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A methodology to compute emission projections from road transport (EmiTRANS)

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ABSTRACT

Atmospheric emissions from road transport have increased all around the world during the last decades more rapidly than from other pollution sources. For instance, they contribute to more than 25% of total CO, CO_2, NO_x, and fine particle emissions in most of the European countries. This situation shows the importance of road transport when complying with emission ceilings and air quality standards applied to these pollutants.

This paper presents a modelling system to perform atmospheric emission projections (simultaneously both air quality pollutants and greenhouse gases) from road transport including the development of a tailored software tool (EmiTRANS) as a planning tool. The methodology has been developed with two purposes: 1) to obtain outputs used as inputs to the COPERT4 software to calculate emission projections and 2) to summarize outputs for policy making evaluating the effect of emission abatement measures for a vehicle fleet.

This methodology has been applied to the calculation of emission projections in Spain up to 2020 under several scenarios, including a sensitivity analysis useful for a better interpretation and confidence building on the results. This case study demonstrates the EmiTRANS applicability to a country, and points out the need for combining both technical and non-technical measures (such as behavioural changes or demand management) to reduce emissions, indirectly improving air quality and contributing to mitigate climate change.

1. Introduction

Economic growth generates a sequence of environmental problems that become noticeable at the local scale [1] before causing evident regional or global effects. Increased mobility demands and consequent road transport growth constitute an example of this issue. Road transport is a major source of air pollutant emissions all around the world, particularly in urban areas. Moreover, its contribution to total emissions has increased during the last decades more rapidly than other sources [2,3]. According to the International Energy Agency, this tendency may continue in the mid-term. The World Energy Outlook Reference Case foresees a 50% increase of transport energy use in OECD countries between 2000 and 2030, despite recently adopted and ongoing policy initiatives intended to dampen this growth [4].

In addition, vehicle exhaust emissions have been the cause of much concern regarding greenhouse gas (GHG) emissions and the effects of urban air pollution on human health [5]. In spite of significant progress towards Kyoto targets, GHG emissions from road traffic have steadily increased in the past until very recent years, strongly affected by economic crisis [6]. Concerning urban air quality, there is a general positive trend across Europe, although recent dieselization of the fleet has led to increased primary NO_2 [7] and it is expected to keep growing in the mid-term [8]. This poses an important challenge for the compliance with NO_2 limit values in most of the major European cities (e.g. Carslaw and Beevers, [9]). This is also true for Spain, where road traffic is responsible for 24%, 38% and 24% of CO_2, NO_x and $PM_{2.5}$ emissions respectively [10]. Subsequently, both local and regional authorities may have

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the need to develop strategies to control vehicular emissions through technological and socioeconomical measures in order to achieve a more sustainable mobility [11]. Such abatement measures usually entail relevant economic and social costs [12]. As a consequence, to prevent the implementation of costly and unpopular measures with limited effect on emission reductions, model-based assessment systems are needed for the evaluation of emission abatement strategies and emission scenarios, especially in the transport sector [13,14], during the political decision making process and prior to their performance.

As shown in Borge et al. [15], these road transport models have evolved from formulations based on the average speed to those that define different traffic situations and more realistic vehicle driving patterns. A comprehensive literature review is provided in Smit et al. [16], were the authors present a meta-analysis of 50 studies dealing with the validation of various types of traffic emission models with increasing complexity (from 'Average-speed' models, to 'Modal' models through 'Traffic-situation' models, 'Traffic-variable' models, and 'Cycle-variable' models). A more elaborated discussion on their complexity, advantages and disadvantages is presented in Smit et al. [17].

In Europe, the main model applied to estimate road traffic emissions at either national or regional level for reporting purposes has so far been the European Environment Agency (EEA) software called COPERT4 [18]. This model is able to estimate the fuel consumption and exhaust emissions from vehicles within a specific area and is currently integrated in the EMEP/EEA methodology for emission computation [19].

The development of abatement strategies implies not only emission models, but also methodologies to assess the effect of policies and measures, even assuming their associated uncertainties that could demand alternative approach to policymaking, especially for long-term transport policies [20]. In this sense, some important efforts have been made worldwide in the last few years. Most studies rely on a common methodological framework based on the projection of activity data and emission factors taking into account socio-economical drivers, legislation and technological factors [21]. This approach is conceptually rather simple but its implementation may vary widely depending on the target sectors and pollutants and the temporal horizon and detail of the projections. Very often emission projections are related to very specific location, sources and/or pollutants. Inter alia Seika et al. [22] estimated the changes in the concentration of NO_x and other pollutants from vehicle emissions under different traffic control strategies; Sælensminde [23] presented cost-benefit analyses of walking and cycling, planning to reduce the effect of motorized transport revealing that the investment in walking and cycling networks has a net benefit for the society. Turton and Moura [24] looked into potential benefits of the penetration of electric vehicles under several long-term scenarios whilst McDowall [25] identified hydrogen technologies as an important option for deep decarbonisation of the transport sector. Other studies such as Shrestha et al. [26] focused on determining cost effective transport technologies and energy options to reduce atmospheric emissions in a city for future years, resulting in scenarios where gasoline and diesel vehicles were replaced by LPG, electric and hybrid vehicles improving local air quality for all pollutants except CO. At the European Level, Giannouli et al. [27] investigate the effects of specific emission control measures on the air quality of urban centres and local area hotspots applying a sequence of regional, urban and local scale models.

All these examples apply different methodologies with their advantages and disadvantages mainly concerning the level of detail of policies and measures, types of vehicles affected and spatial scale. However, as authors are aware, only the TREMOVE model [28] evaluates emission reductions in road transport planning involving both technical and non-technical measures. Technical measures are those end of pipe actions that reduce emissions by technological changes (catalytic systems, filter, etc.) whilst non-technical measures include behavioural changes (e.g. downsizing cars), demand management, and changes in energy mix. Its scope, however, avoids detailed calculations for specific countries.

This paper presents a methodology to estimate detailed atmospheric emissions from road transport for a country/region including the development of a tailored software tool and considering technical and non-technical measures. This contribution reports the development and application of the emission projection methodology for road TRANSport (EmiTRANS), a model to evaluate emission under particular conditions for the road transport model, providing therefore a necessary complement to forecast models used for general planning and sectoral analysis [29]. The aim of the EmiTRANS model is twofold:

- to generate the inputs needed to run COPERT under any particular scenario,
- to provide a platform for the study of the effect of the implementation of policies and measures (P&M) on emissions, including both technical and non-technical options.

The methodological approach and model structure are described in Section 2. Afterwards, a case study is shown for a better understanding of the model capabilities. The system was used to calculate emission projections from road transport in Spain up to 2020 under several scenarios. The application includes a preliminary sensitivity analysis that may be relevant to build the confidence needed for the decision-making process. This can also be used to identify areas in the model that need better refinement to reduce uncertainty. The main results from this application are reported in Section 3. Discussion and conclusions regarding both, the system itself and the case study are presented in Section 4.

2. Methodology

2.1. Model objectives and theory

The aim of the paper is to develop a model to help policy making on road transport sector at any spatial level. Considering that COPERT4 was selected as the software to estimate air emissions and it needs several inputs to be run, the model has to meet the following two objectives: 1) to obtain outputs (MS Excel™ spreadsheets) to be directly used as inputs to COPERT4, and 2) to summarize some other outputs that are particularly useful for policy making (e.g. mileage, technology distribution, and driving mode sharing).

A general methodology for emission projections, including the way to project activity data, was presented in Lumbreras et al. [21]. For this particular case, the methodology was