DYNAMIC ASSESSMENT OF WASTE-TO-ENERGY SCHEMES IN CURRENT EUROPEAN LANDFILL-DOMINATED REGIONS

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ABSTRACT: Even when European regulation has been encouraging landfill reduction in the last decades, 13 out of 28 EU countries still landfill more than 50% of their municipal solid waste (MSW), mainly located in Southern and Eastern Europe. In this paper, waste-to-energy (WtE) schemes based on gasification are proposed in order to minimize the landfill disposal in European landfill-dominant regions. These schemes are assessed by means of a dynamic GHG emissions methodology since comparing with a dynamic reference system (i.e. methane emissions are delayed several years after the landfilling of the wastes and the emissions continue unevenly for at least 20 years more). The evolution of current waste management system and mix of electricity production is also modeled. The results reveal that the incorporation of gasification-based WtE plants in dominated-landfill European countries has a positive climate impact compared to current waste management in the short term. The long-term climate impact is, however, not secure since it depends on the evolution of the reference system in the analyzed region. Among the assessed configurations, the fluidised bed gasifier with internal combustion engine (FBG/ICE) configuration achieves the best climate benefit since has the highest energy efficiency.
Keywords: bioenergy, climate change, municipal solid waste (MSW), greenhouse gases (GHG), reduction.

1 INTRODUCTION

Even when European regulation has been encouraging landfill reduction in the last decades [1], 13 out of 28 EU countries still landfill more than 50% of their municipal solid waste (MSW), mainly located in Southern and Eastern Europe (Figure 1). Landfill disposal requires the use of a not always available land and has several environmental impacts associated (land, atmosphere, hydrosphere and biosphere). In fact, recent studies determine the methane concentration in the atmosphere has dramatically rised in last decades. This methane is released from different sources but two thirds of the emissions are attributable to anthropogenic activities related to agriculture and waste management [2, 3]. Because of that, it is necessary to find alternatives to manage the huge amount of urban wastes going to landfill disposal in Southern and Eastern Europe. MSW refuse is the unsorted stream of MSW going currently to landfill disposal or incineration. MSW refuse usually contains a biodegradable fraction over 50% [4]. On the other hand, waste disposal (landfilling or mass-burnt incineration) should be replaced by waste-to-resource alternatives in order to reduce GHG emissions. In this study, advanced Waste-to-Energy (WtE) schemes based on gasification are proposed in order to minimize the landfill disposal in European landfill-dominated regions. Technical development of advanced WtE plants, evolution of waste management schemes according to realistic European targets and electricity production mix, as well as the environmental impact to a changing European society are considered in the study. In order to do so, a previously developed dynamic GHG emission assessment methodology is used [5]. A dynamic assessment is crucial when comparing with a dynamic reference system (i.e. methane emissions are delayed several months or years after the landfilling of the wastes and the emissions continuing for at least 20 years more). Furthermore, the evolution of current waste management and electricity production needs to be modeled and is, therefore, included in the study.

Up to now, only the identification of the potential energy recovery and discussion of the technical and economic feasibility of advanced WtE schemes had been developed. The results indicate that the production of electricity is a feasible option at short term and that the impact of using MSW refuse as feedstock is better than reported in the scarce existing literature. However, the economic results are strongly dependent on the gate fee and wholesale electric tariff for each country. The environmental aspects have not been fully discussed considering the consequential impact. Up to our previous study [5], a dynamic assessment has not been made.

Figure 1: Landfilling ratios of MSW refuse in each European country [6] and specifically in two Spanish regions (South: Andalusia, North: The Basque Country)

2 GOAL AND SCOPE

The aim of this study is the dynamic GHG emission assessment of advanced WtE schemes based on gasification ir order to replace the landfill disposal. Three diferent configurations of advanced WtE plants according to the type of reactor and form of electricity production are proposed: grate gasifier with steam Rankine cycle (GG/SRC), fluidised bed gasifier with organic Rankine cycle (FBG/ORC) and FBG with internal combustion engine (FBG/ICE). The functional input unit is 1 ton of MSW refuse and the output is electricity. Figure 2 shows a simplified diagram of the WtE schemes proposed.

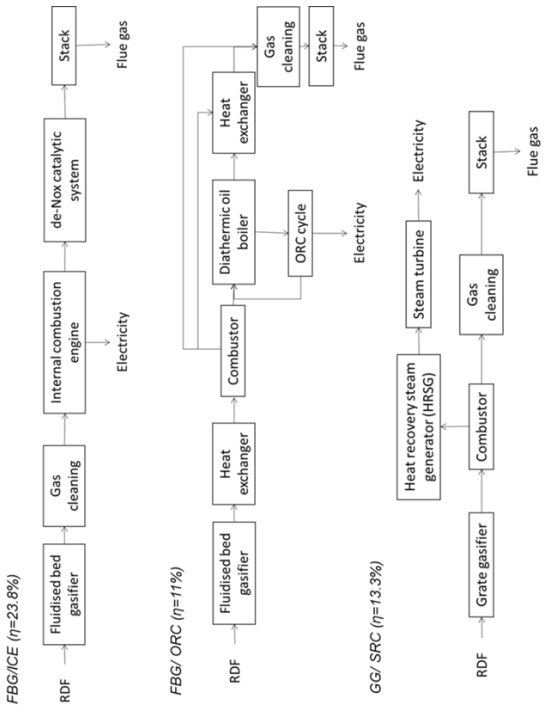

Figure 2: Simplified diagrams of the WtE based on gasification plants proposed according to the gasification technology and the electricity production system

3 METHODOLOGY

The climate benefit indicator chosen for this study is the climate mitigation index (CMI) [5] which compares the behavior of the WtE plant with the current MSW management, and production of products and services for a specific region (Table 1).

Table I: Summary of the main characteristics of the CMI

	Climate Mitigation Index (CMI)
Based on	AGWP (cumulative)
Units	--
Emissions included	Biogenic and anthropogenic emissions
Comparison	BIO and BAU system for the same region
Result	Cumulative climate mitigation for a specific region

Two different scenarios are taken into account: Scenario 1, in which the reference system (landfill) remains unaltered, and Scenario 2, in which there is an evolution towards landfill banning and decarbonization of the energy mix (Figure 3 and 4).

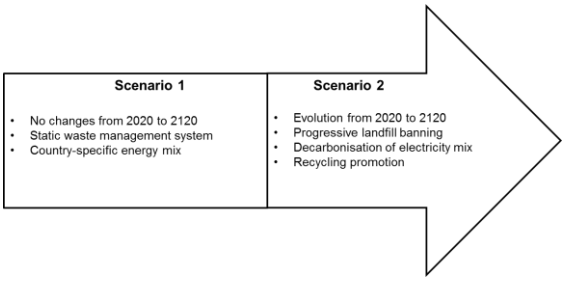

Figure 3: Proposed scenarios in this study

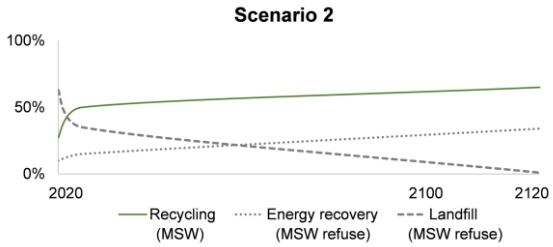

Figure 4: The evolution of waste management schemes in Scenario 2

The case study for this study is the region of Andalusia in Southern Spain. The Spanish waste management scheme is based on recycling and landfilling and, to a lesser extent, on incineration. However, in Andalusia landfilling is dominant and incineration is not implemented, as commonly found in Southern and Eastern European countries.

4 RESULTS

Figure 5 shows the CMI of the three advanced WtE plants (based on gasification) proposed in this study in Scenario 1 (a) and Scenario 2 (b). In scenario 1, there is a sharp reduction of the index from positive to negative between years 3 to 8 depending on the plant configuration achieving the best results the FBG with ICE configuration and the worst the FBG with ORC configuration. Then the trends increase towards the climate worsening (from negative to positive) between years 65 and 80 for FBG/ORC and GG/SRC options. The climate mitigation index in the FBG/ICE option is negative from year 8. The results are according to the energy efficiency. The highest efficiency, the highest climate mitigation. In scenario 2, the period of climate mitigation is shortened and all the options, including FBG/ICE achieve the climate worsening in the last years. In all cases, the highest climate mitigation is achieved at a short time (first 20 years) since the transient emissions from the landfill are concentrated around 20 years after the landfilling of the MSW refuse.

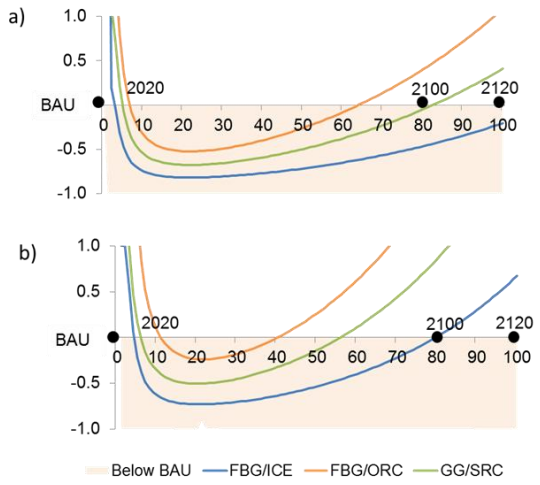

Figure 5: Climate mitigation index (CMI) of the three advanced WtE plants proposed based on gasification in Scenario 1 (a) and Scenario 2 (b)

5 CONCLUSIONS

The results reveal that the incorporation of gasification-based WtE plants in dominated-landfill European countries has a positive climate impact compared to current waste management in the short term. The long-term climate impact is, however, not secure since it depends on the evolution of the reference system in the analyzed region. Among the assessed configurations, the FBG/ICE configuration achieves the best climate benefit since has the highest energy efficiency.

6 REFERENCES

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7 ACKNOWLEDGEMENTS

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8 LOGO SPACE

Grupo de Bioenergía
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