LIFE-CYCLE GHG EMISSIONS OF ALTERNATIVES FOR COLLECTING AND TRANSPORTING MUNICIPAL SOLID WASTE: THE CASE OF A SPANISH COMMUNITY

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INTRODUCTION

Currently, the communities and municipalities are increasingly aware of managing a clean and sustainable transport in their mobility services. Thus, it is usual (and almost mandatory) to include aspects to improve sustainability in tenders for contracts and execution of public services. More specifically, in the case of collecting and transporting municipal solid waste (MSW) several key aspects are important to be considered in order to reduce emissions, energy consumption and other environmental issues.

In this context, both, use of alternative fuels and introduction of electric vehicles are positively valued in order to achieve environmental improvements and energy savings.

This study presents an assessment of different proposals for introducing the use of alternative fuels, such as liquefied petroleum gas (LPG) and compressed natural gas (CNG) instead of conventional diesel in the vehicle fleet of a Spanish small urban community, located in Navarra, in the North of Spain. This fleet, collects and transports MSW, (Figure 1). The possibility of using hybrid and electric vehicles has also been considered.

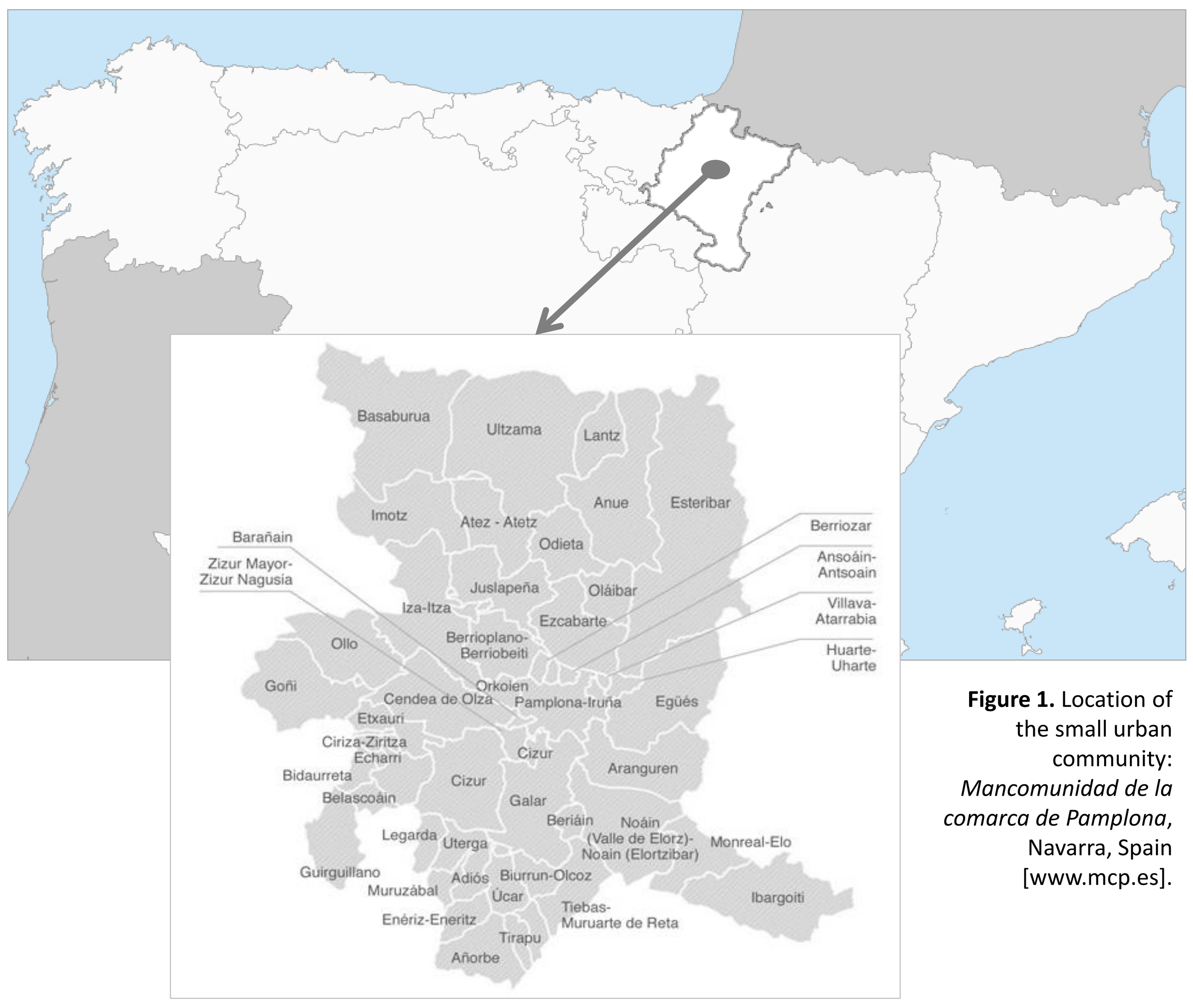

Figure 1. Location of the small urban community: *Mancomunidad de la comarca de Pamplona*, Navarra, Spain [www.mcp.es].

MATERIALS & METHODS

Table 1 shows the vehicle fleet and description of the three alternatives compared to the Base Case (BC). As apart of life cycle inventory analysis, emissions have been calculated from emission factors (Table 2) and the annual mileage for each type of vehicle .

In order to complete the environmental assessment of the whole activities regarding the management of MSW, the annual GHG emissions of the processes of washing containers and pneumatic collection of waste have also been included. The corresponding emission factors of electricity mix of Navarra have been the following, in kg/kWh: 3.27E-01, 3.73E-04 and 1.20E-05 for CO_2, CH_4 and N_2O, respectively [1].

Table 1. Vehicle fleet of the *Mancomunidad de la Comarca de Pamplona* (2014) and the three alternatives to conventional fuel.

Vehicle type (*units*)	Base case (BC)	Alternative 1 (A1)	Alternative 2 (A2)	Alternative 3 (A3)
Garbage truck, 32t (*5*)	Diesel	**CNG**	Diesel	Diesel
Garbage truck, 26t, type I (*23*)	Diesel	**CNG**	Diesel	**Electric**
Garbage truck, 26t, type II (*9*)	Diesel	**CNG**	Diesel	**Electric**
Garbage truck, 26t, type III (*1*)	Diesel	**CNG**	Diesel	**Electric**
Garbage truck, 18t (*4*)	Diesel	**CNG**	**Diesel-electric**	Diesel
Garbage truck, 3.5t (*1*)	Diesel	**CNG**	**LPG**	**Electric**
Tow truck, 10t (*3*)	Diesel	**CNG**	Diesel	Diesel
Container truck, 18 m^3 (*2*)	Diesel	**CNG**	Diesel	Diesel
Multilift truck, 26t (*1*)	Diesel	**CNG**	Diesel	**Electric**
Van, 3.5t, type I (*16*)	Diesel	**CNG**	Diesel	Diesel
Van, 3.5t, type II (*4*)	Diesel	**CNG**	**LPG**	**Electric**
Van, 3.5t, type III (*2*)	Diesel	**CNG**	Diesel	Diesel
Van, 3.5t, type IV (*6*)	Diesel	**CNG**	**LPG**	**Electric**
Van, 7.5t (*4*)	Diesel	**CNG**	**Diesel-electric**	Diesel
Cleaning van, 3.5t (*3*)	Diesel	**CNG**	**LPG**	**Electric**

Table 2. Life-cycle emission factors of the pollutants by each type of vehicle [1-11].

Pollutants	Diesel vehicles			CNG vehicles	LPG vehicles	Electric vehicles	
	Trucks and Vans (3.5-20 t)	Trucks (20-28t)	Trucks (>28t)			Trucks	Vans
CO_2	**6.50E-01**	**8.87E-01**	**1.30E+00**	**1.25E-01**	**2.07E-01**	**4.35E-01**	**5.72E-02**
CH_4	**6.49E-04**	**8.81E-04**	**1.29E-03**	**1.48E-04**	**Not available**	**5.16E-05**	**6.79E-06**
N_2O	**1.06E-05**	**1.10E-05**	**1.11E-05**	**3.02E-06**	**Not available**	**1.58E-05**	**2.08E-06**
CO	1.44E-03	1.71E-03	2.11E-03	4.10E-04	4.81E-04	1.19E-04	1.56E-05
SO_2	5.40E-04	7.37E-04	1.08E-03	1.41E-04	1.20E-03	4.86E-04	6.39E-05
NO_2	6.48E-03	8.60E-03	1.15E-02	4.10E-03	1.70E-05	6.71E-04	8.83E-05
VOCs	6.89E-04	8.21E-04	1.03E-03	7.57E-04	Not available	4.26E-05	5.61E-06
PM_{10}	6.89E-05	7.34E-05	8.12E-05	Not available	Not available	4.96E-04	6.53E-05

RESULTS & DISCUSSION

Figure 2 shows the GHG emissions of BC *versus* the three alternatives, using IPCC 2007 characterisation factors. There is an important decrease not only in GHG emissions but also in the rest of pollutants when CNG is used as fuel. Nevertheless, this measure entails an increase of other harmful gases, such as the volatile organic compounds (VOCs), when compared to other alternatives. Moreover, it should be remarked that A1 substitutes the totality of the fleet, whereas the others only replace a part of them.

Finally, Figure 3 shows the GHG emissions of the processes of washing containers and pneumatic collection, which could be responsible for the 10 to 40% of total GHG emissions of the waste management in the community.

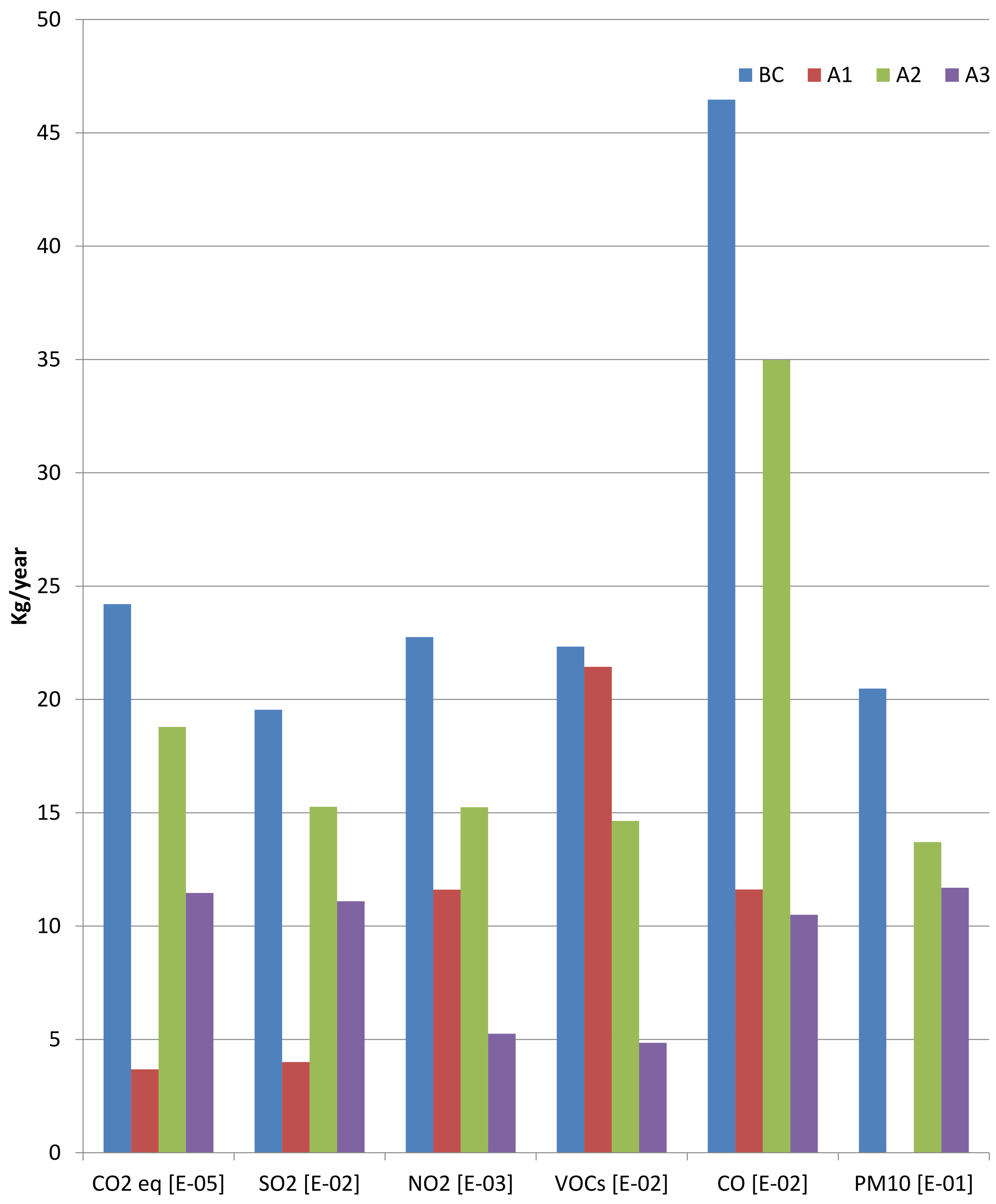

Figure 2. Annual emissions of pollutants of BC and the three alternatives.

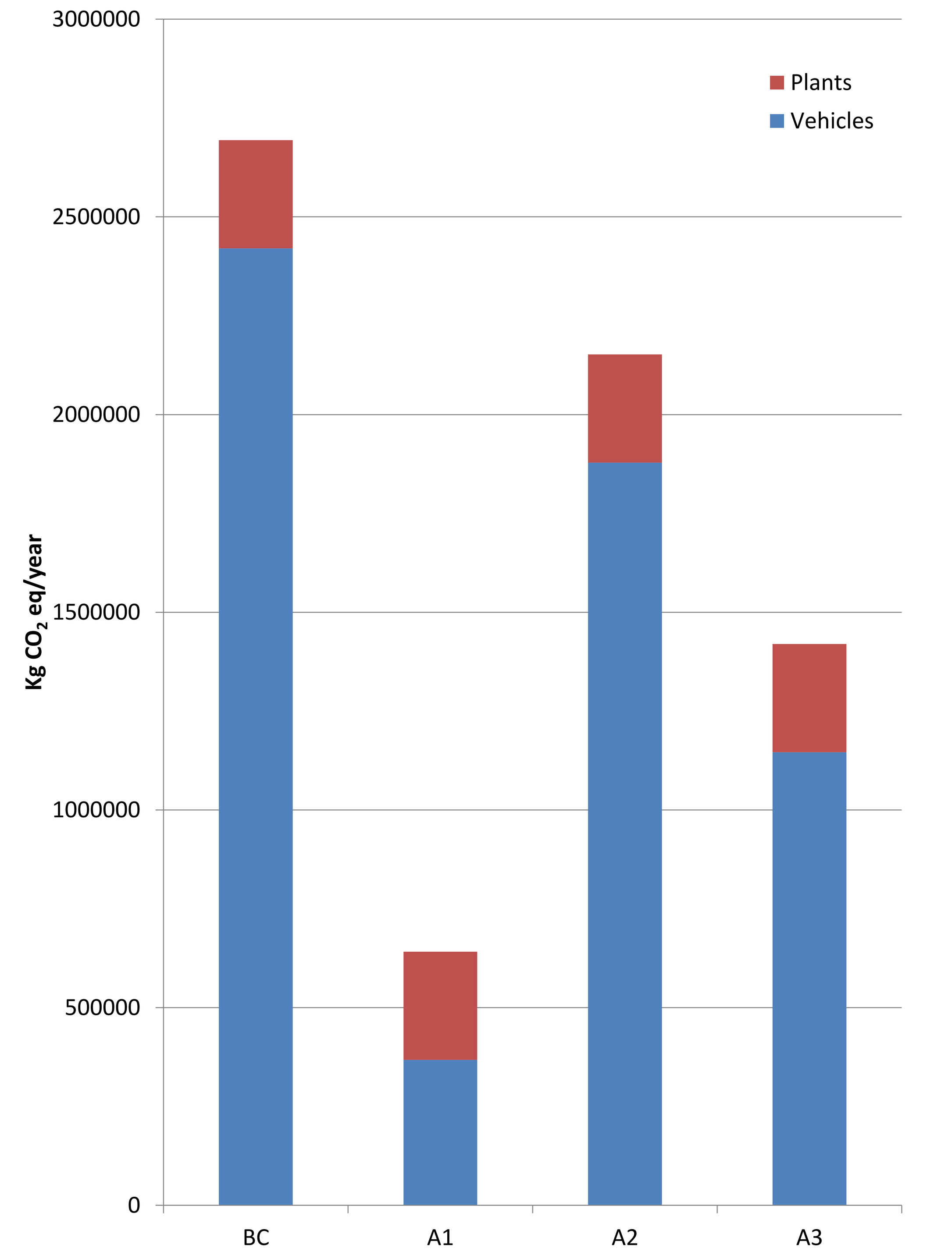

Figure 3. GHG annual emissions of BC and the three alternatives, considering plant processes.

CONCLUSIONS

- CNG vehicles could be an interesting alternative to substitute diesel fleet, regarding to decrease of pollutant emissions, especially in GHGs.
- Electric vans present low GHG emissions compared to other alternatives.
- A higher input of renewables in the electricity mix is useful to decrease the GHG emissions in collection and transportation of MSW. The rest of emissions have a similar behavior in terms of decreasing.

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