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TECHNOLOGICAL INNOVATIONS IN THE WASTE-TO-ENERGY TREATMENT OF WASTE FROM FERROUS AND NON-FERROUS SCRAP*

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Abstract

The aim of this paper is to carry out an accurate technical, economic and environmental analysis of the pilot project concerning the treatment of Sicilian ferrous waste. The plant will be managed according to the best business risk prevention principles, as it is preferred to achieve the objective in different phases and with several years of amortization to limit the financial outlay. Starting from a static chamber incinerator, you will get a plant with an hourly treatment capacity that will also be able to produce energy through the waste-to-energy technology of the waste subjected to combustion. The company Sicilia Rottami srl, located in the Catania area, which deals with the management of ferrous scrap and industrial waste from various production cycles has been investigated. Among the advantages of the technological innovation analyzed, we find the recovery of the waste content through the exploitation of the heat developed during combustion, recovered to produce the steam used for the production of electricity or as a heat carrier.

Keywords: circular economy, energy recovery, scrap waste, technological innovation,waste-to-energy

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1. Introduction

The activities of Sicilia Rottami Srl. are of various types, as different are the services at high level of quality offered in compliance with and with attention to the needs of the customer and in full compliance with the regulatory provisions. The company's original business is the recovery and trade of ferrous and non-ferrous scrap (iron, aluminium, steel, copper, lead, etc.), industrial scrap, railway/naval demolition activities and scrapping of metal plants and structures (Del Tedesco, 2009; Di Maria et al., 2017). Sicily Scrap deals with the collection of ferrous and non-ferrous scrap (scrap of iron, aluminum, steel, copper, lead, etc.), industrial production scrap from railway demolition activities. After collection, the ferrous scrap is subjected to a radiometric check for the presence of radioactive material, in accordance with the procedures laid down in the European directive (Gentile et al., 2019). The company, then, takes care of storing the material in special plants, where pre-recovery operations take place (sorting, selection, volumetric reduction or compaction); the ferrous material thus obtained is stored and subsequently carried by means of Sicilia Rottami Srl or on behalf of third parties in the melting steelworks, thus starting a second life (Bartolini, 2006). The company, then, takes care of storing the material in special plants, where pre-recovery operations take place (sorting, selection, volumetric reduction or compaction); the ferrous material thus obtained is stored and subsequently carried by means of Sicilia Rottami Srl or on behalf of third parties in the melting steelworks, thus initiating a second life. The ferrous scrap trade is still today a core business and one of the company's main activities, which makes the company a reference point in Sicily in its sector.

Sicilia Rottami S.r.l. is a company in Catania, which deals as a core business of the management of ferrous scrap and industrial waste from various production cycles, operating with respect for the environment and striving to achieve and maintain the best quality standards in its field, with a view to continuous improvement and the pursuit of the circular economy. Thanks to its organizational structure and the experience gained in forty years of service in the trade of ferrous and non-ferrous scrap, collection, transport and storage services and treatment of industrial waste, liquid and solid, hazardous and non-hazardous, etc. the company has developed solid relationships of collaboration with important national and international partners (for example the partnership with COBAT, national consortium collection and recycling spent batteries) and represents a strong and prestigious business reality in the context of the industrial reality of Catania, as well as an undisputed authority in its sector.

2. Case study: Sicilia Rottami ltd

This paper has as its objective the evaluation of the economic but also engineering data relating to a preliminary project of incinerator that the company Sicilia Rottami S.r.l. is considering to build: the plant under consideration, of the type "SP-H-AB-300" for the disposal of hazardous and non-hazardous special waste from industrial and commercial activities, it consists of a machine with a static chamber furnace, of approximately 300 square meters , that will be located in a land of 12,000 square meters in the industrial area of Catania, not far from the place where the company itself owns its factories, and will go to set up a new company distinct from Sicily Scrap Srl. (Alvim Ferraz et al., 2000). The proposal consists of a project for the ex-novo construction of a special waste combustion line, which the company itself treats, as an alternative to the outsourcing of this phase. Currently, the company is transferring the special waste to an incinerator located in Augusta in Sicily, which, however, is sometimes saturated and is not able to cope with the entire demand for waste incineration in the entire region; therefore in numerous circumstances (Matarazzo and

Baglio, 2018). This waste is transported to plants in northern Italy (Milan, Verona, etc.) or out of Europe and the company is having to bear the heavy costs of safely transporting tonnes of waste each year.

3. Materials and methods

Energy production is a strong incentive for companies to invest in waste-to-energy technology, as energy can be used within the same company, with substantial savings in electricity costs, and can be sold, offering the producer a profit. In some cases, governments also offer incentives for renewable energy production (waste to energy is considered a renewable energy source) (European Commission, 2018). As a result, increasing the efficiency of energy production produces revenue increases, but usually also causes higher investment and maintenance costs. The best techniques to achieve the maximization of energy recovery involve the use of an integrated approach to the overall energy optimization of the plant rather than its units individually, use of heat exchangers to reduce the input of energy from external sources, use of energy already produced by the waste to energy and that should (Integrated Pollution Prevention and Control), wasted/not used differently for feeding the processes themselves of the waste to energy plant, etc. (Asdrubali et al., 2012).

It is important to understand, however, that energy recovery not only corresponds to increasing the output of energy obtained from combustion, but must aim to minimize waste, losses and consumption and optimize the entire process, which depends on operational factors such as plant allocation, energy demand and variability, climate, the price of heat and energy produced in the local market, the composition of waste, etc. To improve energy recovery, for example, it is necessary to reduce the volume of emission fumes: emission gas losses correspond to a reduction in temperature, which can be minimized by reducing the emission gas flow, which can be achieved with gas recycling technology, which is to be recycled in the plant instead of the air that would normally be blown up inside the plant. The result of good management of the supply of energy or heat produced by waste replaces the need for this energy to be produced from other external sources, resulting in a reduction in resource consumption and lower emissions and consumption (Munda and Matarazzo, 2020).

The optimization of energy recovery requires that the incineration plant is designed to meet the requirements of users who will use the energy produced: In this sense, systems that will only produce heat will be designed in a different way from those designed to produce energy or those that will produce both. In order to maximize energy efficiency, it is important to choose which turbines to apply to the plant. From the engineering point of view we distinguish:

- Condensing turbines, for the production of electric current;
- Counter pressure turbines

4. Results and discussion

After passing from a description of the strictly technical-engineering aspects of the plant, we will now analyze the economic aspect, which plays a decisive role in defining the cost-benefit analysis.

The definition of the economic aspects (investment costs, operating costs and revenues) is influenced by several factors, even highly variable; some of the main ones are: the type of refusal and the capacity of treatment of the plant; the availability of the plant (annual operating hours); finally, mention should also be made of all regulatory and administrative factors such as emission limits, authorization procedures, special requirements required by the competent control authority, etc. which can heavily affect technical choices.

The calculation of the gross revenues that can be obtained from the waste treatment activity of the incinerator has been carried out as follows: bearing in mind that the incinerator will be the destination plant for different categories of special, hazardous and non-hazardous waste, the farmer has estimated that the owner of special waste who needs the incineration service offered by the plant in question will have to pay a fee, which is considered as the price for the waste to be delivered to the plant, from a minimum of 60 cents to a maximum of about 1€ per kilogram of waste to be disposed of (Arfò et al., 2019).

On this indicative value of unit revenue, it should be considered that the maximum hourly treatment capacity of the incinerator is 500 kg/h, which means that in the case of the best-case scenario a gross hourly revenue of about 500€/h is expected, which is reduced to 300€/h in the worst case scenario (Table 1). Wanting to make an average, the average revenue forecast by the entrepreneur, resulting from waste disposal, is around 400€/h. With particular regard to the case of energy recovery from waste, the definition of economic aspects is certainly even more complex, due to the higher incidence of costs related to this option (Biondario et al., 2012).

In order to have the necessary elements for a general assessment of the economic implications (investment costs, operating costs and revenues) associated with the construction and operation of the incineration plant, the following will be analyzed the main factors to consider in the assessment of the economic convenience of the investment (Arduino et al., 2010). The main factors affecting the total investment cost relate to fixed costs such as fixed assets costs, the investment cost of building the plant itself and ancillary machinery (forklifts for loading and unloading waste and ash), as well as factors such as "business risk"; but also factors of a variable type depending on the amount of waste delivered such as the calorific value of the waste delivered, the costs of disposal of the ash produced, the costs of structural and managerial staff, the costs of reagents and additives used, etc. Among the many variables important for the evaluation of an investment in a new incineration plant or for a step of growth of an existing plant, the sizing of the plant has a decisive impact on: the choice of the installation analyzed in this chapter is affected by a prior market survey by the entrepreneur, concerning the possibility of access to quantities of waste adequate to justify the hourly capacity sustainable by the installation, as well as an analysis of how the size of the plant itself affects the environmental impacts, as well as the prospects of economic return for the company (Ingrao et al., 2019).

The study carried out on a design of a rotary rather than static combustion chamber plant, with an hourly waste treatment capacity of twice (1 tonne/h) compared to the static chamber plant under examination, leads to about doubling the amount of waste disposed of, against an increase in the initial cost of only 30% (Engdahl et al., 1979). As for the operating costs of the plant at the time when it will be in operation (Table 2), that is the cost of hourly use of the machine, these are estimated to correspond to about 105 Euro per hour.

Table 1. Summary scheme of expected revenues

Hourly Revenues	400	€/h
Hours of operation daily	8	h
Daily Revenues	3200	€/giorno

https://siciliarottami.it/it/about.html

Table 2. Summary diagram of the management and operating costs of the plant

Hourly operating cost of the plant	105	€/h
Hours of operation daily	8	h
Cost of daily operation of the system	840	€/giorno

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5. Concluding remarks

The purpose of this paper was to complete the discussion on the incineration technology, providing a case study on the territorial reality of the industrial area of Catania, accompanied by the main values and technical data and design, confirming compliance with minimum legal requirements, a relatively low environmental impact, with a concrete contribution to the circular economy and environmental sustainability, although, as has been mentioned, we are far from an idyllic era in which exactly what is produced is recycled.

The construction of this plant, in fact, denotes real advantages from the point of view of reducing the environmental impacts of the company Sicilia Rottami Srl., in the form of a reduction in mass, weight and volume of waste treated, which have no other useful destination than the landfill, which accounts for about 80% of the incoming waste; the products of this plant will be stable and inert solid ash, and air emissions filtered and purified in such a way as to ensure compliance with the legal requirements regarding the entry of pollutants into the atmosphere. Furthermore, the implementation of this project will undoubtedly benefit the community in terms of creating new jobs and reducing the amount of waste in tonnes that accumulates in landfills, with the aim of producing greater quality of life and well-being for future generations.

The project of construction of the plant carried out by Sicilia Rottami Srl. it was also accompanied by the prospects of the investment's economic return, which was highly remunerative, covering the higher operating and management costs, with very positive prospects of returning the initial investment costs, where it is estimated that the profits expected from the operation of the plant will be able to adequately cover what the entrepreneur considers to be the "business risk".

Finally, the prospects of efficiency of the plant described were compared with those of a larger plant, able to also produce electricity, going to show that what could seem at first sight, an alternative investment convenient (higher operating profits, obtained by doubling the plant's hourly disposal capacity, compared to an initial investment cost increased by only 30%), which fell in the concrete territorial reality of the Catania-based company, would be a largely unsuccessful investment, leading to expected inflated net profits, not corresponding to the actual amount of waste available to the company for incineration.

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