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## Prospective application of municipal solid wastes for energy production in Portugal

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### H I G H L I G H T S

- MSW collection and disposal are a major problem of urban environment.
- Portugal is facing multiple problems and improving the MSW management system.
- Gasification offers the most attractive solution to both waste disposal and energy problems.
- Plasma gasification seems to be validated but the economic viability must be proven.

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### A B S T R A C T

Municipal solid waste (MSW) collection and disposal is a major urban environment issue in the world today. MSW management solutions have to be technologically feasible, legally and socially acceptable and environmentally and financially sustainable. European policy is pushing for a rational management of natural resources; a promising technological perspective today is waste valorisation, a process that involves sorting at the source, combined with material recycling and waste-to-energy conversion. In this paper, we analyze the evolution of the Portuguese MSW management system, criticize the environmental policy issues for MSW management in Portugal and identify weak points in the criteria used for the technologies selection. Portugal is facing multiple problems with MSW management and is attempting to tackle them by passing legislation in order to improve the performance of waste management systems. At the technological level, gasification increasingly presents as an efficient and viable alternative to incineration. Gasification is a waste-to-energy conversion scheme that offers an attractive solution to both waste disposal and energy problems. Waste gasification by plasma has been validated but the economic viability of this technology must be proven before to be accepted by the industry.

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### 1. Introduction

Population growth, technological development and increasing consumerism have led to high consumption of resources. Consequently, there is increasing production of waste, and the need to develop an integrated management of municipal solid waste (MSW).

The implementation of the first strategic plan for municipal solid waste (PERSU I) marked a turning point in the field of MSW management in Portugal. This document defined the application of a hierarchy of principles based on the strategic foundations of the European Union (MAOTDR, 2007).

MSW management activities contribute to the generation of greenhouse gas and consequently to the climate change problem. Landfill waste decomposition contributes greatly to the formation of these gases. Another environmental problem associated with MSW management systems is the potential generation of dioxins and furans associated with incomplete combustion of wastes (Smith et al., 2001).

Despite some strategic plans of MSW management having been adopted, several studies have shown the lack of data and inconsistencies in a number of results regarding MSW management (Magrinho et al., 2006).

Nowadays, in Portugal there is official data thanks to the strategic plans PERSU I and PERSU II. The wide variety of processes and technologies for MSW treatment and the various possibilities of combining them have given rise to various structures and

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solutions for MSW treatment. The optimal solution for MSW treatment is not yet fully established (Magrinho et al., 2006).

In this paper the main objective is to assess the influence of MSW strategic plans and legislation on the wastes management system and infrastructures facilities. The second goal is to analyse the various technologies associated with MSW management systems.

## 2. Materials and methods

According to the EU Directive 1999/31/EC, municipal waste means waste from households as well as other waste which, because of its nature or composition, is similar to waste from households. This contains household residues, agricultural residues, commercial residues and those resulting from civil construction. The composition of these residues is extremely variable; it is influenced by factors such as geographic location as well as season of the year. In this type of residue alimentary remains, sanitary residues, paper, plastic, glass, wood, cement and metals can be found. The responsible entities for collecting MSW must meet several requirements, in agreement with the European implemented directive 2008/98/EC.

Nowadays, the base for any waste management system is to reduce, recycle and reuse. Until the end of the 1990s, closing open dumps was the first process adopted for MSW management in Portugal. Since then, MSW management has developed towards partial treatment and disposal options such as recycling, composting, and incineration with energy recovery. However, landfills were the dominant option for MSW disposal in Portugal up to 2002.

Since 1997 when the PERSU I was issued, the number of systems for municipal solid waste recovery and treatment (SGRSU) decreased from 40 to 23 in 2010. A progressive merger of systems contributed to this reduction, which was imposed by the goals of PERSU II, which favoured the aggregation of systems to maximize waste recovery using the existing infrastructures (APA, 2010). Nowadays there are 23 SGRSU in mainland Portugal, 12 are multi-municipal and 11 inter-municipal. Table 1 describes the SGRSU in 2010 and their characteristics in detail, including their infrastructures.

Thus, in mainland Portugal 2010 there were 34 landfills, 29 sorting centres, 81 transfer centres, 190 ecocentres, 37,971 ecopoints, two energy recovery centres, 11 organic recovery facilities and seven mechanical biological treatment facilities (MBT). This number of management systems is not yet ideal for the implementation of energy recovery, organic recovery and MBT facilities articulated with the PERSU targets.

A scheme of the Portuguese MSW management organization as described in Fig. 1 involves collection, storage, treatment and disposal. MSW collection includes selected wastes and unselected wastes. The unselected wastes are under the responsibility of each municipality, although the selected wastes can be under the responsibility of the municipalities, the MSW management system and private companies (Magrinho et al., 2006). The ecocentres and ecopoints are devoted to selected wastes. Ecopoints are devoted to separate collection based on the use of different containers for glass, paper/ cardboard, and plastic/metal, placed together at ecopoints preferably located on public thoroughfares and strategic points near shopping malls, schools, parks, pools, sport complexes, markets, fairs, etc. Ecocentres are sorting centres, where the selected wastes from the ecopoints are delivered for recovery.

In addition to the materials referred to above as part of mechanical recycling there are other specific fluxes of waste (used oils, batteries, electrical and electronic wastes, construction and demolition residues, end-of-life vehicles and used cooking oil). Transfer stations provide the facilities required for unselected wastes when landfills or MBT station are far away. Therefore, unselected collection can be understood as the sum of landfill wastes with energetic and organic refuse. The selected collection includes ecopoints and door-to-door collection with ecocentres and biodegradable municipal waste collection (APA, 2010). MBT plants are designed to process mixed household wastes as well as commercial and industrial wastes. The MBT tolerates recycling paper, metal, plastic and glass. It can produce refuse-derived fuel (RDF) or stabilize the biodegradable materials by composting or anaerobic digestion. The RDF can be further used as alternative fuel in cement kilns or incinerated to produce energy. The ash formed during incineration contains mostly inorganic constituents of the wastes and is often landfilled (Stantec, 2011).

**Table 1**  
SGRSU and infrastructure existing in mainland Portugal in 2010 adapted from APA (2010).

| System            | Region                 | Inhabitants | Infrastructure |                 |                  |           |           |                        |                         |     |
|-------------------|------------------------|-------------|----------------|-----------------|------------------|-----------|-----------|------------------------|-------------------------|-----|
|                   |                        |             | Landfill       | Sorting centres | Transfer centres | Ecocentre | Ecopoints | Energy recovery centre | Organic recovery centre | MBT |
| Valorminho        | North                  | 77,704      | 1              | 1               | 1                | 2         | 470       | –                      | –                       | –   |
| Resulima          |                        | 322,096     | 1              | 1               | 1                | 2         | 912       | –                      | –                       | –   |
| Braval            |                        | 290,508     | 1              | 1               | 1                | 2         | 1131      | –                      | –                       | –   |
| Resinorte         |                        | 956,763     | 5              | 4               | 8                | 15        | 3282      | –                      | 1                       | –   |
| Lipor             |                        | 984,047     | 1              | 1               | –                | 21        | 3565      | 1                      | 1                       | –   |
| Valsousa          | Centre                 | 337,609     | 2              | 3               | 2                | 8         | 756       | –                      | –                       | –   |
| Suldouro          |                        | 441,485     | 1              | 1               | –                | 4         | 1489      | –                      | 1                       | –   |
| Resíduos Nordeste |                        | 143,777     | 1              | –               | 4                | 14        | 580       | –                      | –                       | 1   |
| Ersuc             |                        | 956,808     | 3              | 2               | 6                | 7         | 3557      | –                      | –                       | 1   |
| AMR               |                        | 349,720     | 1              | 1               | 3                | 19        | 1334      | –                      | 1                       | 1   |
| Reisistrela       |                        | 202,761     | 1              | 1               | 8                | 14        | 625       | –                      | 1                       | –   |
| Valnor            |                        | 272,195     | 2              | 1               | 7                | 13        | 1346      | –                      | 1                       | –   |
| Valoris           |                        | 307,265     | 1              | 1               | 3                | 4         | 984       | –                      | –                       | 1   |
| Valorsul          |                        | 1,610,786   | 2              | 2               | 6                | 8         | 5537      | 1                      | 1                       | –   |
| Ecoleziria        |                        | 127,058     | 1              | –               | 2                | 4         | 336       | –                      | –                       | –   |
| Resistejo         | Lisbon and Tejo Valley | 209,587     | 1              | 1               | 3                | 9         | 1201      | –                      | 1                       | –   |
| Amtres            |                        | 831,178     | 1              | –               | 3                | 2         | 4406      | –                      | –                       | 1   |
| Amarsul           |                        | 778,028     | 2              | 2               | 1                | 7         | 2378      | –                      | 1                       | –   |
| AMDE              |                        | 155,268     | 1              | 1               | 4                | 7         | 652       | –                      | –                       | 1   |
| Amagra            |                        | 115,417     | 1              | 1               | 4                | 7         | 505       | –                      | –                       | –   |
| Amcal             |                        | 25,506      | 1              | 1               | 2                | 4         | 111       | –                      | –                       | 1   |
| Amalga            |                        | 95,763      | 1              | 1               | 4                | 5         | 380       | –                      | –                       | –   |
| Algar             |                        | 450,484     | 2              | 2               | 8                | 12        | 2404      | –                      | 2                       | –   |

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