Technological Forecasting & Social Change 81 (2014) 177–191

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

journal homepage:

Decarbonizing road freight in the future — Detailed scenarios of the carbon emissions of Finnish road freight transport in 2030 using a Delphi method approach

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ARTICLE INFO

Article history:
Received 18 April 2012
Received in revised form 29 October 2012
Accepted 1 March 2013
Available online 22 March 2013

Keywords:
Carbon footprint
Road freight transport
Delphi method
Scenarios
Cluster analysis

ABSTRACT

Research on the future of carbon dioxide (CO_2) emissions of road freight transport in Finland is reported in this paper. Delphi method is utilized to forecast the changes of GDP and seven indicators which determine the CO_2 emissions of road freight. Information about the factors affecting the future of these indicators was also collected and an innovative method for acquiring qualitative data in the first round of Delphi study and quantifying it in the second round is presented. Cluster analysis is used to create six scenarios for 2030. The scenarios are mostly driven by different economic developments, which result in very different demand for transport. Despite of this, all scenarios forecast at least 26% reduction in CO_2 emissions from 2010 level, while the maximum reduction in one of the scenarios is 74%.

1. Introduction

Climate change, energy issues, demands for reduction of carbon dioxide (CO_2) emissions and goals for energy efficiency improvements have increased the importance of developing sustainable road freight transport. These drivers related to sustainable development have become one of the major discussion points among citizens and are also affecting strategic decision-making in politics and business. The discussion has been inspired by research results about global warming due to human activities [1], limited amount of fossil fuels to use, growing demand of oil due to economic growth and gradual increases of the oil price. This carbon challenge affects all sectors of modern societies, but especially transport, which is almost entirely dependent on fossil fuels [2].

New target-oriented transport policies are needed in the light of the challenges we face. Transport is the only sector in Europe, which carbon dioxide emissions have increased in recent years and the growth is expected to continue without appropriate transport policies to reduce emissions. Total emissions (including transport) have reduced by 11% from 1990 to 2008, while transport emissions have increased by 24% [3,4]. The new Transport White Paper of European Union has set a target to reduce carbon dioxide emissions of transport by 60% by 2050 compared to 1990 emission level. This also indicates the special problematic status of transport, because at the same time the target to reduce total emissions is 80–95% in order to curb the global warming below 2° [2]. The reduction is needed rather sooner than later, since carbon dioxide is a greenhouse gas lasting in the atmosphere and slow reductions result in increased carbon dioxide concentrations in the air (see [5]). By 2020 the European Union has set a target to reduce CO emissions by 20% and increase the share of renewable energy sources to 20% EU's total energy consumption [6].

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0040-1625/$ – see front matter © 2013 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.techfore.2013.03.001

EU's White Paper focuses on a global perspective at developments in the transport sector, at its future challenges and at the policy initiatives that need to be considered in order to reduce transport emissions [2]. Similar targets have been also set earlier, for example in the Energy Service Directive [7] and in Climate Change Goals and Action Plans [6,8].

As a response to these EU level targets, ministries and transport unions in Finland entered into an energy efficiency agreement in freight transport and logistics in 2008. The agreement aims at 9% improvement in energy efficiency over the period 2008–2016 [9]. The goal is that 60% of transport companies be covered by an agreement in year 2016. Also, a "9% energy saving compared to the 2001–2008 average energy consumption, if total haulage (ton-kilometers) has remained at the level of 2008" should be achieved by 2016 [9]. The Ministry of Transport and Communications has also made a climate policy program, which seeks 15% reduction in greenhouse gas emissions by 2020 compared to 2005 emission level [10].

Road freight transport currently accounts for 18% of transport CO_2 emissions in Finland and it has an important role in decreasing the emissions. In academic literature there are a few researches focusing on the future of road freight. Piecyk and McKinnon [11] apply the Delphi method in forecasting various trends which affect the CO_2 emissions of road freight transport in the UK. They present three scenarios predicting that the emissions could decrease by 10% (baseline scenario) or 47% (optimistic scenario) or increase by 56% (pessimistic scenario) from 2007 level by 2020. Piecyk and McKinnon [11] show that the CO_2 emissions from road freight transport may vary greatly depending on the assumption made on the development of the different key variables, yet they do not consider the economic development in various branches of economy and its effects on the transport demand and CO_2 emissions. Kveiborg and Fosgerau [12] and Sorrell et al. [13], for example, highlight that the freight operations are very different between commodity groups or industry branches and thus studying only national aggregate values may be misleading. Economic development of different branches has affected the past trends of CO_2 emissions in Finland greatly [14], so it is considered as a major driver in the future forecasts of this study.

The purpose of this paper is to describe the future of energy efficiency and carbon dioxide emissions in road freight transport in Finland. Different scenarios of the carbon footprint in 2030 based on the Delphi study and trend analysis of national statistics are presented. The Delphi study explored the visions of experts considering the future of road freight transport and elements affecting that in two Delphi rounds by emailed questionnaires. Different scenarios were made to answer the question, if road freight transport will achieve its objectives by 2030.

2. Methodology

2.1. Decarbonization framework for detailed analysis of the freight sector

McKinnon and Woodburn [15] presented a framework for analyzing the interrelations between the economy and road freight transport. Cooper et al. [16] included an environmental aspect into this framework and it has been utilized in many different forms since [17,11]. The framework utilized in this paper is a slightly modified structure from the earlier studies (Fig. 1).

The framework divides the connection between the economic development, represented by gross domestic product (GDP), and carbon dioxide emissions from road freight transport into seven indicators which can be analyzed to understand the connection. The framework can also be presented as an equation:

$$\begin{aligned} CO_2\ \text{emissions} = {} & \text{GDP/value density} \times \text{modal split} \times \text{avg.length/avg.load} \\ & \times \left(1 + 2.3053 \times \text{empty running}^{1.3971}\right) \\ & \times \text{avg.fuel consumption} \times \text{fuel } CO_2\text{content}/100. \end{aligned} \quad (1)$$

Value density [€/t] is the ratio of the GDP [billion €] and the total weight of transported goods. Modal split [%] describes the weight-based share of goods transported on road compared to all goods transported in Finland. Average length of laden trips [km] shows how many kilometers the goods are transported on road in average and average load on laden trips [t] shows the average payload weight transported when the vehicle is loaded. Empty running [%] is the ratio of mileage run without payload and total mileage. Average fuel consumption shows how much fuel the trucks use and the unit is l/100 km as it is the unit mostly in use in Finland. Fuel CO_2 content shows how much CO_2 is emitted when fuel is burned in the engine, the content is fixed for a certain type of fuel, e.g. 2.66 kg/l of diesel [18], but it will change if biofuels are blended in the fuel.

Alternative future values of these seven indicators are outlined in this paper to determine the scenarios of the carbon footprint of Finnish road freight transport in 2030. In addition to the seven indicators, also the development of the GDP must be estimated to make this possible. As the respondents were freight transport experts, the GDP estimates should be regarded merely as a reference point to the rest of indicators, not as an expert forecast of GDP itself. Data on the past development of these indicators were given to the Delphi panelists to help them in their estimates. This data was derived from the Finnish national accounts [19], annual transport statistics [20] and goods transport by road statistics (GTRS) [21] as well as the annual reports of the Finnish road traffic emission calculation system [22].

2.2. Delphi method and alternative scenarios

We used the Delphi method to explore the future of decarbonizing freight. Delphi is an expert view based method that includes several rounds of inquiry, feedback of statements and arguments of the previous rounds while reconsidering the topic, maintaining anonymity of responses [23,24]. Delphi is an especially suitable method for explorative studies, when changes in the relations between key variables are intuitively expected, respondents are not close to each other geographically and/or when there are strong persons dominating the discussion (bandwagon effect) [23–28].

Classical Delphi studies focused on expert estimates of the most probable future and the general aim was consensus. But non-consensual forms of Policy Delphi have also been developed addressing the plurality of views of the future [23,27,29]. According to Kuusi [26], Delphi method is at best in exploring