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Mobile platform of SRF production and electricity and heat generation

Tallini A.[a], Vallati A.[b], Cedola L.[a]*

[a]*Department of Mechanical and Aerospace Engineering, Sapienza, University of Rome, via Eudossiana 18, Rome, Italy*
[b]*Department of Astronautic, Electric and Energetic Engineering, Sapienza, University of Rome, via Eudossiana 18, Rome, Italy*

Abstract

The technological frontier is ripe for action on the cycle of municipal waste at local level through the optimization of existing treatment processes, adapting to European Union directives. The study concerns the analysis of the waste cycle in order to rationalize the current paths of the waste by adapting to EU directives, with a view of the entire supply chain - from the delivery to the energy production (WtE, Waste to Energy) – with a intermediate stage of SRF (Solid Recovered Fuel) production. The DIMA has developed an innovative platform for MSW treatment (unsorted and not), based on newly developed technologies that enables its weight and volume reduction and the transformation in SRF high quality, by achieving consistent chemical-physical and particle size parameters through the innovative technology of mechanochemical micronization. This standardized fuel product is therefore suitable for energy recovery within the platform using the most advanced gasification process. The study aims at developing a mobile demonstration plant of 100-200 kW_e for energy recovery from waste in cogeneration by conversion of MSW into SRF through a system of characterization, treatment and recycling based on a highly innovative mechanochemical refining system. The SRF is enhanced through more advanced gasification process and it can used for the production of electricity and thermal energy. The production, the gasification and the syngas combustion take place in modular units arranged in appropriate mobile units (containers) appropriately configured, to fully meet the objectives of a sustainable policy management and security of waste. b Unit 1 (waste treater - SRF producer) is developed to operate the transformation of industrial waste in SRF for subsequent gasification inside unit 2 (Boiler Gasifier). It carries out a pre-treatment and mechanochemical micronization waste treatment. The SRF is reduced into pellets to be introduced into the 2 (boiler gasifier) to its gasification (syngas production). The pellet (auxiliary unit 4, pellettizer) is gasified in the unit 2 and enriched in order to obtain synmethan gas for producing electricity in the cogeneration unit 3 (energies production).

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Keywords: Solid Recovered Fuel; Cogeneration; Municipal Solid Waste; Waste to Energy; Gasification; Micronization;

* Corresponding author. Tel.: +39-06-44585734; fax: +39-06-484854
*E-mail address:*luca.cedola@uniroma1.it

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1. Introduction

Recovery of waste (energy and resources recovery from waste) and their proper disposal (with eco-friendly technologies) represent a technical, social and economic challenge. The technology has reached the necessary maturity and at present it is able to act on the cycle of mixed waste and/or products in industries working on a local scale with the aim to optimize routes current waste adapting to EU Directives with a view along the entire chain, from delivery of unsorted waste up the energy production (WtE) with an intermediate stage of production of SRF - an alternative and standardized fuel having constant chemical and particle size parameters - for its subsequent use as a fuel by means of the most advanced gasification process or by recourse to conventional energy systems. The DIMA Department of Faculty of Engineering of "Sapienza" University of Rome has developed an innovative platform for the treatment of MSW, unsorted and not, based on newly developed technologies which allow the reduction in weight and in volume and their transformation in SRF, a fuel product suitable for energy recovery by gasification under the same platform. Objectives of this research is the development of a mobile demonstration plant of 100-200kW$_e$ for energy recovery from waste in cogenerative asset after processing of MSW in SRF and pellets, you can use in contexts like military bases, in-house electricity urban, etc. The study involves the implementation of a system for the transformation of MSW to SRF, the its subsequent gasification and finally the production of electrical and thermal energy through modular units placed inside mobile units - container - to achieve the objectives in term of a sustainable and safe waste management policy. In fact, under recent regulatory updates the MSW before being handled and managed needs to be turned into SRF. In the absence of such physical transformation management of waste it must be operated with restrictions and special equipment. The pilot plant has the following objectives: provide solutions industrially proven and reliable; check the efficiency values; check the availability values; offer a concrete example to potential users, managed with rigorous economic criteria, repeatable and replicable in the territory.

Nomenclature

t/h	tonnes per hour	m^3/h	cubic meters per hour
kCal/h	kilocalories per hour	MSW	Municipal Solid Waste
EoW	End-of-Waste	GCV	Calorific Value
WtE	Waste to Energy	NCV	Net Calorific Value
RDF	Refuse Derived Fuel	RDF-Q	High-quality Refuse Derived Fuel
SRF	Solid Recovered Fuel	PV	Photovoltaic
MCT	Mechanochemical Treatment	MCM	Mechanochemical micronization
RES	Renewable Energy Sources		

1.1. Sectorial legislation

At the European level the opportunity to use alternative fuels derived from waste is a relatively recent and dates from the mid-90s. Following the successful conclusion of the work of the task force TF 118, of a specific mandate M/325 of the EU Commission the Technical Committee CEN TC 343 was established in 2002 which aims to setting up: a set of technical specification of SRF, also published in Italy as UNI

CEN TS over the years 2006-2009;a set of European standards obtained from these TS downstream of adequate validation phase, the publication of which is virtually complete at the national level;The reference of the market, but also of the legislator, as indicated by the EU Commission, it is therefore represented by these technical rules among which are cited, for their relevance: CEN EN 15359 *"Solid Recovered Fuels - Classification and Specification"* with a SRF classification based on just three parameters, respectively economic (lower calorific value, PCI), technical (content of chlorine, Cl) and the environment (mercury content, Hg) [1]. This standard has been taken as a technical reference by the Legislative Decree nr. 205 of December 3, 2010 and is currently the basis for the definition of the SRF identified by Ministerial Decree of February 14, 2013 nr.22 (DM 22/2013) [2,3];CEN EN 15440 *"Method for the determination of biomass content*" that identifies the methods for the determination of biomass content (withdrawn, replaced by: BS EN 15440:2011) [4].Nationally the turning point imprinted in terms of production and use of waste-derived fuels is realized with the enactment the Legislative Decree nr. 205 of December 3, 2010. With this choice Italy intends to align with regulatory and market guidelines that characterize the EU for this specific sector. In particular the Legislative Decree no. 205/2010 repealed (Article 39, paragraph 3) Article 229 of Legislative Decree no. 152/2006 that concerns the "waste fuels and high quality waste fuels - RDF and RDF-Q ". In their place the "refuse-derived fuel" (SRF) was defined as "solid fuel produced from waste that meets the characteristics of classification and specification identified by the technical standards CEN/TS 15359 and subsequent amendments and additions; subject to the application of Article 184-ter (11), the refuse-derived fuel is classified as hazardous waste". It is significant that, while describing the SRF a special waste, it is with the explicit reference to the application of Article 184-ter that are laying the foundation for the subsequent definition of the SRF, as embodied by the issue of DM 22/2013.DM 22/2013governs the production, storage, handling, transport and end-use of the SRF in (partial) replacement of traditional fuels. For the purposes of the definition of SRF the DM in question uses as the reference: environmental legislation and, in particular, the provisions of article 184-ter concerning the EoW specific criteria; technical standards applicable to SRF, developed at European level by CEN and published in Italy by UNI. It should be noted that in reporting the table with the limits set by the UNI EN 15359 Annex 1 to the DM. 22/2013 it is clarified that "for the purposes of this Regulation can be classified SRF only fuel the refuse-derived fuel with NCV and chlorine content as defined by the classes 1, 2, 3, and combinations thereof, and - as regards the Hg - as defined by the classes 1 and 2".Then, CDR whitin UNI 9903-1and CDR-Q can not have SRF qualification.

2. Methodology

The first phase of the research was on establishing the development, design and implementation of an innovative platform for the treatment of waste aimed at the SRF production. The system will be able to produce SRF from waste as received eliminating the stage of separate collection. Through the innovative system the unsorted waste is transformed into SRF with elimination of the bacteria, the moisture reduction to 5% and its restitution in geometry minute and regular, possibly compactable in the form of pellets with constant physicochemical characteristics. The CSS so treated no longer regarded as waste but becomes fuel. The innovation is to obtain a microbiologically pure fuel with NCV comparable to that of coal and constant physic-chemical characteristics ready to be turned into electricity and heat in such quantities as to make the whole process self-sufficient. The second phase involves the energy production through an innovative plants of robust gasification of the SRF. Compared to traditional combustion of RDF (Refuse Derived Fuel) in large systems the project proposal is the adoption of gasification technology with basic modules from 100 to 200 kW_ein cogenerative asset, which allows to achieve environmental benefits (reducing emissions) and in terms of energy efficiency, with yields that comply fully with the Italian and European regulatory guidelines. Centralized combustion installations do not adapt to the use of "small" scale, for the following reasons :high consumption of auxiliaries, optimization feasible only on systems larger size; high investment costs which can be optimized only on a large scale; operating costs and maintenance significantly higher for small scale; the energy conversion efficiency (for electricity) can be optimized only for large systems. These reasons forced then to design choices of large-scale plants with resulting high local impact, authorization issues and local opposition. The technology of "robust gasification" is considered the cleanest way to energy waste recovery for these following reasons: the gasification does not provide any combustion of waste, but their gasification in a closed environment and "hermetic", without combustion fumes emitted in a fireplace; production of syngas which, properly treated and filtered, feeds a conventional generator with gas engine that generates electricity; the only source of emissions into the atmosphere is represented from the engine exhaust gas; the solution allows the creation of "small/medium condominium installations" with a low environmental impact.

3. Results

The design solution responds to the pressing need of a technological approach suitable to effectively solve the problem of waste disposal in the industry. The study describes the realization of an integrated technological system that includes the steps of inspection, opening, crushing and MCM, as well as the recovery of ferrous and nonferrous parts. The MCT system (Figure 1) covered by patent allows to obtain a certificate falling in the first three classes as defined in the UNI EN 15359. The waste transformation process essentially consists in a combination of treatments of physicochemical type with low-cost methods. The micronized product finally undergoes a purification process from chlorinated components and/or inert and is then subjected to pelletization. The final destination for the electrical and thermal energy enhancement of the product may consist of a gasification system or for direct use in the boiler.

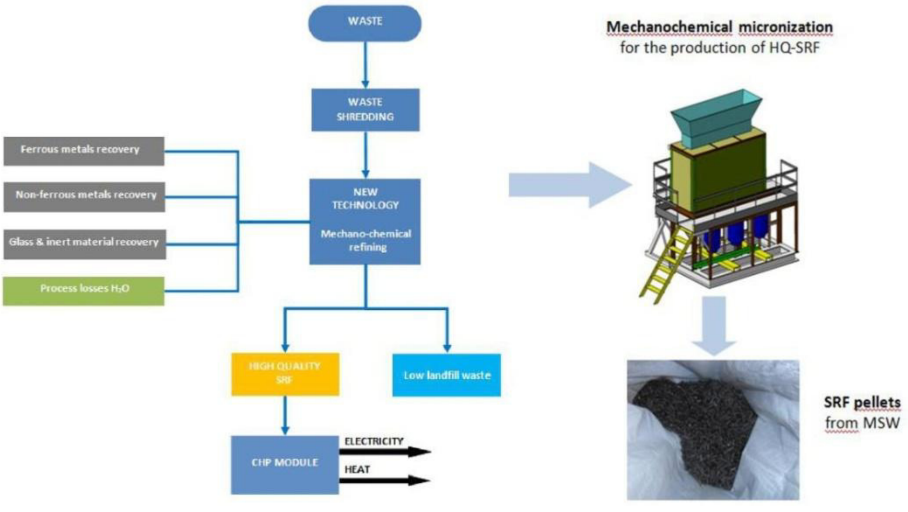

Fig. 1. Integration of the mechanochemical refining system within waste treatment plant.

MCM is a refining process consisting of chemical and mechanical treatments to be carried out in one continuous cycle plant, able to produce a high-quality SRF. The micronization resulting from the application of an innovative technology of materials processing, the MCT [5,6].The waste transformation process is a combination of treatments with low-cost physical-chemical methods realized through friction and impact actions, putting variable pressures (from 8,000 to 15,000 atm) so as to destroy the bacterial flora (removing smells and fermentation), and make the product sterile, completely dehydrated (the water is vaporized) and always free from chlorine, sulphates and inert. With this technology you can obtain a reduction in volume by approximately 70%, a reduction in weight of around 50%, a reduction of the bacterial load and an increase in NCV of waste approximately up to 80%.From the environmental impact point of view, during processing do not use hot processes, do not use chemical additives (the only possible not channeled emission form is water vapour), does not produce smells or volatile microparticles or dioxin or any kind of pollutant in the air, water and soil, lack of water consumption, do not produce eluates, being treated waste daily[5].The study deals with the development and implementation of a characterization, treatment and recycling system through a waste mechanochemical refining system. The technological apparatus is composed of two major systems, each of which will be the subject of a specific assessment technique: unit 1 performs a pre-treatment and treatment of waste micronization with production of SRFin form of pellet to be introduced in unit 2 for its gasification and syngas production. Unit 1 then produces a quality refuse-derived fuel. The pellet (in unit 4 auxiliary pellet) produced in unit 2 is gasified and enriched for synmethangas for the production of electricity in CHP unit 3 (Figure 2).

Fig. 2. Diagram of the integrated waste treatment platform with the innovative SRF production system.

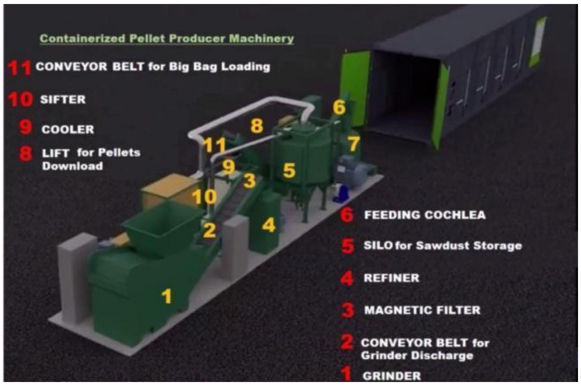

Fig. 3. Unit 1: 3D rendering of containerized pellet producer machinery with its components.

The position of the machinery harmonized with the previous available through contaneirization of 4 units and their engineering suitable for application. Unit 1(waste treater - solid fuel producer, WtE machinery, Figure 3) is developed to operate the transformation of industrial waste in SRF prepared for subsequent gasification mobile Unit 2, a containerized thermal unit for SRF gasification.

Table 1 shows main features of the modular units of the waste treatment and energy recovery system.

Table 1. Productivity of the integrated waste treatment platform.

Unit	Product	Hourly capacity	Hourly thermal availability
UNIT 1 Waste treater			
Shredder – separator	HQ pellet or Solid Fuel	0,5 t/h	$3.25x10^6$ kCal/h
Solid fuel producer			
UNIT 2 Boiler gasifier			
Gas enrichment	Synmethangas	1,334 m^3/h	11.4 $x10^6$ kCal/h
Gas tanks- hot water tanks			
UNIT 3 Energies productions			
Electric generators	Synmethangas	1,250-1,450 m^3/h	333kWh (GCV) 120 kWh(NCV)
Micro Gas turbine –Combined Electric Power Generators			

3.1. Key features of the project

Project type size: typical sizes from 45 kW_e scalable up to 500 kW_e system designed for the needs of users with type needs to dispose of in-house waste and enhancing them for the purposes of self-production of energy (in addition to the recycling of recoverable materials as below products for subsequent industrial change).With a view to the extension of the project to non-military applications, such as industry and civil applications, a first important area of use is applications at the condominium/hotel scale.

Technological scale: the project may have different connotations ranging from research to R&D, technological innovation, improving energy efficiency. The basic choice is to favour the forms of conversion which ensure the maximum efficiency of transformation and the minimum environmental impact in terms of reduction of pollutants.

Wasteas a RES: the principle was introduced in Italy in recent legislation to encourage RES (Ministerial Decree of 6 Jul. 2012[7] and D.M. 22/2013 on SRF). Italy occupies the last positions within industrialized countries in the use of this renewable source, the potential of which is considerable, to the equal if not superior to that of biomass from agricultural cultivation, which have the downside of competing with food destination in land use. A quick recovery in this direction will allow the further development of RES.

Gasification: mature technology consolidated in recent years in several countries. Compared to other forms of conversion of the primary source, such as combustion, it has advantages in terms of energy (higher yields) and the environment (less impact), without a significant burden in investment costs. The competitive potential will be fully realized with the improvement of the learning curve in stage management and the growth of the industrial base in the components and subsystems.

4. Conclusions

At the base of the addresses chosen for the formulation of the study there are well-known reasons of energy policy, environmental and industrial. The energy benefits are: the need for Italy to reduce the heavy dependence on imported primary energy sources as well as on imported electricityat non-peak hours of load diagram, not covered by renewable sources and PV in particular; tendency to meet the basic energy needs with renewable sources, with products that affect the baseload, those using vegetable biomasses and fuel obtained from the organic waste recovery. The environmental benefits are: the reduction of negative impact of the production-treatment-disposal waste cycle by reducing the fraction destined to landfill; reduction of CO_2 emissions by maximizing the recovery of energy contained in waste and cutting down air pollutants which are in solid form; reduction of the impact from the transport of waste on the territory, identifying optimal solutions as much as possible within the same municipalities of waste production; reduction of the impact (and costs in the form of losses) on the electricity distribution network of the national transport over long distances the electricity produced by large plants, to facilitate the production of energy distributed through stations trigeneration size limited (window up to 500 kW_e of power, preferably in cogeneration configuration, it seems the best match to saturate the needs of condominium use of waste as fuel and electricity consumption).The consequences in the industrial sector is the opportunity for the domestic industry to participate in the implementation and management of the WtE, already now developed in Northern Europe, as well as in the US, but still in their early life in Italy, also not to repeat the model in Italian renewable puts the consumer in a position to support a high load on the energy bill in the face of reduced relapse manufacturing and internal effects of exponential growth in imports of technological components.

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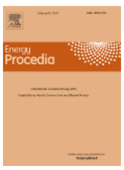

Biography

Luca Cedola, Ph.D. in Energetics and Environmental Management Systems. From 2000 Research Associate and from 2009 Assistant Professor at the DIMA-Sapienza University of Rome. A significant part of its research activity filed concerns R&D activities, industrial innovation and technology, particular attention to SMEs, environmental sustainability and renewable energy sources.