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Challenges in greenhouse gas mitigation in developing countries: A case study of the Colombian transport sector

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ABSTRACT

CO_{2eq} emission scenarios for the Colombian transport sector were estimated for 2010–2050. We used a marginal abatement cost approach to assess an emission mitigation pathway. For this purpose, we constructed a carbon emission accounting model linking travel demand to vehicle stock, fuel consumption, and emissions for the Colombian transport sector. Actions related to energy efficiency, fuel switching, new engine technologies and modal change were considered. The analyzed measures have the potential to reduce the cumulative emissions by 8% and 18% under the BAU scenario through 2030 and 2050, respectively. Mitigation costs are high and imply annual capital costs that range from 0.5% to 4% of the national GDP. Gains in efficiency as well as synergy with other sector objectives might help justify some of the actions in financial terms. Non-technological actions, such as high public transit participation in the urban modal share and reorganization of the freight system, play a significant role in attaining low-carbon transport systems in Colombia.

1. Introduction

The average annual growth rate of global greenhouse gas (GHG) emissions from fossil fuel and industrial production increased to 2.3% during 2000–2015 from 1.3% during 1990–2000 (IPCC, 2014; Olivier et al., 2016). The highest contribution to total emissions has been shifting from developed countries to both emerging and developing economies. While net emissions from Annex I countries stagnated from 1990 to 2014, emissions from non-Annex I countries tripled during the same period (IEA, 2016).[1] In 2014, non-Annex I countries accounted for 58% of the global carbon dioxide equivalent (CO_{2eq}) emissions.

National climate action plans proposed by developed and developing countries at the 21st Conference of the Parties (COP21) reflect the agreement that in order to achieve a low-carbon world, mitigation needs to occur globally (IEA, 2016). Via its nationally determined contribution (NDC) presented to the United Nations Framework on Climate Change (UNFCCC) under the COP21, the Colombian government committed to reducing 20% of its GHG emissions under a business as usual (BAU) scenario by 2030 (UNFCCC, 2016). Even though the Colombian NDC does not establish sectoral goals, it does refer to transportation as one of the segments in which GHG mitigation must be pursued. This characteristic is common among COP21 commitments, in which 63% of the NDCs submitted in the representation of 187 countries included mitigation actions in the transport sector to comply with national goals (PSLCT, 2016).

The transport sector is critical in terms of its contribution to GHG emissions, and significant potential to mitigate GHG has been identified for this sector (Kahn Ribeiro et al., 2007). However, previous actions have shown the difficulty in achieving net emission reductions in transportation. In Europe, despite mitigation actions in place between 1990 and 2012, emissions generated by transportation continuously increased, and this trend was opposite than that observed for other emitting sectors (Santos, 2017). The difficulty in reducing GHG emissions in the transport sector can be attributed to several factors, including high capital costs, rebound effects, the absence of comprehensive policies that consider these types of indirect effects, and the lack of international legally binding agreements to reduce GHGs (Ajanovic and Haas, 2017; Druckman et al., 2011; Eliasson and Proost, 2015; Santos, 2017).

The wide range of local contexts and conditions among countries influence GHG emission patterns (IEA, 2016) and determine the feasibility of the mitigation options, by factors such as the institutional capacity (Zimmer et al., 2015). In this lies the importance of identifying the factors that drive emissions in each case and to find opportunities to reduce CO_{2eq} emissions in accordance with local circumstances.

The aim of our study is to assess GHG mitigation strategies in the

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[1] Annex I and non-Annex I countries as defined by the United Nations Framework Convention on Climate Change. Annex I parties are classified as industrialized, developed countries or economies in transition. Non-Annex I parties are primarily low-income and developing countries.

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Colombian transport sector in terms of their technical reduction potential and financial costs. This paper is structured as follows: Section 2 describes the main characteristics of the transport systems in Colombia; Section 3 explains the methodology used to conduct the analyses; Section 4 presents the main results regarding the costs and mitigation potential of the actions assessed and presents the lessons of the participatory approach; Section 5 discusses the consistency between GHG mitigation actions in the transport sector and other national objectives; and Section 6 concludes and presents the next steps.

2. Background information

The energy sector is the second contributor to GHG emissions in Colombia, after agriculture, forestry and other land use (AFOLU). The energy production contributes to a relatively small proportion of the national GHG emissions (9% in 2010 and 8% in 2012), due to the high share of hydropower, which represents nearly 70% of all electricity produced in recent years (UPME, 2015a). Transportation is the main contributor to energy-related CO_{2eq} emissions accounting for 10% of the national emissions inventory (22.6 Mt CO_{2eq} in 2010) (IDEAM, 2015). The road segment was responsible for 88% of the transportation emissions, whereas waterborne, aviation, and rail segments contributed 6%, 5% and 0.5%, respectively.

The transportation fleet increased from 6.3 million vehicles in 2010–12 million in 2015 (MT, 2017a, 2013), mainly determined by private transport demand. Despite the rapid growth of the fleet, aging vehicles lacking emission control technologies still characterize the fleet (MT, 2016). Due to obsolete technologies, public transit fleets, freight vehicles and motorcycles serve as important sources of local air pollution (GM, 2015; IDEAM, 2016; Rodríguez et al., 2016; SDA, 2010).

With respect to urban passenger transportation, public systems and non-motorized modes are the predominant alternatives for traveling. Conventional transit bus systems and bus rapid transit (BRT) systems are in place. The conventional type exists in all cities, while the BRT system exists only in the eight largest cities. Similar to other developing countries (Cuenot et al., 2012; Figueroa et al., 2013; Wang et al., 2017), a transition from public and non-motorized modes of transportation to private modes has been observed in recent years in urban areas in Colombia (Ipsos, 2016; Pojani and Stead, 2017). In particular, there has been a significant growth in the use of motorcycles. Currently, there are more motorcycles than passenger cars (MT, 2017a). To reduce transport externalities, a goal of the current government is for BRT systems and non-motorized modes to account for 40% of urban trips in the eight largest cities by 2018 (DNP, 2014a). In addition, taxis act as a complement to other modes; however, the growth of the taxi fleet is constrained by regulation (Rodríguez and Acevedo, 2012).

The high proportion of non-motorized trips and public transportation is related more to low income levels (Acevedo et al., 2009; Combs, 2017; Combs and Rodriguez, 2014) than to other factors, such as environmental awareness. Indicators such as the number of daily trips per capita, the proportion of transportation costs in relation to household income and other factors related to affordability and accessibility (Bocarejo S. and Oviedo H, 2012) indicate that many people in Colombian cities still face transport poverty. Low travel demand, high proportion of public transport and non-motorized modes translate into low carbon emissions per capita with respect to urban transportation.

Regarding freight transportation, more than 95% of goods in the country are transported by trucks (MT, 2017a). Notable exceptions include crude oil and coal (both for exporting), which have exclusive transportation infrastructure: oil pipelines and railway (Roda and Perdomo, 2011). High costs derived from a suboptimal logistic system have been reported (Anif, 2017; DNP, 2015a, 2013). Existing efforts to improve this sector include a program aimed at reducing the total size of the fleet; financial incentives to retire old vehicles would exist (DNP, 2014a). Additionally, the implementation of national platforms and multimodal projects have been prioritized and are currently in the planning phase (Anif, 2017; MT, 2017b).

In terms of energy demand, road cargo is the segment that uses the most energy; this segment accounted for 54% of all the energy demanded by road transportation in 2012 (UPME, 2014). Most light-duty vehicles are gasoline powered, whereas heavy-duty vehicles, including buses and trucks, run on diesel. The share of other energy carriers such as natural gas and electricity is small, representing 5% of the final energy consumption in 2012 (UPME, 2015b). Diesel fuel is blended with palm oil biodiesel (8–10%) and gasoline is mixed with sugarcane ethanol (8–10%) (CREG, 2015).

3. Methodology

We constructed a carbon emission model that accounted for the Colombian transport sector defined at the national scale; the model linked travel demand to vehicle stock, fuel consumption, and emissions (Fig. 1). Using a scenario analysis approach, we assess different mitigation options, and by comparing the results to those of a baseline

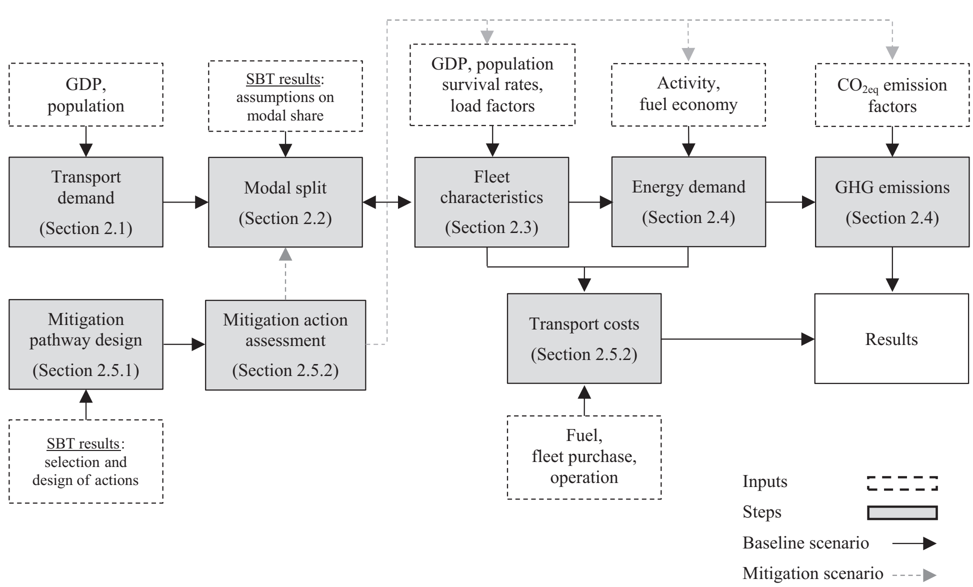

Fig. 1. Model structure. SBT: Scenario building team meetings. GDP: Gross domestic product.
Adapted from Wang et al. (2017).