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Evaluation of energy potential of Municipal Solid Waste from African urban areas

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ABSTRACT

Energy is a critical issue for Africa, where large number of people do not have access to energy. Energy recovery from waste can play a role in minimising the impact of Municipal Solid Waste (MSW) on the environment with the additional benefit of providing a local source of energy. This study was carried out to assess, at the African level, the role which waste could play in providing energy to citizens and provides an estimate of the total potential of energy from waste incineration and from landfill gas (LFG). The results show an energy potential of all waste generated in Africa of 1125 PJ in 2012 and 2199 PJ in 2025. Nevertheless, if energy recovery through LFG is considered, about 155 PJ could be recovered in 2012 and 363 PJ in 2025 if waste actually collected, or projected to be collected, is considered. The electricity generation could reach 62.5 TWh in 2012 and 122.2 TWh in 2025, in case of full waste collection, compared with electricity consumption in Africa of 661.5 TWh in 2010. If waste actually collected is considered, these estimates decrease respectively to 34.1 TWh in 2012 and 83.8 TWh in 2025. Apart from continental estimates, the study provides detailed information at the country level and a vision of the spatial distribution of energy from waste based on the city population in major African cities.

Contents

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1. Introduction

There is a growing understanding, at global level, about the negative impacts that waste can have on the local environment (air, water, land) and human health etc. The increasing complexity, costs and coordination implied by proper waste management require multi-stakeholder involvement at every stage of the process. Waste management is usually one of the most complex and cost-intensive public services, even when well organised and operated properly. In developing countries, waste management has the highest share in municipalities' budgets, spending from 20% to 50% of their available budget on solid waste management. A significant part (up to 80–90%) of the solid waste management budget is used for waste collection. Services typically cover, however, only about 40–70% of all urban solid wastes, with the remainder being uncollected and less than 50% of the population being served [1–4].

Population growth, urbanisation and economic development are expected to produce increasing quantities of waste that are overburdening existing waste-management systems. Many cities in Africa face significant difficulties related to waste management, collection and disposal of Municipal Solid Waste (MSW). Increasing city size poses great problems linked to increasing population and city area as well as lack of infrastructure development [2,5,6].

The poor waste management in Africa has important consequences for the disposal of uncollected waste in dumps and the associated severe environmental and health related problems. An integrated approach to solid waste management is required in order to enable local/ national authorities to reduce the overall amount of waste generated and to recover valuable materials for recycling and for the generation of energy.

Despite all efforts to reduce, recycle and reuse waste, there is a growing amount of waste that needs to be disposed in landfills. Several options are available and the choice of the most adequate should consider the local specific conditions [3]. Waste incineration might be an option for waste disposal, but technical and economic problems are preventing large scale deployment of waste to energy plants, especially in developing countries. Landfill gas (LFG) recovery could be a solution, an opportunity for energy recovery and a potential source of energy in areas with low access to energy, such as Africa.

This paper addresses the issue of waste management in Africa and investigates the potential of energy production from waste, contributing to energy supplies and alleviating energy poverty. It focusses on the assessment of the potential of MSW to produce energy. Several studies relate to the use of MSW for energy production and provide estimates of the energy potential of MSW. However, the data about the waste generation, collection and the use of waste for energy production for the African continent is very scarce and covers only few cities or countries.

The study makes GIS spatial explicit analysis of the energy potential MSW in Africa using the best available data related to MSW from the United Nations, World Bank, Food and Agriculture Organisation (FAO). This study provides a complete overview and wider perspective of this potential for the whole African continent, while providing detailed information at country and city level.

2. Energy recovery from waste at global level

2.1. Challenges and opportunities for energy recovery from waste

The world population grew from 3.1 billion in 1960 to almost 7 billion in 2010 and it is projected to increase to 8 billion by 2025 and to 9.3 billion by 2050. World urban population also sharply increased from 1 billion in 1960 to 3.5 billion in 2010 and it is projected to reach 4.5 billion in 2025 and 6.4 billion in 2050 accounting for a population share increasing from 30% in 1960 to 68% in 2050 [7].

As the world's population grew and became more urban, global solid waste generation is estimated to have increased tenfold in a century from 110 million tonnes in 1900 to 1.1 billion tonnes in 2000 [8]. Currently, the global MSW generation is estimated at about 1.3 billion tonnes per year, and it is expected to increase to approximately 2.2 billion tonnes per year by 2025. A significant increase of the waste generation rates per capita has been also projected, from the current 1.2 kg per person per day to 1.42 kg per person per day until 2025 [1].

Africa faced a particularly rapid population growth, from 294 million in 1960 to 1.0 billion in 2010 and it is expected to increase to 1.4 billion by 2025 and 2.2 billion by 2050. The urban population grew from 56 million in 1960 to 409 million in 2010 and it is projected to further increase to 672 million in 2025 and 1364 million in 2050. In 2010, more than 42% of the population in Africa lived in urban areas, increasing from 20% in 1960, and could reach 47% in 2025 and 62% in 2050 [7]. Even if waste generation rates per capita are lower than in developed countries, developing countries produce large amounts of waste. These amounts are expected to rise with increased population, urbanisation and improved lifestyle; this is would result in additional challenges to waste management systems and in an additional pressure on the environment.

Improvements in waste management are needed, especially in Africa, where current waste management is often in a poor state; the use of the energy content of waste could be one of the leading ideas for such progress. The energy content of waste can be recovered by means of either thermo-chemical processes (combustion, pyrolysis or gasification) or biological processes (anaerobic digestion). The global energy potential of waste can be estimated at 8–18 EJ/year in 2010, which could increase to 13–30 EJ in 2025, if a heating value of municipal waste ranging from 6 to 14 MJ/kg is considered, with a best estimate moving from 12 EJ in 2010 to 20 EJ in 2025, for an average heating value of 9 MJ/kg for waste [9,10].

Currently (2010 data), there are more than 600 waste-to-energy facilities worldwide, most of them in Europe (472 in EU, Switzerland and Norway), Japan (100) and the US (86) [11,12]. In the European Union (EU), energy recovery by incinerating Municipal Solid Waste produced more than 8.0 million tonnes of oil equivalent in 2010, with 73 million tonnes of waste treatment capacity. This capacity is expected to rise to 85 million tonnes by the end of 2016 and 94 million tonnes by 2020 [13].

The International Solid Waste Association (ISWA) reports that on a global scale, landfilling still represents the main disposal method for Municipal Solid Waste [14]. In particular, Low and Middle Income countries are still almost exclusively depending on