Transport Policy 17 (2010) 342–348

Contents lists available at ScienceDirect

Transport Policy

journal homepage: www.elsevier.com/locate/tranpol

Environmental footprint of road freight: Case studies from Switzerland

L.D. Poulikakos *, K. Heutschi, M. Arraigada, P. Anderegg, P. Soltic

Empa, Swiss Federal Laboratories for Material Testing and Research, Überlandstrasse 129, CH-8600 Dübendorf, Switzerland

ARTICLE INFO

Available online 21 April 2010

Keywords:
Environmental footprint
Heavy vehicles
Weigh-in-motion
Noise
Vibration
Pollutant emissions

ABSTRACT

Current Swiss policy aiming to reduce the environmental footprint of heavy vehicles is presented. The environmental footprint of 46 heavy vehicle cases defined as dynamic load, noise, vibration and gaseous emissions is measured based on criteria set by the European project Eureka Logchain footprint. These parameters were measured for freight vehicles selected from the traffic stream and were compared to the criteria set up as a result of current Swiss policy. Results show that parameters that are currently controlled and their reduction encouraged such as gaseous emissions, axle loads and gross weight are indeed below or close to acceptable limits. However, other important parameters such as tyre pressure and noise remain higher than acceptable limits. In order to encourage the operation of vehicles with a low total environmental footprint parameters need to be set and controlled systematically.

1. Introduction

According to the data published by the Swiss federal office for spatial development (ARE), the external costs of land transport in Switzerland lie between 7.7 and 8.9 billion Swiss Francs, which is between 1.8% and 2.1% of the Gross National Product (GNP). Most of this is caused by road transport specifically from accidents, health care costs due to air pollution and climate change (ARE, 2007a). There is legislation in place to reduce the external costs and the Swiss heavy vehicle fee (LSVA) effective since 2001 is in place for this purpose. Monitoring the traffic development and the environmental effect of traffic from 2001 until 2005 shows that the LSVA has been able to accomplish its intended purposes and the efficiency of the traffic has increased (ARE, 2007b). The expected initial side effect that the regional roads would see heavier traffic proved not to be a problem.

The Swiss Federal office for the environment has reported that 1.68 million people in Switzerland are exposed to road noise over the daytime threshold limit for housing areas set at 60 dB(A), this is more than other sources of noise such as rail (Umweltstatistik Schweiz, 2009).

Current projects in Switzerland aim at the remediation of roads, so that the exposure in 2015 for motorways and 2018 for main roads and other roads will be below the impact threshold. According to the law the remediation should primarily be done at the source and on the propagation path (silent road surfaces, operational measures, sound protection barriers, etc.). If remediation at source is not possible, substitution measures are applied (e.g. sound proof windows). 800,000 people have benefited in the past 20 years from the remediation projects. However, almost 3/4 of the work remains to be done at a total cost of 4 billion Euros.

As part of the European cooperative project Eureka Logchain Footprint (2008) (www.eureka.be) a monitoring site has been installed on the A1 motorway in order to monitor the environmental footprint of heavy vehicles. As seen on the map (Fig. 1) this site is located on the motorway with the heaviest traffic in Switzerland.

This paper presents the results of 46 vehicles (cases) that were measured statically and dynamically on the Footprint Monitoring Site (FMS) and a temporarily set up static station nearby. The resulting total footprint, an indication of the environmental friendliness of these vehicles is compared to the LSVA criteria. The goal is to determine if the LSVA encourages environmentally friendly vehicles in accordance with the footprint criteria.

2. Road pricing in Switzerland and its consequences

As of 1st January 2001 a new road pricing system (Leistungsabhängige Schwerverkehrsabgabe or LSVA) has been introduced in Switzerland in order to internalize some of the external costs (Suter and Walter, 2001). The LSVA is a variable road pricing method that considers some of the external costs of heavy goods vehicles (HGV). It replaced the previous road pricing method that was a flat fee. A detailed presentation of the LSVA can be found elsewhere (Krebs, 2004; Suter and Walter, 2001). The introduction of the LSVA was in conjunction with the increase in the

* Corresponding author. Tel.: +41 44 823 4479; fax: +41 44 821 6244.
E-mail addresses: lily.poulikakos@empa.ch (L.D. Poulikakos), kurt.heutschi@empa.ch (K. Heutschi), martin.arraigada@empa.ch (M. Arraigada), peter.anderegg@empa.ch (P. Anderegg), patrik.soltic@empa.ch (P. Soltic).

0967-070X/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.tranpol.2010.03.002

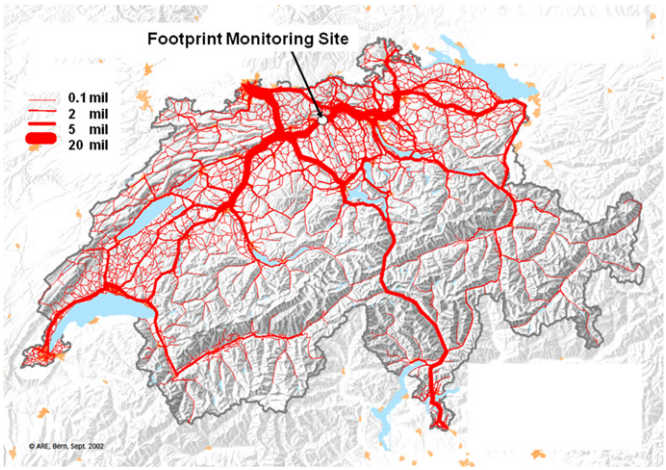

Fig. 1. Intensity of road freight transport in million tonnes in year 2000 (www.are.ch2000) and location of the Footprint Monitoring Site in Switzerland.

allowable weight limits for HGV from 28 to 34 t and then to 40 t in 2005 (ARE, 2004, 2007a, 2007b).

The goal of the LSVA that is based on the "polluter pays principle" was threefold. Firstly, to limit the growth of road heavy goods vehicle traffic, secondly, to transfer freight from road to rail and thirdly to protect the environment.

The LSVA applies to HGV over 3.5 t and is calculated based on three criteria:

- Number of kilometres travelled in Switzerland
- Allowable gross vehicle weight of the vehicle
- The gaseous emissions of the vehicle based on the vehicle engine type approval record

At the introduction of the LSVA the price was calculated based on the above at 1.68 Rappen pro tonne and kilometres (Rp/t-km) for trucks that meet Euro I requirements. In 2005 this value was increased to 2.44 and as of 1 January 2008 to 2.70 Rp/t-km. Vehicles with Euro 0 would pay more and with Euro II/III would pay less (Suter and Walter, 2001).

In order to further encourage vehicles with environmentally friendly engines as of 1 January 2009 the three emission categories have been revised (http://www.ezv.admin.ch):

Category 1 (Euro 0,I,II):	3.07 Rp/t-km (2.00€Ct/t-km)
Category 2 (Euro III):	2.66 Rp/t-km (1.85€Ct/t-km)
Category 3 (Euro IV+):	2.26 Rp/t-km (1.70€Ct/t-km)

EU emission limits for heavy duty vehicle, HDV, engines were introduced in 1992 (Euro I). These limits were successively tightened in, 1995 (Euro II), 2000 (Euro III), 2005 (Euro IV) and 2008 (Euro V). For the type approval of HDV engines, their emissions are measured under exactly defined ambient conditions with a reference fuel on engine test benches.

Four examples of vehicle fee calculations are presented in Fig. 2. As shown the fourth vehicle which is a truck and trailer will pay a lower fee (2.26 Rp/t-km) with a Euro IV+ engine that is cleaner. The fee which is based on the average external costs of HGVs applies to the declared capacity of the vehicle and not the actual load carried in order to reduce the number of empty vehicles on the roads (Suter and Walter, 2001). This allows a vehicle to declare a lower capacity and be eligible for a lower fee even if the vehicle is capable of carrying more.

Examples of the calculation of the fee

tariff level in centimes 1	2	3		kilometres travelled in Switzerland		truck and trailer		Fee in CHF
3,07			x	300	x	without trailer	x 18t	165,80
	2,66		x	300	x	truck and trailer	x 30t	239,40
	2,66		x	300	x	articulated lorry[3]	x 30t	239,40
		2,26	x	300	x	truck and trailer 40t	x 40t	271,20

Fig. 2. Example of calculation of the Swiss heavy vehicle fee (ARE, 2007b).

1/3 of the LSVA income is distributed to the cantons and 2/3 to the federal government. The cantons use this income to cover the external costs of transport on road and/or rail and the federal government uses the income to finance large transportation projects such as Bahn 2000, the new alpine transit tunnel (NEAT) and renovation of the rail transportation in order to reduce noise.

Following Switzerland's example, Austria has introduced a similar road pricing system in 1 January 2004 and Germany a year later that applies to the autobahn network only.

The consequences of this road pricing system are continuously monitored by the federal office for spatial development (ARE). Initial results after the first 5 years indicate a reduction in the number of HGV and a new trend in the vehicle fleet. At the end of 2005 the number of HGV was 6.5% less than in 2000. According to the ARE this reduction can be partially attributed to the new road pricing system.

One of the positive effects of the LSVA has been the reduction in air polluting emissions from HGVs. This is mainly due to reduction in mileage and improvement of average emissions per vehicle. Fleets have been upgraded with vehicles complying with the Euro III standard plus a smaller extent also to Euro IV standard. As shown in Fig. 3 in all three categories of inland traffic, import/export and transit traffic the percent of kilometres travelled with Euro III has considerably increased. For example in the transit traffic category the vehicle kilometres with Euro III engines increased from 5% in 2001 to 72% in 2005.

3. Overview of the European Project Eureka Logchain Footprint

The European cooperative project Eureka Logchain Footprint (www.Eureka.be), hereafter referred to as "Footprint" aims to identify road and rail vehicles by means of their environmental "footprint" as characterized by dynamic load, noise, ground borne vibrations and gaseous emissions produced by the vehicle. Once this concept has been defined for various types of vehicles, options can be considered for encouraging the operation of vehicles with a low environmental footprint that is, those that are environmentally friendly. Methodology to measure all footprint parameters for road and rail vehicles by means of a Footprint