TREMOVE 2: Model application for the assessment of alternative scenarios on future light duty vehicle emission legislation

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Abstract
This paper is a follow-up of the TREMOVE 2 paper presented at the 14th "Transport and Air Pollution" Conference in Graz by Van Herbruggen and Logghe (2005). This paper recapitulates the TREMOVE 2 model structure and provides an overview of its applications so far. The results of two applications in Belgium are presented. More specificly, we discuss an analysis of the possible impact of the current EC proposal on new light duty vehicle emission standards (COM(2005)) as well as the impact of a differentiated car taxation scheme. In a last section the planned further development of the TREMOVE model is discussed.
Keys-words*: transport model, transport emissions, emission standards, environmental policy, transport policy.*

Résumé
Cet article suit l'article TREMOVE 2 présenté au 14ième coll. "Transport et Pollution de l'air" par Van Herbruggen et Logghe (2005). Cet article récapitule le structure du modèle TREMOVE 2 et donne une vue d'ensemble de son applications jusqu'ici. Les résultats de deux applications en Belgique sont présenté. Spécifiquement, nous discutons l'analyse de l'impacte possible du propositionn COM(2005) concernant les normes d'émissions des nouvelles véhicules légères, aussi que l'impact d'un différenciation des taxes sur les automobiles. Le dernier paragraphe discute les prochains développements du modèle TREMOVE.
Mots-clefs*: modèle transport, émissions du transport, normes d'émissions.*

1 – TREMOVE 2 Model Structure

TREMOVE is a policy assessment model to study the effects of different transport and environment policies on the emissions of the transport sector. It is an integrated simulation model developed for the strategic analysis of the costs and effects of a wide range of policy instruments and measures applicable to local, regional and European transport markets. The model is property of the European Commission.

The first versions of the TREMOVE model were developed in 1997-1998 by the Catholic University of Leuven and Standard & Poor's DRI as an analytical underpinning for the European Auto-Oil II Programme (European Commission, Standard & Poors' DRI, K.U.Leuven, 1999). The most recent

model version is TREMOVE v2.4 (De Ceuster, Van Herbruggen, Logghe (2006)), which has been developed by the Catholic University of Leuven, Transport & Mobility Leuven and their subcontractors. Recently TML started the TREMOVE 3 (Lot 1) development project in which further development and extension of the model is envisaged.

TREMOVE 2 covers 21 countries and 8 sea regions. All relevant transport modes are modeled, including air and long-distance maritime. The model covers the 1995-2020 period, with yearly intervals.

Figure 1 maps the modular structure of TREMOVE. The model performs a year-by-year loop over its modules. The same modules are used for both the construction of the baseline (business as usual) scenario as for the policy scenarios.

TREMOVE consist of 21 parallel country models, and one maritime model (the latter is not discussed in this paper). Each country model consists of three inter-linked 'core' modules: a transport demand module, a vehicle turnover module and an emission and fuel consumption module, to which we add a welfare cost module and a life cycle emissions module.

The transport demand module describes transport flows and the users' decision making process when it comes to making their modal choice. Starting from the baseline level of demand for passenger and freight transport per mode, period, region etc., the module describes how the implementation of a policy measure will affect the user's and company's choice between these 240 different transport types. The key assumption here is that the transport users will select the volume of transport and their preferred mode, period, region etc. based on the generalized price for each mode: cost, tax or subsidy and time cost per km travelled. The output of the demand module consists of passenger-kilometres (pkm) and ton-kilometres (tkm) that are demanded per transport type for a given policy scenario. The pkm and tkm are then converted into vehicle-kilometres (vkm).

The vehicle stock turnover module describes how changes in demand for transport or changes in vehicle price structure influence the type and age of vehicles in the fleet. The output of the vehicle stock module is twofold: we split both the total fleet and the number of vkm for each year according to vehicle type and age.

The fuel consumption and emissions module is used to calculate fuel consumption and emissions, based on the structure of the vehicle stock, the number of kilometres driven by each vehicle type and the driving conditions. For road transport fuel consumption and emission factors are based on the COPERT 3 methodology (Ntziachristos, Samaras (2000)).

Outputs from the vehicle stock and fuel consumption and emissions modules are fed back into the demand module. As fuel consumption, stock structure and usage influence usage costs, they are important determinants of transport demand and modal split.

In addition to the three core modules, the TREMOVE model includes a lifecycle emissions and a welfare cost module.

The lifecycle emissions module enables to calculate emissions during production of fuels and electricity. The welfare cost module has been developed to compute the cost to society associated with emission reduction scenarios in European urban and non-urban areas. The welfare effect of a policy change is calculated as the discounted sum of changes in utility of households, production costs, external costs of congestion and pollution and benefits of tax recycling. The latter benefits of tax recycling represent the welfare effect of avoiding public funds to be collected from other sectors, when the transport sector generates more revenues.

2 – Applications

So far, the TREMOVE 2 model has been used to evaluate following policy scenarios for the European Commission, Directorate-General Environment :

- Reductions of light duty vehicle emissions beyond EURO 4 standard levels;
- Fuel efficiency improvements beyond the 2008/2009 voluntary agreement of the car industry;
- Heavy duty truck road charge schemes with charges converting external pollution costs;
- Fuel excise tax policies;
- Shore side electricity, aftertreatment technologies and changes in fuel specifications for maritime vessels.

So far, there is no public report on these simulations performed for the European Commission.

The TREMOVE 2 model has also been applied in the ASSESS project (De Ceuster et al. (2005)) in the context of the mid-term review of the White Paper on European Transport Policy. Furthermore, the model has been applied in the context of the thematic network PREMTECH II on improved road vehicle environmental technology.

In the next section we shortly present two applications of the TREMOVE 2 model which were performed in the context of a Belgian project funded by FEBIAC (Belgian federation of the car and two-wheeler industry) and FPSMT (Federal Government Service Mobility and Transport). Full results of this project are presented in Logghe, Van Herbruggen and Van Zeebroeck (2006).

3 – Impact of new EC proposal and variabilisation of car taxes in Belgium

In the latter project TREMOVE 2 has been used to analyse and forecast emissions of transport in Belgium for the 1990-2030 period. Two business-as-usual scenarios have been developed : one without light duty vehicle emission standards beyond EURO 4 and one including the EC proposal COM(2005). Next to these baseline scenarios, three policy scenarios have been analysed :

1. a homogeneous increase in road transport taxation;
2. a sensitivity scenario on the influence of fuel resource costs and fuel taxes including a harmonization of diesel and petrol taxation;
3. a variabilisation of the annual taxes on cars as a function of their emission characteristics.

In this section we present a comparison between the two baselines, as well as results from the third policy scenario (variabilisation). The focus is rather on illustrating the functionality of TREMOVE than on giving an exhaustive overview of the model results.

Figure 2 presents the road vkm and exhaust CO_2 emisson trends calculated for the baseline without the new emission standards proposed in COM(2005). For NO_x and particulates results are presented for both the scenarios with and withouh COM(2005). Note that the impact of COM(2005) on CO_2 (and other pollutants as VOC) emissions has been calculated by TREMOVE, but is not presented in Figure 2.

Between 1990 and 2030 belgian transport activity will increase significantly. Nevertheless, a significant reduction in NO_x and particulate emissions is predicted. This reduction is predominantly the result of the tightening EURO standards for all road vehicles. The emission standards proposed in COM(2005) would lead to strong further reductions in particulate emissions, whereas the effect on NO_x is more limited. Note that these latter reductions will not only result from decreases in vehicle emission factors, but also from changes in the vehicle fleet. TREMOVE predicts that the proposed standards would lead to a decrease of the market share for diesel cars (compared to the baseline without COM(2005).

With respect to CO_2, the increase in transport activity will – in the next ten years – be off-set by a.o. the introduction of more fuel-efficient cars following the voluntary agreement of the car industry and the promotion of biofuels and CNG.

Starting from the baseline including COM(2005), the effects of a differentiated car taxation scheme have

been simulated. This simulation scenario assumes that new differentiated levels of annual car ownership taxes are introduced, which relate to the emission standards and the CO_2 emissions of the cars. The objective of the policy is to promote the use of young environmental-friendly cars. The tax levels were determined such that the current level of tax revenues for the government is maintained. This means that the average ownership tax level hardly changes. As a result the effect of this policy on overall car transport volumes, as estimated by TREMOVE, is very limited.

Figure 3 presents the effects of the policy on CO_2, NO_x and particulate emissions relative to the baseline.

Emissions of particulates are reduced by 1% to 4% in the 2006-2025 period. Figure 3 shows two peaks in this particulates effect. In 2006, the assumed implementation date of the policy, a significant number of older cars is replaced by new cars complying to the EURO 4 standard. In the later years the number of pre-EURO 4 cars in the baseline fleet decreases and so does the potential for replacement by cleaner EURO 4 cars. From 2011 on however, the new sold cars comply to COM(2005). The effect on particulates of replacing old diesel cars by new ones therefore grows again. As by 2026 almost all cars in the baseline fleet comply to COM(2005) the effect of the differentiated tax policy on particulate emissions fades out.

For NO_x a similar trend is calculated as for particulates albeit that the effects are smaller.

The reduction in CO_2 does not fade out in the later years. The reason is that the tax scheme also gives an advantage to CO_2 efficient technologies, like hybrids.

3 – Further developments

Next to further applications of the model for policy scenario analysis, further development of the model are planned in 2006 and 2007. These developments will include, amongst others :

- An update of the road vehicle emission factors to the forthcoming COPERT 4 methodology;
- An extension of the model to 31 countries (EU25, Switzerland, Norway, Turkey, Romania, Bulgaria, Croatia);
- Addition of air freight transport and improvement/extension of modal shift modeling;
- Updating fleet dataset.

Conclusions

With TREMOVE 2 a transport model is available that can be applied for environmental and economic analysis of policies to reduce emissions from all modes of transport in the enlarged European Union.

TREMOVE is an integrated model that estimates transport demands, modal shifts, vehicle fleet renewal, fuel consumption, emissions and welfare levels in baseline and/or policy scenarios.

A wide variety of policy measures can be simulated, including technological measures and fiscal measures. The model has been applied for policy analysis on both EU and national scale.

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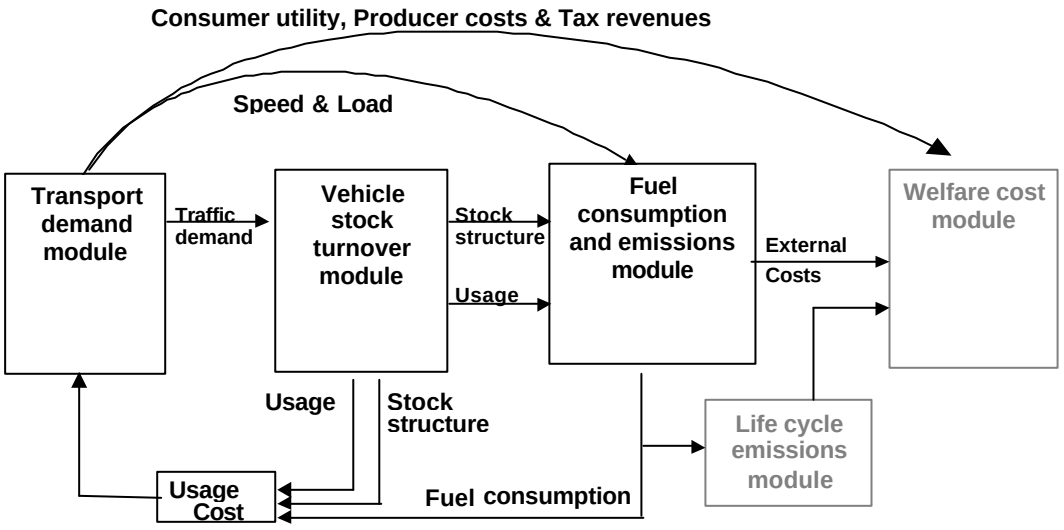

Figure 1 : Modular structure of TREMOVE 2 Model.
Figure 1: Structure modulaire du modèle TREMOVE 2.

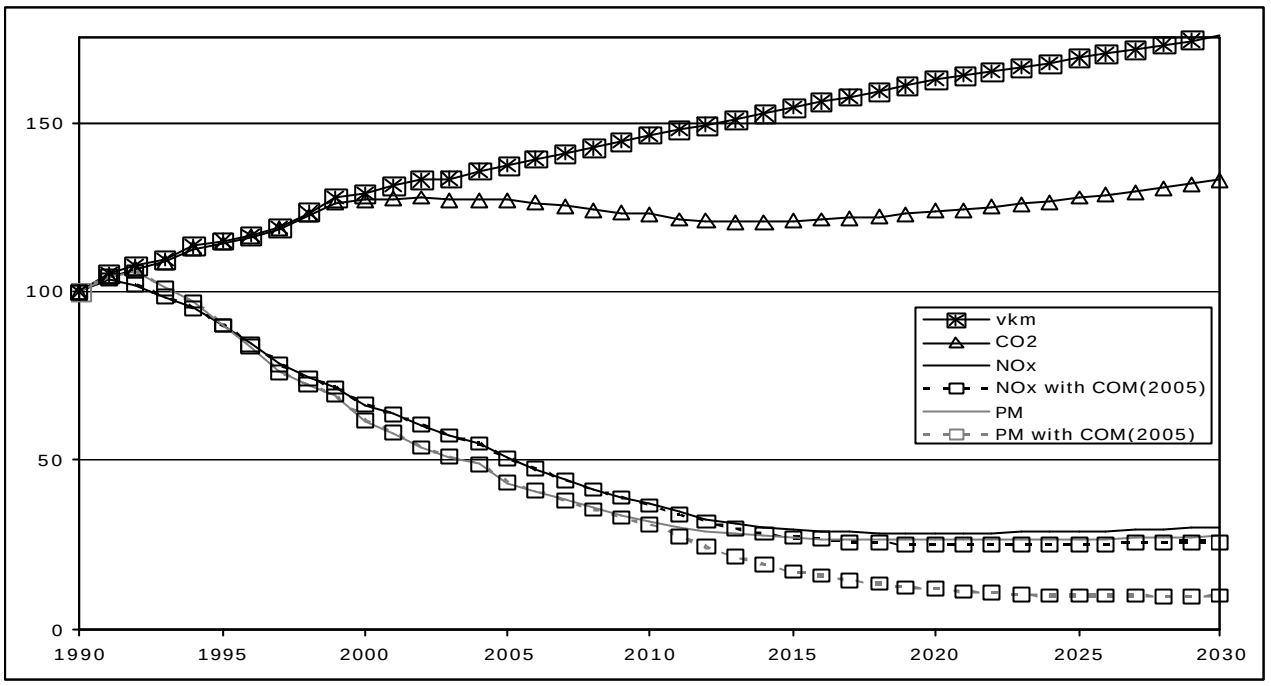

Figure 2 : Road transport exhaust emissions in Belgium (normalised to 1990)
Figure 2: Emissions d'échappement du transport routier en Belgique

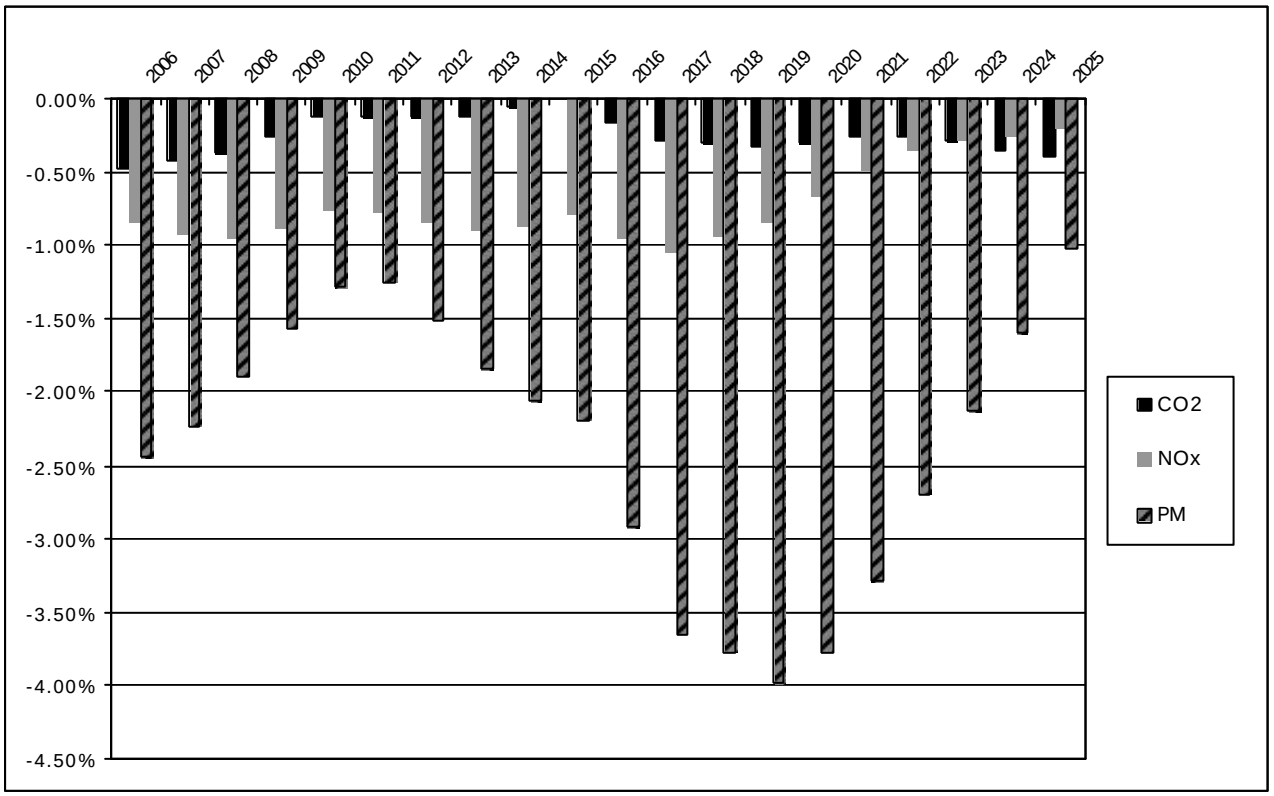

Figure 3 : Effects of differentiated car ownership taxes on total emissions of road transport
Figure 3: Effets en émissions routier d'une différenciation des taxes annuel sur automobiles