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The Ancillary Role of CO_2 Reduction in Urban Transport Plans

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Abstract

Saving CO_2 emissions constitutes one of the most delicate challenges of transport engineering. Coherently with EU and national directives, urban mobility and traffic plans should consider CO_2 savings as one of the goals to be reached. In an apparent contradiction, however, the measures generally proposed within urban transport plans seem to operate primarily for different aims, such as decongestion, improvement of public or alternative transport modes, determining an ancillary role of CO_2 emissions. Recently, other multidisciplinary forms of planning (e.g., SEAP) have been proposed; which also do not fully consider the complexity of the integrated transport approach. To solve this criticality, this paper presents a two-step method (balance and valuation) for considering CO_2 explicitly within mobility plans.

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Keywords: Transport Planning, Urban Transport Plan, CO_2 Emissions

1. Introduction: the importance of CO_2 emissions in transport

The reduction of CO_2 emissions deriving from the circulation of private vehicles is considered as one of the most relevant problems in transport planning (Black, 2010). At European level, transport is responsible for about 26% of the total emissions (EC, 2005) and its increase, in comparison with 1990 levels, has been about 30% (EC, 2009),

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being the only civil sector not providing a reduction in last 20 years. At urban level, such figures are even higher: transport accounts for about 40% of the overall urban emissions (Glaeser & Kahn, 2010).

This means that transport is a real issue when concerning the reduction of carbon emissions, and it is not actively contributing to their reduction, as required from international agreements such as the Kyoto Protocol (UN, 1998) or the European "20-20-20" targets (EC, 2012). According to several technical reports, this could bring to severe damage to the community in the form of severe temperature increases and other environmental, social and economic consequences (IPCC, 2007) .

Two different strategies are normally referred to as the main ways of reducing carbon emissions. The first focusses on the supply side and intends to improve the energy efficiency of vehicles, to reduce the carbon content of the energy used and to improve the efficiency of ITS systems (Bell et al., 2012). The second one is centred on the demand side and aims at diverting demand segments to less impacting transport modes. So far, the emphasis of transport policies has been mostly focused on the supply side at the expense of measures designed to influence travel behaviours (Anable & Bristow, 2007), whereas the studies regarding demand are limited (Libardo & Nocera, 2008). Several technological solutions, particularly within car passenger and freight technology, have been developed and transport plans highlight their relevance in addressing the CO_2 issue. King (2007) states that market ready technology could reduce CO_2 emissions of new cars by 30% within 5 to 10 years. This is valid for the private car, but a comprehensive analysis about the effectiveness of the measure should also take into account the availability and cost of oil. In addition, the "rebound" effect seems to influence the price of certain transport solutions (Sorrell & Dimitropoulos, 2007): for example, the owners of a new vehicle tend to use it more than needed to abate the overall cost per kilometre, making the improvements in vehicle efficiency not lead to a corresponding decrease in overall vehicle emissions. Moreover, the evidence on the cost-effectiveness of behavioural instruments has been downplayed: total CO_2 from transport is a product of both the efficiency of the vehicles used and of the way they are used. If the users are asked to cooperate in order to achieve a carbon abatement, awareness campaigns or a series of measures must be promoted.

The distinction between supply and demand can be reinterpreted from a broader perspective, by adopting the distinction between push- and pull-measures (as discussed thoroughly in Nocera & Cavallaro, 2011). The former have been defined as those measures imposed on travellers and freight operators in order to influence individual decisions. They can be divided into financial instruments (e.g., taxes, charges and tolls) and technical and regulatory constraints (e.g., orders and bans). They are closely related to a more efficient and equitable transport pricing, seeking to require transport users to bear a greater proportion of the real costs of their journeys (including costs of pollution, accidents and infrastructure). On the other hand, pull-measures have been defined as those measures implemented in order to discourage the use of cars and trucks by improving the attractiveness of existing public transport alternatives. The results of our previous analyses (Nocera et al., 2012; Nocera & Cavallaro, 2012, 2014) identified the combined adoption of push- and pull-measures as mostly effective in promoting CO_2 savings when the realization of new infrastructures is at-stake.

2. The limited approach of urban transport plans

The European Green Book on the Urban Environment clearly states that CO_2 emissions must be taken into account to develop a sustainable mobility concept in urban areas (CEC, 2007). This document lists some measures, to be further investigated within the national context, with the overall goal of creating a new mobility culture and a reduction of urban congestion. Alternatives to the use of the private car, such as walking, cycling, public transport or the use of the motorbike and scooter have to be attractive and safe, so that citizens will prefer them over the car. Authorities should promote co-modality and reallocate space that becomes available after congestion mitigation measures. Intelligent and adaptive traffic management systems also have to be incentivized.

The issue of urban mobility is addressed at national and local level in a coordinated way, through the development of national and local plans. The single States provide general guidelines through the development of the national transport plans; because of the vast territorial scale and the differences of specific cities, the practical solution is demanded at local level, with the adoption of the regional, provincial and local transport plans. Particularly, this last form of plan seems to offer the most appropriate answers: a local transport plan aims at providing a sustainable form of urban mobility that considers the social, economic and environmental aspects. Such

plans include the improvement of road safety and circulation, the reduction of air and noise pollutants, environmental protection, energetic saving and the concordance with other plans. Not surprisingly, the reduction of CO_2 emissions is set as one of the main objectives. The plan should provide a strategy to obtain such a reduction, through the adoption of specific measures. In practice, this occurs only rarely: as already mentioned in the introduction, a good number of plans focus on the supply side of the problem, highlighting the role of technological advances in the matter. Although increased efficiency confers economic benefits in its own right, its effectiveness in reducing fuel consumption and emissions depends on how consumers alter behaviour in response to cheaper energy services due to improved efficiency. To obtain the total savings potential from increased vehicle efficiency would require complementary measures (demand-side) to restrain demand increases, in which case the costs of achieving the reduction would fall. These demand-side measures are normally proposed in the plans but without providing a correspondence with the expected results in terms of CO_2 reduction, as well as the methodologies to evaluate the results economically. Therefore, the link between the measures and the expected reduction of CO_2 emissions is missing. The plan suggests that the reduction of CO_2 traffic emissions is one of the most urgent interventions to be carried out, and it can quantify them difficultly.

Several cases at European level confirm this condition. In France, the urban transport authorities elaborate the Plans de Déplacements Urbains (PDUs), obligatory for cities with more than 100,000 inhabitants and voluntary for smaller ones. PDU aims to assure coordination among all transport modes and to promote less polluting and more energy efficient modes. This can be achieved by reaching specific targets: to improve road safety; to reduce car traffic; to develop public transport and the less polluting sustainable transport systems (Cappelli et al., 2013); to exploit metropolitan routes and to implement traffic information; to organise and regularise on-street parking and public parking; to manage and regulate freight transport and multimodal transport (Cappelli & Nocera, 2006); to promote commuter plans for companies and public administrations; and finally, to develop integrated ticketing for the scope of mobility, parking and co-modality (Bührmann et al., 2013). CO_2 abatement is indirectly considered in the second point ("development of less polluting transport"), but no specific mention about how to reach this goal are given. To integrate this lack, the Paris PDU (CRI, 2012) provides an environmental annex, mostly focused on the externalities related to pollutant substances, including also CO_2. However, the analysis is limited to the past years and no forecasts about future emissions and their economic costs are provided (the only mention about future conditions concerns the technological improvements and reduction in terms of specific emissions expected for the new vehicles).

Vienna is another relevant example that confirms the discrepancies between the goals of the plan and the methods to reach them. The Municipal transport agency has developed the Verkehrsplan (Winkel, 2006), based on the directives of the 1999 Climate Protection Programme (Klimaschutzprogramm, KLIP). According to the Kyoto protocol, the KLIP prescripts a reduction of CO_2 emissions deriving from transport by 5% per capita between 1987 and 2010. To accomplish this goal, the traffic plan designs a set of specific interventions, mostly focussed on the modal split: the increase of public transport to 40%, cycle lanes to 8% and the contextual reduction of private vehicles (25%) by 2020. However, the plan specifies neither the contribution of the single measures to the reduction of CO_2 emissions, nor the expected costs.

The case of London is similar. The London Plan (London Plan Team, 2011) is the programmatic representation of the Mayor's vision in terms of development, growth and wellness, including not only transport but also other spatial and energetic issues. One of the goals of the plan is the reduction of CO_2 emissions by 60% by 2025, thus reaching a level lower than in 1990: a particularly ambitious result that goes beyond the European "20-20-20" targets. The plan lists the areas of intervention, including energy network decentralization, sustainable design and construction, improving the use of renewable energies, encouraging renewable technologies, rationalizing heating and cooling, urban greening, green roofs and waste self-sufficiency. The measures to achieve this goal are presented without their specific effectiveness on CO_2 reduction, especially when the transport field is considered. The reason rests on the primary goal of the transport policies proposed in the document, which is to create "a city where it is easy, safe and convenient for everyone to access jobs, opportunities and facilities with an efficient and effective transport system which actively encourages more walking and cycling". The environmental dimension is not ignored, but it is considered a consequence of other primary objectives. CO_2 reduction is left primarily to other urban fields, such as energy efficient buildings and energy efficient production from alternative sources and fuels.

In Italy, the legislation includes two main plans at local level: namely, the urban traffic plan (Piano Urbano del Traffico, PUT) and the urban mobility plan (Piano Urbano della Mobilità, PUM). PUT is a compulsory plan composed of a set of interventions aiming at improving urban road circulation of pedestrians, public and private vehicles. It is conceived for a short period (the validity is 2 years), hypothesizing an infrastructural urban layout basically unvaried. It is compulsory for all municipalities exceeding 30,000 inhabitants and for those municipalities characterized by a relevant seasonal flow of tourists. According to the Italian rules of the road (Italian ministry of infrastructures and transports, 1992), four main objectives have to be obtained: improvement of circulation (here including both movement and stops); improvement of road safety and security; reduction of atmospheric and acoustic pollutants; energy saving. The indicators adopted to evaluate the effectiveness of this plan are: improvement of circulation conditions (movement and stop); enhancement of road safety; reduction of acoustic and atmospheric contamination (criteria pollutants); energy saving activities; equity (Cascetta & Montella, 1998). The improvement of these technical performances is expected to have positive results on other social and environmental aspects, including the reduction of GHG emissions. However, this is an indirect consequence, not quantified. The old traffic plan of Rome (Comune di Roma, 1999) is representative in this sense, as it does not even mention the issue of CO_2 emissions.

PUM is a more comprehensive form of plan. It aims to improve the mobility system of a city, not limited on the circulation of its vehicles. Introduced by the Italian National Law 340/2000, PUM can be adopted by Municipalities on a voluntary basis. It covers a temporal horizon of at least 10 years, which makes this plan theoretically appropriate to deal with long-term transport aspects. PUM aims at integrating the urban interventions with European and national policies regarding the development of infrastructures, thus granting an intermediate level between, on the one hand, the National, regional and provincial transport plans and, on the other, the urban traffic plan. The overall objectives of a PUM are clearly expressed in the national law: ensuring the accessibility of jobs and services to all; improving safety and security; reducing pollution, GHG emissions and energy consumption; increasing the efficiency and cost-effectiveness of the transportation of persons and goods; enhancing the attractiveness and quality of the urban environment. It is expected to obtain these ambitious objectives through the adoption of concrete measures, including the formulation of future scenarios, the identification of actions to be financed, the monitoring of the effects produced (Regione Veneto, 2004), as well as the introduction of specific measures aimed at improving the infrastructural and transport systems. The theoretical framework is comprehensive and detailed. However, in practice, the Italian approach has revealed significant criticisms. From an economic perspective, the national fund necessary to implement the measures proposed in the PUM has never been operative and only the drafting of the documents has been financed by the Italian Ministry of Transport and Infrastructure, thus creating a discrepancy between the planning and the operative phases. Other criticalities concern the contents: the national guidelines focus on the realization of infrastructures at metropolitan area, but ignore the connection to the national and regional infrastructural level (ISFORT, 2011). Furthermore, the procedures to integrate the PUM with the master plan are missing, as well as the integration with local traffic plans. At operative level, an individual Municipality has to elaborate and implement its own strategies. With its limited financial possibilities, this means a prioritization of interventions. Aspects related to environment and health (including CO_2 emissions) have been considered secondarily, being indirectly obtained by solving the problems of congestion and modal shift. An emblematic example of this approach is the PUM of Rome. It does not ignore the environmental aspects; however, it refers primarily to the criteria pollutants. CO_2 emissions are mentioned briefly, by providing a hypothetical scenario (not described in its assumptions) and based on the forecast of the cars circulating in the future. The methodology is simplistic: the impacts of the measures are calculated by multiplying the expected distance saved by the unitary emissions. No relationship between measures and results is given. The Italian panorama includes examples of plans that try to focus more on the issue, such as the PUMs of Genua (Comune di Genova, 2010) and Venice (Comune di Venezia, 2008). Here, the reduction of CO_2 emissions is expressly one of the priorities and the methods to obtain this goal are outlined. The analysis of the historical data and the forecasts up to 2020 reveals that a reduction of GHG emissions by 20% cannot be obtained through only a renovation of the vehicle fleet, but a contextual reduction of traffic is necessary as well. The percentage of such reductions is a function of the target fixed at political level (for example, a 20% reduction of transport CO_2 emissions can be obtained with a diminution by 5% of traffic in comparison with current levels, whereas a reduction of emissions by 30% implies a decrease in traffic by 15%). The different options are developed by proposing five scenarios. For each of them, the infrastructural measures and

policies are suggested. However, even in this case, no information about the costs and benefits produced by the adoption of these measures is given.

Recently, an evolution of the traditional urban mobility plan has been proposed, which focusses not only on the technical aspects but includes the human, social and environmental dimensions as well. The Sustainable Urban Mobility Plan (SUMP; Wefering et al., 2014) builds on existing practices and takes due consideration of integration, participation, and evaluation principles to satisfy the mobility needs of people today and tomorrow for a better quality of life in cities and their surroundings. The ultimate scope of a SUMP is to design a city for its inhabitants, by taking into account several objectives. Some of them are typical for a traffic plan: to improve safety and security, the efficiency of the goods and passenger transport, to reduce air and noise pollution. Other aspects are less technical and most difficult to be quantified, such as to ensure that all citizens are offered transport options that enable access to key destinations and services or to enhance the attractiveness and quality of the urban environment and urban design for the benefits of citizens, the economy and society as a whole (Bührmann et al., 2014). In this sense, SUMP is not conceived as a technical development of a sectorial knowledge; it is rather the result of a multidisciplinary and integrated process that comprises status analysis, vision building, objective and target setting, policy and measure selection, active communication, monitoring and evaluation. However, to create a SUMP only guidelines are given and many criticalities seem not yet solved, particularly referring to the possible effects on key environmental impacts of transport - namely noise, air quality and CO_2 emission. SUMP is a concept that lacks a practical implementation and a broadly accepted definition and terminology.

To summarize, what emerges from a typical urban mobility or transport plan is a general discrepancy between the overall goals (CO_2 reduction is considered among them) and the effective policies adopted (there are no measures directly related to the reduction of carbon emissions). This does not necessarily mean that CO_2 is ignored. It means that measures conceived for other purposes (e.g., reduction of traffic, increase in the use of public transport, fostering alternative means of transport, reduction of criteria pollutants) seem to give a certain carbon gain as a secondary effect, also producing an indirect positive effect on CO_2 emissions. This is not only due to technical difficulties in quantifying and evaluating the emissions (Nocera & Cavallaro, 2014), but is also caused by political choices. CO_2 is often seen as a global problem: consequently, it can occur that politicians prefer to address other issues mostly related to local scale to increase their consensus with their potential voters. It derives that the real effects of CO_2 may be underestimated or not adequately evaluated in terms of transport planning.

3. A possible solution to assess GHG emissions in mobility plans

To solve the problem of CO_2 emissions in transport planning, an integration to the current approach is necessary: being CO_2 reduction fixed as one of the specific objectives of the plan, direct measures should be proposed, whose effectiveness and applicability at urban level could be tested. Practically, this means to decline the generic guidelines of SUMPs in concrete measures. In Nocera et al. (2012) and Cavallaro et al. (2013), we developed two possible approaches to quantify CO_2 emissions related to the introduction of a specific new infrastructure along a transnational corridor. Referred to urban areas, the approach is partially different and many alternatives can be adopted. The Multi Criteria Analysis (MCA) and the Multiple Agent Multi Criteria Decision Making (MAMCDM) are a first possibility (Scarpellini et al., 2013; Nocera et al., 2014): MCA allows considering criteria in their own unit of measuring, hence disregarding monetization problems. GHG emissions can be part of a deeper analysis that includes other values to decide the most effective measures. However, this method can be affected by important subjective biasing: Browne & Ryan (2011) consider the choice of the criteria, the weights to be assigned and the risk of double counting as the most significant. Alternatively, a Cost Effectiveness Analysis (CEA) can be adopted. This method basically compares the costs of alternative approaches in producing the same result. The outputs of a CEA regarding CO_2 emissions are expressed as the optimum abatement price of emissions, i.e. the intersection between the curves of marginal avoidance cost and marginal social damage. The limit of this method is that it has to be applied to each objective separately, thus preventing a comparative analysis (like in MCA) and making the analysis restricted. Moreover, to grant the comparability of results, the assumptions of the different alternatives have to be similar.

The Cost Benefit Analysis (CBA) is a possible alternative solution. Indeed, this approach is normally preferred to analyse the environmental policies of the transport sector when a fair unitary price is given (Turner, 2007). In the

analysis of CO_2 emissions, CBA can be conceived as the result of an energetic and economic balance. Such combined approach, currently missing in urban mobility plans, can be partially derived from the Sustainable Energy Action Plan (SEAP - EU, 2010[†]) and partially from our previous research in valuation of GHG emissions (Nocera and Cavallaro, 2014). The schematization of such process is illustrated in figure 1.

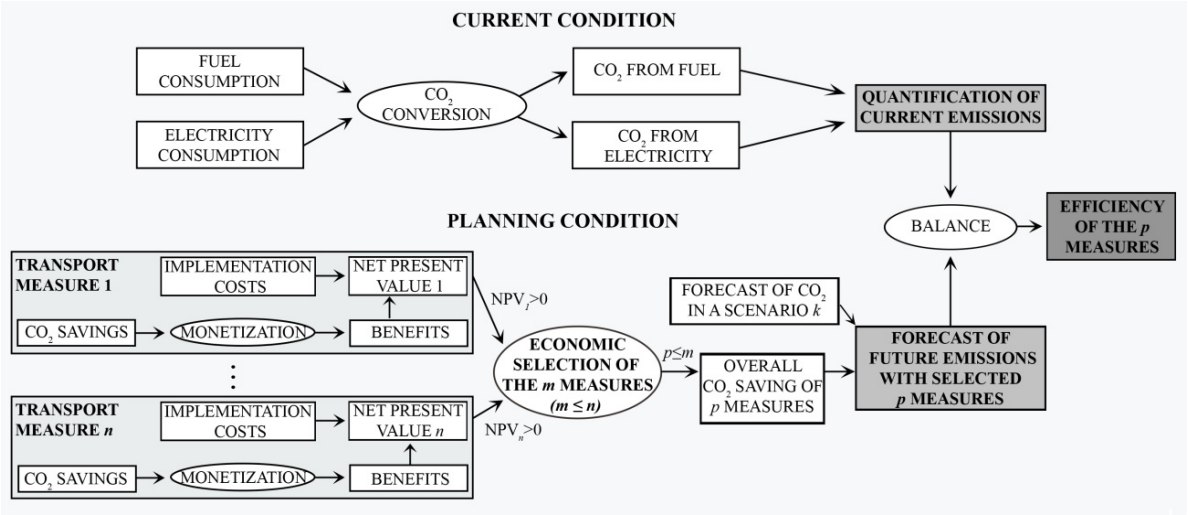

Figure 1. Schematization of the process to include CO_2 evaluation in mobility plans.

The method starts by preliminarily analysing the current condition to be obtained through the quantification of CO_2 emissions deriving from transport in a given year. To this aim, the guidelines of SEAPs suggest to calculate the adoption of the fuel sold at municipal/provincial level by the petrol stations, as well as the electricity adopted for the circulation of trains and electric-powered means of transport. Through appropriate coefficients of transformation (IPCC; 2006; Terna, 2009), it is possible to derive the CO_2 emissions from the electricity and petrol used in a given locality, thus obtaining the baseline emission inventory (BEI).

Subsequently, a set of transport measures has to be chosen and evaluated, according to the reduction target fixed by the mobility plans. To this aim, each measure has to be accompanied by a description of the activities required for their complete adoption, the cost estimation, timing, energy savings and CO_2 reductions, in order to make the choice as transparent as possible. In Table 1, a couple of transport measures are presented, which have been proposed for the city of Granada. At the end of this part of the process, it is possible to define the reduction of CO_2 emissions that the plan has to achieve, as well as the expected costs of each action (table 1, columns 4 and 5).

[†] Even if not legally mandatory, SEAP is a significant environmental instrument at local level to achieve the EU 20-20-20 target (Radulovic et al., 2011), having reached about 5,750 subscriptions from Mayors and covering about 187,500 inhabitants through the whole of Europe (Covenant of Mayors, 2014). SEAP outlines the activities and measures foreseen by signatories in order to fulfil their commitments, with corresponding periods and assigned responsibilities. The goal is to propose a radical change of the current energy model. This plan includes different fields, such as buildings, equipment/facilities, local electricity production, transport and local heating/cooling generation.

Table 1. Transport measures as proposed by the SEAP of Granada to reduce CO_2 emissions. Source: City of Granada, 2012.

MEASURE	DATE	DESCRIPTION OF THE MEASURE	CO_2 REDUCTION (t/year)	COST (€)
Public Transport improvement	2009-2020	Improving the public transport with biofuels, GLP and electricity in public transport. Restructuring of public transport, new minibus line and improving intercity transport.	93.699,97	3.819.251,15
Private and commercial transport ventures	2009-2020	Improving the management rationalization of urban freight distribution, promoting walking and cycling with safe routes and informative materials. Creation of a platform for car sharing. Promotion of cycling and mobility management. Installation of bicycle parking at schools.	22.296,20	2.165.000,00

The following step is the definition of the future emissions, as well as the economic evaluation of the benefits generated by the measures in terms of CO_2 reduction, so that benefits can be related to the costs of implementation through a CBA. With the current methodologies, many difficulties in providing a fair evaluation of CO_2 emission costs seem unavoidable, due the numerous sources of economic and scientific uncertainty, such as the current level of emissions, the forecasting methodologies, the correlation emissions-concentration, temperatures and levels of emissions, the economic damage, the equity weight and the discount rate (Clarkson & Deyes, 2002). Since the range of the estimates covers up to six orders of magnitude (Nocera & Tonin, 2014), it does not allow for the adoption of a fair unitary value. To address this problem, in Nocera & Cavallaro (2014), we proposed yearly values based on a thorough analysis of several European studies carried out in the last 20 years and a statistical approach to define a wider range up to 2035. Three final classes have been defined (the lower, medium and upper ones), according to the different reduction targets fixed by the policy-makers (table 2).

Table 2. CO_2 prices (€/tCO_2) adopted here for the years 2010–2020. Lower, central and upper values. Source: Nocera & Cavallaro, 2014

Year	Lower value (€/tCO_2)	Central value (€/tCO_2)	Upper value (€/tCO_2)	Year	Lower value (€/tCO_2)	Central value (€/tCO_2)	Upper value (€/tCO_2)
2010	19.45	23.14	50.43	2023	26.49	53.90	88.52
2011	19.93	25.46	53.23	2024	27.22	57.06	91.89
2012	20.42	27.77	56.03	2025	27.95	60.22	95.25
2013	20.90	30.08	58.83	2026	28.68	63.37	98.61
2014	21.39	32.40	61.63	2027	29.41	66.53	101.97
2015	21.88	34.71	64.43	2028	30.14	69.69	105.33
2016	22.36	37.03	67.23	2029	30.87	72.85	108.69
2017	22.85	39.34	70.04	2030	31.60	76.00	112.06
2018	23.33	41.66	72.84	2031	32.81	79.22	115.98
2019	23.82	43.97	75.64	2032	34.03	82.43	117.29
2020	24.31	46.28	78.44	2033	35.25	85.65	121.21
2021	25.04	47.59	81.80	2034	36.46	88.87	125.13
2022	25.77	50.75	85.16	2035	37.68	92.08	129.05

By multiplying the expected savings by the unitary price (table 2), it is possible to assign an economic value to the benefits of the single transport measures in terms of CO_2 reduction. This integration allows the adoption of an explicit evaluation of the effectiveness in terms of CO_2 reduction of the measures proposed.

The method previously described may grant four main aspects of a fair evaluation. First, it is possible to measure the performance in an objective manner and within an acceptable degree of accuracy and reliability, thus not making CO_2 a generic externality but an active parameter that affects transport decisions. Second, it is possible to collect, generate or extract reliable data relating to the performance measure without excessive effort, cost or time. This constitutes a relevant advantage because of the limited resources required to monitor the effectiveness of the measures. Third, the performance measures are clear and concise so that the manner of assessing and interpreting its levels can be communicated effectively. This aspect is particularly relevant in transport field, as far as the management of the relationships with stakeholders and public is concerned: a clear and shared definition of the

problems, obtained through evident indicators, helps to prevent the increase in social conflicts (Cavallaro & Maino, 2014). Fourth, the method considered should be generalized and not refer to single cases only: with the adequate modifications deriving from the specific urban conditions and transport systems, the method presented in this paper can be iterated and included in different mobility plans.

4. Conclusions

The evaluation of the cost-effectiveness of transport measures for carbon reduction within transport plans addresses at least three preliminary issues: the assumptions about future costs and level of travel demand, the methods applied to compare policies for cost-effectiveness and the evidence of data used in relation to different types and combinations of policy instruments. One of the main difficulties lies in the fact that only a narrow set of measures targets the reduction of carbon levels as a primary aim and that isolation for carbon abating potential has a quite significant degree of uncertainty. Moreover, any estimate of cost-effectiveness is critically dependent on the future that is assumed. High uncertainty, as in any transport plan including the construction of infrastructures, can carry with it precautionary estimates and hence higher costs. Above all, in the long term, uncertainty includes not only travel demand but also targets oil availability and subsequently the cost of conventional fuels. Analyses tend to assume that oil based fuels will continue to exist at affordable prices and quantities, not considering the primary role of hybrid-electric and battery-electric vehicles (Weiss et al., 2012). This may have the effect of overestimating economic growth and/or stability (and thus travel demand) and downplaying the cost of reliance on conventional technologies and the role that could be played by innovation towards alternative fuels and lifestyles.

As illustrated in section 2, the current forms of transport and mobility planning do not seem to evaluate the effects of GHG emissions properly. Local traffic plans generally include their reduction as one of the overall goals but do not quantify the expected impacts of specific measures, nor general values, thus revealing a discrepancy between general aims and indicators. The scheme adopted by this kind of plan focusses more on the adoption of practical measures; it describes the effects in terms of traffic decongestion and improvement of public or alternative transport, without actively assessing the consequences in terms of global warming. This does not necessarily mean that the measures are ineffective, but rather that it is very difficult to appraise their impacts if they are not evaluated specifically, consequently leading to a potentially incorrect appraisal of the overall plan.

To overcome such a critical condition, transport plans have been recently flanked by other alternative forms of plans such as the SEAP, which deal specifically with CO_2 reduction, including different sectors of civil society. However, these plans do not seem to be the most appropriate solution to address the issue of transport emissions, because they focus only on the energetic aspects hereby lacking in the solution of transport issues. Indeed, a mobility plan is very complex thematically and normally requires a holistic approach that includes the relevant values related to traffic circulation, transport modes, etc... CO_2 emissions are one of these points, but cannot be considered as the exclusive one.

In the present paper, we have proposed an integration of the methodology developed by SEAP with a valuation of the benefits deriving from the reduction of CO_2 emissions through a balance. This can be included in urban mobility plans as one of the components that contribute to determine the final proposals. The method has been kept intentionally simple in order to make it available for the use of policy-makers and stakeholders and because of several scientific and economic uncertainties. Several aspects can be improved upon, such as the quantification of current emissions with methods that are more accurate or the definition of a fairer unitary value of emissions by assessing the different uncertainties that affect the process.

Nevertheless, as a transport plan has traditionally reflected the policy concerns of the time in which it was occurring (Meyer & Miller, 2001), carbon emissions have now to be included as a part of it. Because of this, as the success of planners to analyse and evaluate transport systems is influenced by the tools available, it is necessary to conceive efficient and integrative methods to be included within traditional transport analyses. If agreed upon, this approach will likely be trending in transport planning over the next several years, bringing a challenge to transport planners: making sure that this change is made to preserve the substance of the planning process, while at the same time producing the desired results.

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