 18 August 2013
Accepted 11 October 2013

Keywords:
Energy recovery
Quantitative model
Waste management
Delay cost
Social benefits

ABSTRACT

Current economic crisis brought to light the structural deficiencies of European economy. This paper aims to improve the performances of a policy on sustainable municipal solid waste management strategies. Specifically, the attention is focused on Italian country that reports a high rate of landfilling. Waste to Energy plant is an attractive technological option in municipal solid waste, but it is a subject of intense debate. Incinerators require effective and efficient controls to avoid emissions of harmful pollutants into the air, land and water, which may influence human health and environment.

To address waste management situation, this study uses a multi-objective mathematical programming. A new plan is presented to evaluate and quantify the effects of initiatives for diversion of current waste from landfill. In an attempt to better simulate realistic waste management scenarios, the amount of waste generated is not annually constant and changes are accounted in waste diversion rates. Moreover, due to the geographical characteristics of Italy, the realization of new facilities is replicated with a regional detail. In this paper economic and financial indicators are used to define the profitability of waste facilities. Moreover, a sensitivity analysis is used to test some of the initial assumptions. Once identified the efficient Waste to Energy plant, regional strategies of waste management are proposed to optimize financial and environmental benefits of the sector. The proposed waste management framework provides a concrete scheme for future research in assessing quantitatively the effectiveness of waste management.
© 2013 Elsevier Ltd. All rights reserved.

1. Introduction

Due to climate changes, economic crisis, public health management, reduction of emission pollutants and the selection of new renewable sources, European Union (EU) emphasises the importance of improving resource efficiency and sustainable material management through the green economy concepts. The final aim is to make Europe more competitive, create new jobs opportunities, increase the investment opportunities [1–3].

This paper focuses on waste management with the aim to develop a management system that satisfy the EU regulations that, according the 2008 directives, require to Member States to introduce legislation on waste recycling. The landfill use has to be the last resort for waste management. Really a correct waste management is based on the amount minimization of waste generated, in this way, new waste prevention initiatives are required for waste minimization and new waste reuse initiatives are required [4–6].

In 1975, with the Directive 75/442/EEC, European Union introduces the waste hierarchy concept into European waste policy. The relevance of waste minimization is emphasized and political actions have to be regulated to ensure a high level of protection for the environment and human health.

A responsibility common framework is established by EU for preventing and remedying damage to animals, plants, natural habitats and water resources, and damage affecting the land. Directive 2004/35/EC on environmental liability is based on the "polluter pays" principle for preventing and remediate to environmental damages. Legislation, with the aim of waste prevention and correct waste management, has also defined a "guiding principle" as proposed by Council: a priority order (waste hierarchy) is defined to prevent and reduce waste production.

"The waste hierarchy generally lays down a priority order of what constitutes the best overall environmental option in waste legislation and policy, while departing from such hierarchy may be necessary for specific waste streams when justified for reasons of, inter alia, technical feasibility, economic viability and environmental protection" (Directive 2008/98/EC).

The Waste Hierarchy approach is finalized to avoid, eliminate and prevent the causes of environmental problems. It represents a fundamental change with echoes widespread in human health and medicine: prevention is better than cure. The benefits deriving by a proper waste hierarchy application can be identified on: greenhouse gases emission prevention, pollutants reduction,

* Corresponding author.
E-mail addresses: federica.cucchiella@univaq.it (F. Cucchiella), idiano.dadamo@univaq.it (I. D'Adamo), massimo.gastaldi@univaq.it (M. Gastaldi).

0196-8904/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.enconman.2013.10.024

energy saves, resources conservation, new jobs creation, development of green technologies.

The directive defines a hierarchy of waste management options based on five steps which must be applied by Member States: the preferred option is waste prevention, the following ones are the reuse, recycling, recovery including energy recovery and, only as last resort safe disposal. Waste incineration is contemplates as an energy efficient recovery (Fig. 1).

In the present paper, the attention is focused on the waste energy recovery given by the incineration: this form of waste management has more benefits than the landfill disposal. Incineration can be classified as a recovery treatment rather than disposal, additionally the incineration meets certain energy efficiency standard [7,8]. Landfills can create pollution of air, land and water. One environmental problem deriving from landfills is groundwater pollution from leachates. Moreover, there are over 10 toxic gases released from landfills, of the most serious of which is methane. The use of incinerator for waste management presents environmental risks; indeed, this facility can create toxic air pollution and toxic ash. It is necessary the use of technology new facility and the application of advanced regulation scheme to prevent and minimize any risks that can derive to the environment or health [9–11]. Incinerator facilities also contribute to externalities but they represent a positive aspect since not only the direct externalities are to be considered (due to waste incineration) but also the indirect one (due to avoided emissions from conventional energy production) [12,13]. Even if some authors identify in landfill the best solution for waste management [14] and others sustain that is necessary but not sufficient to improve the economic efficiency [15,16], the present paper is focused on incinerators. The scope is individualize a framework to optimize the national performances deriving from these facilities and increase the heat and electric energy recovery [17,18].

A correct waste management system requires that several aspects have to be integrated: local governments have to follow sustainable development approach in solving the waste problems, additionally environmental, economic and social impacts of investments in waste sector have to be well integrated. All steps of waste management (for example: waste minimization, segregation and containerization, intermediate storage, internal transport, centralized storage) are relevant decisional points and it is necessary to adopt proper analysis for the definition of an optimal and correct waste management framework [19,20]. To proceeding in this way, this research has required analysis, previously achieved, related to:

- localization of incinerators facilities, evaluation of centralized or decentralized solutions, economic, financial and environmental analysis of incinerator investment [21]
- sensitivity and risk analysis [22]
- definition of optimal waste management strategy for the Italian regions [23]

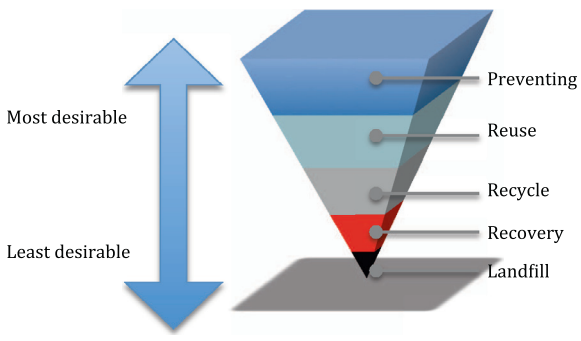

Fig. 1. Waste management hierarchy.

In the follow of paper, the current management systems in Europe and Italy are presented (Section 2). Since the final scope is to define a national optimal waste management strategy, is required to analyse the possible waste management disposal and the connected financial benefits (Section 3). The estimated results show that, to achieve a financial benefit, the facilities realized have to be not smaller than 350 kt incinerator capacity. The estimation of incinerator minimum sizing is based on several variables: lower heating value, selling price of electricity, heat selling price, investment cost, and interest rate. Before to proceed, a sensitivity analysis is performed with the object to analyse if the definition of the minimum plant is affected by changes in the assumptions.

To improve environmental outcome from the management of waste sector each State promotes the adoption of a waste management system (WMS). In Section 4 is firstly described the current waste Italian outcomes (cWS) achieved with the adoption of current WMS (cWMS). Given that the major aim of government in promoting WMS is to improve the waste management, it has to estimate the waste situation to be managed in the future WMS (fWMS). The definition of future waste systems (fWS) is based on the amount of wastes produced in the nation, and the waste share geared at energy recovery. After the description of cWS and fWS, the second aim of the paper is to define the fWMSs to achieve adequate outcomes. More specifically, the proper fWMSs processes based on the optimal mix of incinerators size are defined. A quantitative approach is adopted for defining the fWMS based on the optimization of financial net present value (FNPV), Waste Valorisation (WV) and wealth public benefit (WPB). The fWMSs are defined with a regional detail. The regional results are analysed in Section 5. In Section 6, a national perspective of results is presented. In addition, frequently occurs that there is a delay in investment project realization, also when it is defined a waste management system that can determine positive outcomes. In Section 7the losses deriving by an implementation delay are quantified. Concluding remarks close the paper (Section 8).

2. European and Italian current waste situation

Based on Eurostat data, CEWEP (Confederation of European Waste-to-Energy Plants) analyses the municipal waste treatment in 2010. For each EU-27 member, are defined the waste share landfilled, incinerated, recycled and composted (Fig. 2). Germany, Netherlands, Austria, Belgium, Sweden and Denmark have a share of waste landfilled below 3%. Reported share of landfill for Italy is 51%, a share 13% highest with respect to European average. The implementation of EU legislation has determined share reduction of landfilled in EU-27 members. In Denmark, Austria, Sweden, and Germany it is not allowed to open new landfill. Greece is the only old Member State where the landfill has a share upon 80%; all the other Members with a so high landfill use are new Member States.

In EU-27 the waste generation have been reduced from 2009 to 2010. The drop has been of 1.1% (from 255.2 Mt to 252.5 Mt) similarly from 2008 to 2009 a 1.5% decrease has been observed. For the Countries with high population level, municipal waste generation decreases in Spain (1.8%) and Germany (1.6%). Whereas in United Kingdom it is achieved a slow waste reduction (0.2%), this indicator increases in Italy and France respectively for 1.1% and 0.1%. This is due to the growth of socio-economic indicators, like GDP and household consumption, which are strongly correlated to waste generation.

Based on ISPRA data, Italian waste generation has been of 32,479 kt in 2010 and 32,110 kt in 2009. In Friuli, Emilia and Lazio the increase has been more than 3%, Veneto, Toscana, Umbria and Campania have increased the waste generation of 2%. On the

Download English Version:

https://daneshyari.com/en/article/7166013

Download Persian Version:

https://daneshyari.com/article/7166013

Daneshyari.com