Research in Transportation Economics xxx (2017) 1–12

Contents lists available at ScienceDirect

Research in Transportation Economics

journal homepage: www.elsevier.com/locate/retrec

A two-step method to evaluate the Well-To-Wheel carbon efficiency of Urban Consolidation Centres

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ARTICLE INFO

Article history:
Received 21 November 2015
Received in revised form
20 June 2016
Accepted 16 November 2016
Available online xxx

JEL codes:
R4
R410

Keywords:
Urban freight transport
CO_2 emissions
Well-to-wheel analysis
Urban consolidation centre
Lucca

ABSTRACT

With 25% of CO_2 transport-related emissions, urban freight mobility is a relevant cause of climate change. Its optimization is a main aim of the Sustainable Urban Logistic Plans. Currently, the CO_2 analysis of such plans is mostly based on a Tank-To-Wheel approach, which does not consider fuel production and distribution, thus not providing a comprehensive evaluation of its carbon effects. In this paper, we propose an alternative two-step approach: after quantifying CO_2 emissions through a Well-To-Wheel methodology, which assesses the entire energy pathway of the fuel, we valuate them economically, using a meta-analysis of 700 studies. We test this model to assess the carbon potentialities of a new Urban Consolidation Centre (UCC) in the city of Lucca, Italy. Our results indicate a potential yearly saving of up to 190 tCO_2 (which corresponds to about €10,000 of social cost savings). These benefits are mostly obtained through third funds, which make the investment financially sustainable for the municipality. With adequate adaptations, the model can be used in other urban areas to assess the carbon potentiality of different transport measures. Furthermore, an integration of the long-distance freight movement can provide the total CO_2 contribution of freight transport.

1. Introduction

Transport sustainability is a complex topic that involves several economic, social and environmental aspects (Sinha & Labi, 2007). Of these, greenhouse gas (GHG) emissions represent an important aspect to be investigated (Black, 2010). Policy makers are aware of this and, since the early 1990s, the EU has constantly increased its efforts to reduce GHG emissions (DGET, 2006), with encouraging results in many sectors (e.g., agriculture, industry, buildings). Transport is an exception, since GHG emissions have increased by about 22% in comparison to the 1990 levels (EU, 2014).

There is a common understanding that this issue has to be addressed mostly at the macro-scale level (MDS Transmodal Limited, 2012). The ambitious mid-term goals proposed by the European Commission are coherent with this approach, aimed at reducing continental GHG emissions by 40% by 2030 (EC, 2015a) and by around 60% within 2050 (EC, 2011). The recent agreement achieved at the Paris climate conference (EC, 2015b), where a long-term goal of keeping the increase in global average temperature to well below 2 °C above pre-industrial levels, tries to address this issue with a more resolute – even if operatively vague-approach. Several attempts have been made to propose an integration of the municipal level to the solution of the GHG issue. Cities have been recognized as primary centres of economic, political and social innovation, where the largest amount of money is being invested. Consequently, climate change cannot be ignored at this scale.

In transport and mobility planning, carbon dioxide (CO_2), which is the main component of GHG emissions, continues to have an ancillary role. Measures, proposed primarily for other aims, such as decongestion, improvement of public or alternative transport modes, can also have a positive impact on CO_2 emissions, the quantification of which in most cases is oversimplified (Nocera & Cavallaro, 2014a). This makes it difficult to ascertain the real carbon impact and efficiency of the proposed measures. The urban energy plans (e.g. the Sustainable Energy Action Plan - SEAP) have not solved the issue completely, because they limit their analysis to CO_2 emissions, not integrating them with the traditional mobility aspects mentioned previously. Furthermore, SEAP aims to obtain an overall reduction in different civil sectors, leaving the policy makers the possibility to decide the relative weight allocated to each sector.

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http://dx.doi.org/10.1016/j.retrec.2017.04.001
0739-8859/

In such cases, mobility impacts can be secondary and other sectors (e.g. building efficiency, waste management, energy production) provide the main contribution to the urban CO_2 reduction. Hence, an integration of the GHG issues into the urban mobility plans is required. The recent development of the Sustainable Urban Mobility Plans (SUMPs - Wefering, Rupprecht, Bührmann, & Böhler-Baedeker, 2013) could represent an alternative vision to address this issue appropriately. However, a method like this still lacks operative recommendations to assure its full replicability in other contexts.

In some of our previous researches, we have tried to address this issue at different scales. In Nocera, Maino, and Cavallaro (2012), Cavallaro, Maino, and Morelli (2013) and Nocera and Cavallaro (2014b), we have developed a methodology to quantify and valuate CO_2 impacts of the construction and the operation of a new main infrastructure. In Nocera, Tonin, and Cavallaro (2015a), we have assessed the CO_2 impact of some European transport policies; in Nocera, Tonin, and Cavallaro (2015b), we have proposed a method to integrate CO_2 emissions in SUMPs. In the present paper, we extend our analyses to the Sustainable Urban Logistic Plan (SULP; Ambrosino, 2015), a new form of mobility plan developed within the ENCLOSE project,[1] which adopts the principles of SUMP and adapts them to the urban freight distribution. Our aim is to understand the carbon impact deriving from the adoption of specific freight measures and to propose a methodology to include it in a clear way within the SULPs. Currently, SULPs adopt a simplified approach that uses Copert III (Kouridis, Ntziachristos, & Samaras, 2000). However, this approach fails to provide the total impact of CO_2 emissions, because it ignores the phases of fuel production and distribution. The paper is structured as follows: after this introduction, section 2 describes the issues related to urban freight transport, with a focus on CO_2 urban freight emissions and the possible solutions to reduce them. Section 3 presents a comprehensive methodology, which allows the quantification and economic valuation of the real carbon impact of urban freight transport measures. In section 4, we apply this method in a case study of the Italian city of Lucca. Conclusions are drawn in the last section.

2. Urban freight transport and CO_2 emissions

Urban freight transport includes all movement of goods into, out of, through or within the urban area, mostly carried out with light and heavy vehicles. However, the adoption of alternative transport systems such as cargo bikes is increasing and should be considered as well (Schliwa, Armitage, Aziz, Evans, & Rhoades, 2015). Several sub-categories of freight transport have been identified, according to the types of shop and delivering system (TRS, 2009):

- *Independent retailing* represents up to 30–40% of all daily urban deliveries. They are normally served by own account vans, up to 10 times a week (depending on the nature of the goods sold). In this sector, urban freight seems to leave a certain room for improvement.
- *Chain retailing*, with subsidiary or franchises, and *commercial centres* are progressively substituting independent retailing in historical cities. Their provision system is based on larger and better loaded vehicles and is characterized by less frequent deliveries.
- *Food markets* are characterized by frequent deliveries (in many cases with daily –or even higher-frequency).
- *Express transport services* are based on consolidated delivery tours departing from cross dock terminals located in peripheral areas. Large vans or small trucks are adopted to distribute the goods, which can serve from 20 up to 90 (or even more) receivers.
- *Home delivery* can be seen as a subgroup of the express transport services, but its recent introduction and its constant increase is leading to the adoption of specific and innovative transport systems.
- *Urban building sites* generate a high percentage of urban freight (up to 30%), due to the tonnage generated. Usually, such sites are serviced by lorries, which cause several problems (such as noise, congestion, safety) due to a lack of planning in scheduling the deliveries.

Less restrictive classifications include other categories, such as the shopping trips made by private households, the reversal logistic and the trips of service vans for maintenance, supply and removal of parts (ALICE and ERTRAC, 2015). Whichever urban freight components are considered, their environmental impact is relevant, reaching up to 15% of vehicle equivalent km and contributing up to 25% of urban transport-related CO_2 (EC, 2015c).

Europe is trying to reduce such impacts by introducing further policy measures: in the European White Paper (EC, 2011), one of the aims is to halve the use of 'conventionally-fuelled' vehicles in urban transport and achieve essentially CO_2-free city logistics in major urban centres by 2030. The technological development is one of the approaches to address this issue: market-ready technology, based on petrol and fossil fuels, could reduce CO_2 emissions per new vehicle by 50% within 2030 (IEA, 2012). The European normative that limits the unitary GHG emissions of vehicles is an important driver to accelerate this innovation process: according to the EU regulation 510/2011, the average compulsory value of CO_2 emissions from new light commercial vehicles (LCVs) must not exceed the threshold of 175 g/km by 2015 and 147 g/km by 2020.

Yet, to obtain substantial results, the technological development alone is not enough (Dray, Schäfer & Ben-Akiva, 2012). A more comprehensive approach is needed, which can be achieved by a balanced mix of policies and concrete measures. Stelling (2014) adopts four categories to classify them, namely: economic, legal, knowledge-based and societal. We adopt a different classification, by distinguishing the push-from the pull-measures. Push-measures are imposed on freight operators to obtain a more equitable transport pricing, seeking to require transport users to bear a greater proportion of the real travel costs (including costs of pollution, accidents and infrastructure). They include financial instruments (e.g., taxes, charges and tolls) and technical and regulatory constraints (e.g., orders and bans). Literature has evaluated the potential impacts of such measures. The adoption of push-measures alone, such as a Limited Traffic Zone (LTZ), a pedestrian area or a Low Emission Zone (LEZ), is expected to produce negligible results in terms of CO_2 reduction (Bush, 2006). Furthermore, the low acceptability of push-measures among stakeholders makes their adoption often difficult due to an increase of constraints generated (Stathopoulos, Valeri, & Marcucci, 2012). The adoption of an agent-specific approach during the preparatory phase (Gatta & Marcucci, 2014) could help policy-makers to obtain a broader consensus in the adoption of the measures. Operatively, the multi-actor multi-criteria analysis (MAMCA – Macharis, De Witte, & Turcksin, 2010) has also provided good results, by obtaining a shared vision among politicians and actors directly involved in the freight delivery actions.

Pull-measures are implemented in order to discourage the use of private trucks and commercial vehicles by improving the attractiveness of existing less polluting alternatives. The acceptance of these measures among operators is usually higher than of push-measures, because they are conceived as a further opportunity and not as a limitation. An example of pull-measure can be the building of off-street delivery areas in commercial or industrial

[1] See http://www.enclose.eu/.

Please cite this article in press as: Nocera, S., & Cavallaro, F., A two-step method to evaluate the Well-To-Wheel carbon efficiency of Urban Consolidation Centres, *Research in Transportation Economics* (2017), http://dx.doi.org/10.1016/j.retrec.2017.04.001