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Sustainable management of waste-to-energy facilities ☆

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ABSTRACT

In 1995, Porter and van der Linde defined pollution as a manifestation of economic waste. Currently, incorrect information and conflicting theories among scientists hinder the diffusion of sustainable practices in waste management [1]. New industrial market research reports highlight that the value of the global waste incineration market has increased in recent years (+$1.3 billion dollars from 2008 to 2012), and this sector will continue to grow (+$6.8 billion dollars from 2012 to 2022) [2].

The paper focuses on the Italian situation on which urgent actions are required because more than 50% of waste is landfilled [3]. The correct environmental management increases the financial performance because waste investments offer both environmental and economic benefits. The problem to solve is related to both waste management and high levels of recycling, where an unsorted fraction of waste will remain. Based on a thorough review of the topic, a national waste management plan (NWMP) for energy recovery is herein proposed for evaluating all the aspects of sustainability of waste-to-energy (WTE) plants: the reduction of greenhouse gases (GHGs) with respect to landfill, the estimation of financial net present value (FNPV) and the economic net present value (ENPV) and, finally, the estimation of new employment opportunity.

Contents

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1. Introduction

The global population is likely to grow, and the rapidly increasing standards of living in some developing countries, along with the escalating accumulation of greenhouse gases in the atmosphere, make the goal of sustainability increasingly urgent [4,5]. This topic continues to attract a significant amount of attention within the academic, managerial and policy-making communities [6,7]. Sustainable development requires viable answers following economic, social and environmental criteria [8]. Interdisciplinary research (e.g., between the above criteria) is increasingly recognised as an essential cornerstone for linking together specialised knowledge [9]. A literature review of quantitative studies offers interesting implications for managers, as a real commitment to green management may result in positive influence on financial performance [10]. With investments in renewable energy, investors gain access to reliable and healthy long-term returns at low risk. This is a sector characterised by relevant growth, and with the definition of renewable energy goals and portfolio standards, it is possible to meet short- and long-term objectives for renewable energy [11].

The generation of electricity, heat or biofuels from renewable energy sources has become a high priority in energy policy strategies at the national level as well as on a global scale [12]. An analysis of the protection policies of the United States indicates that strong environmental programs result in lower levels of pollution and better public health [13]. Environmental corporate social responsibility generates new and competitive resources for firms. Waste management can lead to achieving significant financial benefits, and, in the case of waste management violations, the firms are subject to substantial fines or civil penalties [14].

This paper aims to study the sustainability of WTE plants. Thus, a multisectorial analysis is required for evaluating all aspects necessary to reduce pollution, to create new jobs and to provide financial and economic benefits. The paper is organised as follows. Initially, the role of WTE plants in waste management is described (Section 2), and some statistics are presented describing waste management and resource recovery in Italy (Section 3). The data indicate growing waste production. Moreover, the data also indicate separate collection rates of municipal waste management (MSW) which are increasing in all Italian regions for all waste fractions. However, the share of separate collection is increasing more slowly than in other European countries. Previous papers underline that it is proper to proceed with regional plans finalised at the realisation of incinerators with energy recovery. In this manner, an appropriate NWMP allows a considerable reduction of 34% in landfilling [14–16]. A multi-sectorial sensitivity analysis for an in-depth evaluation of NWMP is presented, and the input data required to evaluate the NWMP of incinerators investments are described (Section 4). Specifically, facilities realisation is evaluated according to several points of view:

- Environmental: computing emissions of kg of equivalent CO_2 avoided incinerating a metric ton of waste instead of placing it in a landfill, and this was also the case of modern landfill with biogas capture. To take into account several aspects (incineration operation, biogas capture option), several scenarios are analysed.
- Financial: evaluating market conditions and how financial revenues (FNPV) depend on critical inputs (selling price of electricity, lower heating value, heat selling price, investment cost and interest rate).
- Economical: evaluating ENPV that, differently by Public Benefits (WPB), accounts both for externalities and market failures.
- Social: quantifying the new employment opportunity due to the facility realisation.

The sustainability of the national incinerator plan is also evaluated by a sensitivity analysis (Section 5), and some final remarks are also presented with the aim of promoting the sustainability of a mixed waste strategy in real case applications (Section 6).

2. Literature review

Sustainable waste management (SWM) has a central role in sustainable development. It varies regionally and also depends on waste composition. According to an analysis provided by a research company in North America, landfills are by far the preferred methods of disposal for MSW [15,16]. In China, the government is depending on all forms of SWM, including WTE, to minimise and reduce anticipated future waste management burdens [17].

Over 80% of MSW in China is still being disposed of in anaerobic landfills [18]. The appropriate MSW management in China is crucial to solving problems caused by the large generation and accumulation of wastes [19]. It is estimated that MSW incineration will account for approximately 35% of waste elimination by the end of 2015 [20]. Recycling is necessary, but China is facing several obstacles: the improvement of public awareness, the limitations of traditional garbage classification, the lack of laws and regulations, and the garbage of recycling facilities is not complete [21].

The Southern European Union (EU) countries need to develop further measures to implement more integrated MSW management and reach EU directives, whereas the Central EU countries need models and tools to rationalise their technological choices and management strategies [17].

As shown in Table 1, Germany, The Netherlands, Belgium, Austria, Sweden and Denmark represent the more advanced countries from an environmental point of view. The benefits derived from a proper MSW management include greenhouse gases emission prevention, pollutants reduction, energy saves, resources conservation, new jobs creation, development of green technologies and economic opportunities [3].

Public relations issues remain to be solved as in many territories it is believed that incinerators are more polluting then landfill. A holistic approach has been introduced to evaluate social acceptance of renewable energy [22]. In contrast to previous models, this model specifically analyses market acceptance in addition to public and political elements. Reputable firms are more likely to invest in the clean energy sector and utilise risk reduction strategies more extensively [23]. An interesting paper asks: “Profit or sustainable advantage, what should be the dependent variable for strategy?” [24].

The value of the global waste incineration market was equal to $9.2 billion dollars in 2012, up from $7.9 billion dollars in 2008. By

Table 1
Landfill usage in Europe (2011).

% MSW in landfill	Countries
Less 5%	Germany, the Netherlands, Austria, Belgium, Sweden, Denmark
Between 5% and 30%	Luxembourg
Between 30% and 40%	France, European average
Between 40% and 50%	Finland, United Kingdom
Between 50% and 60%	Italy, Ireland, Spain, Slovenia
Between 60% and 75%	Portugal, Czech Republic, Hungary, Poland
Between 75% and 90%	Estonia, Cyprus, Slovakia, Greece, Malta
Between 90% and 100%	Latvia, Lithuania, Romania, Bulgaria