

Energy and environmental issues as choosing elements for selecting options in the transportation sector aimed at reducing CO₂ emissions: an application to the Italian case

D. Barbieri, A. Nucara, M. Pietrafesa and G. Rizzo

Istituto di Ingegneria Civile ed Energetica, Facoltà di Ingegneria, Università di Reggio Calabria
Via E. Cuzzocrea, 48, 89128 Reggio Calabria, Italy

Abstract

A new transportation demand model is described showing a simple data-base structure. It only requires input data referring to the fleets and the engine characteristics of the transportation park.

The main characteristic of the model is its expertise in analysing the effects of different policies oriented to the reduction of the pollution levels and to the energy savings in the transportation sector. The results are provided both in terms of energy consumption and quantities of pollutant released to the environment.

The effects of different transportation scenarios can be easily analysed using a simple "electronic sheet" way of representation.

1. INTRODUCTION

In this paper we will present a new transport demand model, showing a simple data-base structure. It is founded on generally available information about the structure of the transportation park and on the size and type of the used engines and allows the obtaining of a desegregated view of the system and the evaluation of the pollutant emissions.

The model, built-up for the whole Italian sector, is easily applicable, with minor modifications, to any country for which the required input data is available. It is also suitable for analysis regarding smaller areas, even to a regional scale.

The main feature of the model is to provide results both in terms of energy consumption and quantities of pollutants released in the environment, as effects of the assumed scenarios. Starting from the "zero" scenario, referring to the system when all the requirements of the Italian government's rules are accomplished, some alternative options are analysed.

2. DESCRIPTION OF THE MODEL

The structure of the model is essentially founded on the following four points:

1. the transportation demand of the analysed region is organised with respect to three components: the object of the transportation (people or goods), its spatial domain (urban or

non-urban) and the way with which the transportation is accomplished. The units employed are the passengers per kilometre and per year (pkm/y) or the tons of goods per kilometre moved per year (tpk/y);

2. a distributive model assigns the total energy consumption to each fuel source, by means of the specific values of the consumptions, available in the literature. The units here utilised are the kilotons equivalent of oil (ktoe);
3. for each pollutant component released by the transportation means, the *emission factor*, intended as the quantity of pollutant released for unitary energy (t/ktoe) is calculated. These parameters link the energy consumption with the CO₂ emissions [1-2];
4. the quantities of the CO₂ emissions are then computed for each component of the transportation demand and for each energy source.

A description of the main features and potentialities of the model can be offered by analysing one of the tables that constitute the way of representation of the results obtained.

Fig. 1 contains an example of these print outs: along with the modal distribution of the transportation demand, subdivided into the urban and extra-urban components. The figure reports the specific and total energy consumption by each component. The share of the energy demand covered by the fuel sources is also shown.

The yearly increasing rate, for each modal component of the whole transportation sector, represents the most important parameter in order to characterize the scenarios.

In any case, the numerical quantities reported in Fig.1 are to be considered only as an example, since the main purpose of this paper is the presentation of the structure and the potentialities of the model.

The model also allows evaluations of the emissions of the main environmental pollutants linked to the transportation sector: carbon monoxide (CO), nitrogen oxides (NO_x), volatile organic compounds (VOC), including hydrocarbons and suspended particles (SP), in terms of yearly tons of quantities given off. The types of pollutants chosen depend on the kind of

1992 (ESTIMATED VALUES)																					
Passengers and freight movements referring to final energy consumptions					Energy rate by sources					CO ₂ emissions (ktC)											
Forms of transportation	Yearly increasing rate (%) 1989-1992	Accomplished demand (Mrd pkm)	Modal split %	Specific consumption (g/kpkm)	Energy consumption (ktC)	Energy sources						Energy sources									
						Gasoline	Diesel	Jet fuel	LPG	El energy	CNG	Gasoline	Diesel	Jet fuel	LPG	El energy	CNG	Total			
Passengers urban traffic																					
Cars	3.14	196.85	75.12	52	8676.17	0.674	0.242		0.073	0.011			5269	1892		571		62	7193		
Motorcycles	3.89	35.51	15.99	21	745.74	1							672						672		
Buses	0.56	15.13	6.81	18	272.36		1						245						245		
Underground	0.56	2.60	1.17	10	26.03					1							48		48		
Other collective means	0.56	2.00	0.90	15	30.95						0.976			1				55	55		
Urban passengers total	3.02	222.10	100.00		9750.36								5941	2136		571	103	62	8814		
Extraurban pass traffic																					
Cars	3.14	560.48	79.93	35	12610.85	0.541	0.372		0.076	0.011			6150	4229		864		90	11332		
Motorcycles	3.89	17.73	3.49	22	350.91	1							351						351		
Buses, trams	4.05	76.35	15.02	15	1145.30		0.947			0.053				917					917		
Aircrafts	8.54	7.32	1.44	3*1	2291.64			1							2065				2065		
Railways	1.41	46.35	9.12	8	370.77		0.25			0.75				84				517	630		
Extraurban pass total	3.21	598.23	100.00		16814.37								6501	5290	2065	864	517	90	15326		
Freight traffic																					
Trucks < 5 ton	3.03	23.71	9.88	90	2133.99	0.088	0.912						169	1754					1923		
Trucks > 5 ton	3.03	20.57	8.57	82	1696.92		1							1520					1520		
Trucks, long vehicles	3.03	118.61	57.74	35	4851.46			1						4371					4371		
Ships	0.95	34.98	14.57	6	209.87			1						189					189		
Railway	1.39	22.20	9.25	9	199.91		0.25			0.75				45				279	324		
Total freight traffic	2.56	240.08	100.00		9082.05								169	7679				279	8326		
Total	1.00	970.43			31646.78								12611	15306	2065	1435	896	151	32466		

Figure 1. Example of the output structure of the model.

analysis required [4].

Energy consumptions and pollutant emissions represent the selecting criteria in order to judge the effects produced by an assigned modal and structural distribution [5–6].

3. APPLICATION TO SOME TRANSPORTATION SCENARIOS

Three scenarios have been assumed here in order to show the features of the method.

- *The “zero” scenario.* This scenario has been identified as “zero” because it is considered the reference point for the whole analysis [7]. It is characterised by the absence of specific interventions and therefore it appears as simply driven by the demand of mobility, for which an increasing tendency is supposed.
- *The “modal split” scenario.* This option takes into account the effects of some interventions that modify the modal split of transportation. From 1995 until 2020 the transportation demand is supposed to shift toward the public means, with rates of 20% for the urban passenger, 25% for the extra-urban passenger and 20% for the freight movement. Moreover, an increase of 15% in the use of bicycles in the urban context is also supposed.
- *The “car pooling” scenario.* Within this alternative we suppose that the italian occupancy coefficient rises from 1.3 to 2.0 persons per car in the urban context and from 1.7 to 2.5 persons per car in the extra-urban context by the year 2020.

The model provides a graphic representation of the compared effects of the assumed scenarios, but also details numeric results, within each scenario under analysis, referring to the other environmental pollutants.

An analysis of the results provided by each of the previous mentioned scenarios is beyond the purposes of the present paper.

Fig. 2 depicts the estimated trends of CO₂ emissions of the whole Italian transportation sector from 1995 until 2020. Curves refer to the different scenarios.

Table 1 contains the percentage of reduction for the considered emissions and for the energy consumption recovered by means of the “car pooling” scenario referred to the base case, that is the “zero” scenario.

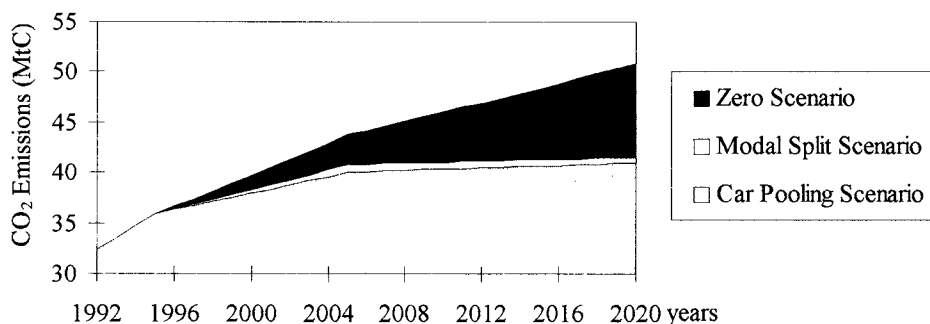


Figure 2. Estimated trends of CO₂ emissions for the whole Italian transportation sector.

Table 1

Reductions percentages obtained with the car pooling scenario with respect to the zero one.

	CO ₂	CO	NO _x	VOC	PS	Final energy consumptions
Urban	30.9	26.2	29.8	19.3	29.8	31.2
Extra-urban	23.1	21.3	19.6	18.9	26.9	23.5
Total	19.4	23.3	8.7	17.1	17.5	19.7

4. CONCLUSIONS

As it is possible to note, even within the summary here presented, the reliability of the approach strongly relies on the accuracy of the available data. Data on the car and truck fleet and on the freight movements are, as matter of fact, capable of affecting in a remarkable way the results obtained. This data, in fact, is employed as multiplier parameters by the algorithm of the model.

On the other hand, the main assumptions of the methodology, especially concerning the evaluation of the emission factors, could introduce some simplifying features within the frame of approach. These considerations suggest a need for further attention when analysing the transportation sector and the complex links between energy consumption and environmental emissions.

But the "electronic sheet" structure of the model and its capability of investigating different phenomena, such as pollutant releases and fuel use, make it a suitable tool in order to explore the effects of different scenarios referring to the policies to be selected in the transportation sector.

5. REFERENCES

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