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Green House Gas emissions from alternative waste management technologies in a city. The case of Madrid (Spain)

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INTRODUCTION

According to United Nations (UN, 2014) urban population accounts for 53,6% of total world population while projections for 2050 estimates this figure increasing up to 66%. The most challenging issues for building sustainable cities, especially in developing countries, are food security, water and sanitation access, clean energy access, better air quality, lower Green House Gas (GHG) emissions, and improved waste management (UN, 2013). Concerning waste management, a big effort in the reduction of waste production and improvement of waste collection and recycling systems is needed in most cities across the world (UN, 2013). Indeed, unsustainable waste management produces several health, social and environmental troubles such as proliferation of flies, mosquitoes, rodents, cockroaches; transmission of germs that cause diseases; generation of gastrointestinal problems; and pollution of rivers, estuaries and oceans. When uncontrolled disposal is implemented, additional problems arise (e.g. plugging of waterways, floods and landslides causing human and material losses, direct pollution of groundwater and surface water and soil, or uncontrolled burnt). Moreover, social problems related to collectors and recyclers also appear such as diseases, accidents (i.e. cuts wounds, landslides, bubbling methane from organic degradation), as well as problems derived from contact with hazardous and infectious wastes.

Therefore, different solutions should be implemented to decrease those problems. A change of consumption and production patterns is needed (UN, 2014b). Some of the effort to achieve this objective will be based on technology, supported by the old concept of “decoupling” economic growth from resource requirements (Pearce, Markandya and Barbier, 1989). However, each waste will emit any amount of GHG during its final life phase. Specific amounts depend on the technology and transport system implemented, so specific analyses on carbon emissions between technological alternatives are necessary to reduce total GHG emissions from waste management.

Consequently, this work presents different technological solutions for waste management focusing on their impact on GHG emissions, and therefore, on their contribution to climate change. Several alternatives are shown using Madrid as a case study to quantitatively illustrate differences in carbon emissions and potential effects.

METHODOLOGY

The case of Madrid was used as a case study to analyze carbon emissions from different waste alternatives from collection system to treatment phase (Fig. 1). Concerning collection phase, different load systems and fuel-powered trucks were compared while for treatment alternatives, emission from recovery alternatives (composting, biomethanation and incineration) were compared with conventional disposal operation, a deposit on a controlled landfill.

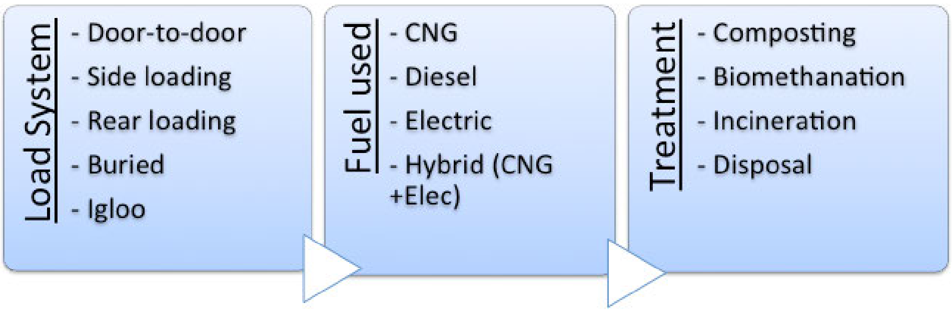

Figure 1. Technological comparison

GHG emissions from transport alternatives were carried out using specific GHG emission tools for transport modes EmiTrans, as Lumbreras et al., 2014 and GlobalTrans as shown in Vedrenne et al., 2014, including emission factors from COPERT 4 (Ntziachristos et al., 2009). As for waste treatment alternatives, IPCC guidelines for national Greenhouse Gas Inventories (IPCC, 2006) and EMEP/EEA air pollutant emission inventory guidebook (EEA, 2009) were applied. For the Madrid case, waste is separately collected under four fractions: paper, glass, packaging and rest (including organic matter). This work was only focused on the two fractions that are specifically treated in a waste treatment plant: packaging (fraction 1) and rest (fraction 2).

RESULTS

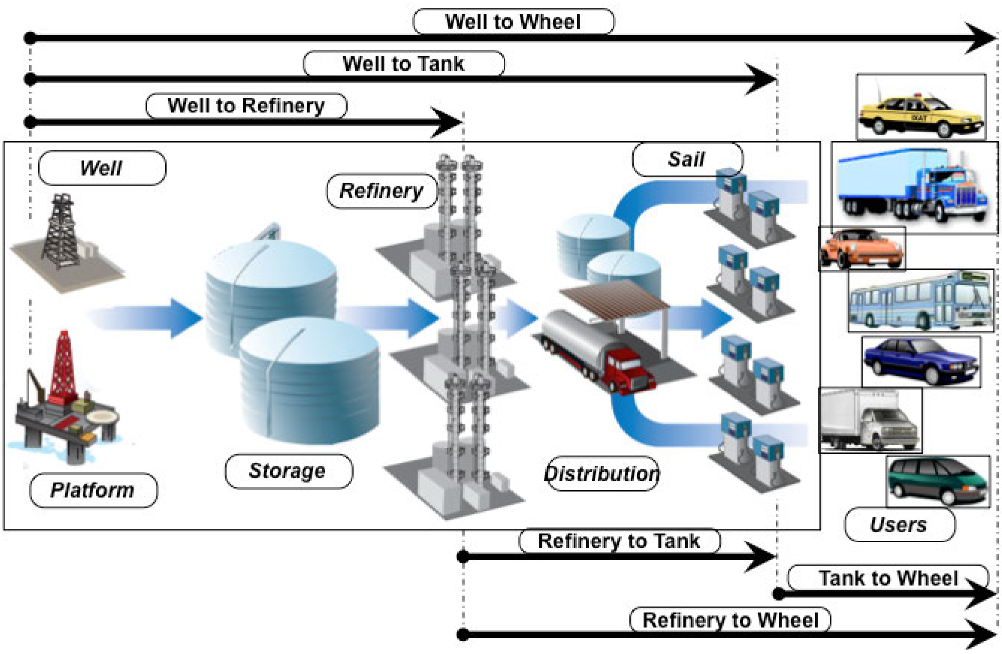

Figure 2. Life Cycle for the fuel used in the transport system (from GlobalTrans)

For the transport phase, carbon footprint was calculated both for the vehicles and the fuel used. Thus, GHG emissions were computed for each fuel from Well to Tank (WtT) and from Tank to Wheel (TtW), accounting the whole life cycle (according to Fig. 2). With regard to the transport technology, Life Cycle Assessment was conducted both for the vehicle manufacturing, as well as for its maintenance (oil changes, repairs, etc.) and end of use. Additionally, the following feasible scenarios on fuel used were developed to assess potential benefits of fuel switch: i) overall use of diesel vehicles and ii) CNG substitution by biogas from biomethanation plants.

As for the waste treatment stage, GHG emissions were computed for current technological situation in Madrid (i.e. a combined use of biomethanation, composting, incineration and landfilling). Specific carbon emissions per annual mass of waste treated were calculated for each technology to compare direct emissions in terms of $CO_{2\ equivalent}$ per t/year. Additionally, to evaluate the potential effect of alternative approaches, emissions from different scenarios were estimated as shown in Fig. 3.

Scenario	Packaging in fraction 1	Organic Matter in fraction 2	Rest from fraction 1 and 2
Biomethanation	Recycling	Biomethanation	Landfilling
Composting	Recycling	Composting	Landfilling
Incineration	Recycling	Incineration	Incineration
Landfilling	Recycling	Landfilling	Landfilling
Disposal	Landfilling	Landfilling	Landfilling

Figure 3. Scenarios developed to compare GHG emissions from alternative waste treatments

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