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Comparative assessment of road transport technologies

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ABSTRACT

The aim of the paper is to assess energy technologies in road transport sector in terms of atmospheric emissions and costs and to indicate the most competitive and environmentally friendly transport technologies. The main tasks of the paper are: to develop the multi-criteria framework for comparative assessment of energy technologies in road transport and to apply MCDM methods for the transport technologies assessment. One of the MCDM methods, viz. the interval TOPSIS method, is employed in order to tackle the uncertain criteria. The assessment framework allows comparing road transport technologies in terms of their environmental and economic impacts and facilitates decision making process in transport sector. The main indicators selected for technologies assessment are: private costs and life cycle emissions of the main pollutants (GHG; particulates, NO*x*, CO, HCs). The ranking of road transport technologies based on private costs and atmospheric emissions allowed prioritizing these technologies in terms of environmental friendliness the lowest costs. However the extent, capacity, and quality of road infrastructure affects the overall level of transportation activity, which in turn affects how much energy is consumed by vehicles and the amount of greenhouse gases (GHG) emitted. The paper presents the impact of transportation infrastructure on GHG emissions from road vehicles and policy implications of performed assessment.

Contents

1. Introduction

Combating climate change is a top priority for the European Union. Transport is responsible for around a quarter of EU greenhouse gas emissions making it the second biggest greenhouse gas emitting sector after energy generation sector. While emissions from other sectors are generally falling, those from transport have increased 36% since 1990. Therefore GHG emission reduction from motor vehicles is a major challenge for EU climate change mitigation policy. Modest increases in vehicle efficiency have been offset by increased number of vehicle fleet and total travel [1,2,3,4,5].

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There are few main approaches for reducing GHG emissions from road transport:

- Improving fuel economy by using hybrid electric vehicle (HEV).
- Implementing low carbon fuel such as bioethanol or biodiesel.
- Substitution of the portion of petroleum by electricity used to power vehicle by using plug-in hybrid vehicle (PHEV).
- Improvement of road infrastructure, better traffic management, smart transportation behavior or eco driving practices etc.

The future development and deployment of new road transport technologies in EU highly depends on carbon constraints set by international climate change mitigation regimes [2]. As climate change mitigation is the central environmental policy in EU the long-term assessment of new road transport technologies is useful for policy makers taking into account the main criteria, namely private (fuel and motor vehicle) costs and life cycle atmospheric emissions the most important of which are GHG emissions [2]. Such assessment would help policy makers to identify the most promising motor vehicles in terms of costs and atmospheric emissions and to develop policy tools to promote them. The aim of the paper is to find the cheapest and environmentally friendly motor vehicles in terms of private (fuel and vehicle) costs. The impact of road infrastructure on GHG emissions from motor vehicles is also addressed in the paper and policy recommendations are provided.

The branch of operation research, namely multi-criteria decision making (MCDM) offers a variety of computational techniques for integrated prioritization of decision alternatives. According to [6] the MCDM can also be successfully employed in sustainable energy policy-making. Moreover, MCDM methods relying on interval-data aggregation [7,8] are suitable for evaluation of uncertain phenomena. One of MCDM, the TOPSIS (Technique for order preference by similarity to an ideal solution) method extended with interval number [9] is applied in this study. Initially, the crisp TOPSIS method was presented in [10]. More specifically, TOPSIS relies on measurements of distances from hypothetic ideal alternatives for each alternative considered.

The paper is organized as follows: Section 2 describes the focal issues of the transport policy. Section 3 focuses on the interval TOPSIS method which was employed for the analysis. The following Section 4 presents the results of multi-criteria assessment of the road transport technologies. Section 5 discusses the impact of road infrastructure on GHG emissions. Finally, Section 6 proposes some policy implications for sustainable road transport development.

2. Transport policy

Transport is responsible for 23% of global energy-related greenhouse gas emissions, and its contribution is increasing rapidly. Climate mitigation has thus moved to the heart of transport policy and indeed to the heart of EU policy. The process of establishing a new Common Transport Policy for the EU is essentially about creating this vision and then filling it out with policies that can deliver its goals. This will be the real challenge in creating a pathway towards a de-carbonised transport sector. Some issues have already been addressed. New passenger cars have been put on a trajectory towards emissions of 95 g CO_2/km by 2020—almost a 50% cut compared to 1990. Unfortunately traffic levels are growing at around the same rate as average emissions are projected to fall, meaning that the net effect may still be far from what we need.

Sustainably produced biofuels can also contribute to diversification of energy sources and supplies. Biofuels currently account for about 2% of global fuel consumption for transport. A growing number of countries support domestic production of biodiesel and ethanol through subsidies, reduced taxes and regulations requiring mandatory blending of biofuels with petrol or diesel fuel. However, only a limited number of countries have favorable climatic conditions and the land and water resources necessary for large-scale biofuel production [10,11].

In recent years, a growing number of motor vehicle manufacturers have announced plans or started production and sales of hybrid and plug-in electric vehicles, primarily for use in urban areas. In China, and in a growing number of other countries, electric bicycles have become popular. Electric vehicles are quiet, produce no emissions at the point of use and are, therefore, popular for use indoors (e.g. in hospitals, airports, exhibition halls and similar facilities) and in environmentally protected areas. Several motor vehicle manufacturers have also successfully tested and demonstrated hydrogen-based emission-free fuel-cell technologies [12–14].

When assessing greenhouse gas mitigation options, it is important to consider life cycle impacts. Electricity and hydrogen can offer important opportunities to decarbonize the transport energy system, but the realization of full-cycle carbon reduction depends on the way in which the electricity and hydrogen are produced. Greater use of electricity or hydrogen for private motor vehicles would be sustainable only if future systems are increasingly based on renewable sources of energy. A gradual transition towards greater use of electric vehicles will also only advance sustainable development if the batteries necessary for on-board energy storage are affordable and if the growing quantities of lithium needed in these batteries are produced in a sustainable way.

The decoupling of transport services and energy use is important for mitigating climate change and improving efficiency. In light of the recent volatility in international energy prices, the development of alternative fuels, produced in a sustainable way, including compressed natural gas, ethanol and biodiesel, can offer diversification of transport fuels as part of an array of options for sustainable transport. There is also need to deploy cleaner fossil fuels. Enhancing the modernization of transport technology and redefining the understanding of mobility, including thinking in terms of providing mobility services and promoting climate-friendly mobility management, can curb the projected growth in greenhouse gas emissions and support sustainable development.

The European Commission has a comprehensive strategy to reduce CO_2 emissions from new cars and vans sold in the European Union, to ensure that the EU meets its greenhouse gas emission targets under the Kyoto Protocol and beyond. This strategy, which was adopted in 2007, aims to tackle CO_2 emissions from both the production and consumer sides and is designed to help the EU reach its long-established objective of limiting average CO_2 emissions from new cars to 120 g per km by 2012—a reduction of around 25% from 2006 levels. The goal of reducing new car emissions to 120 gCO_2/km by 2012, as defined in the strategy, is however not likely to be achieved because some measures have been implemented late. Despite a low probability of achieving the 2012 target, the strategy, and the measures it includes, has played an important role in reducing CO_2 emissions from light-duty vehicles.

EU policies in place aiming to lower emissions from the road sector:

- a strategy is in place to reduce emissions from cars and vans, including emissions targets for new vehicles;
- a target is in place to reduce the greenhouse gas intensity of fuels;
- rolling resistance limits and tire labelling requirements have been introduced and tire pressure monitors made mandatory on new vehicles; and