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Vehicle environmental rating methodologies: Overview and application to light-duty vehicles

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ABSTRACT

Several environmental rating methodologies are available worldwide to evaluate and compare the environmental performance of vehicles, which can be useful for consumers decisions and for organizations in the promotion of less pollutant technologies and fuels.

This paper presents an overview of vehicle environmental rating methodologies available worldwide. Four of them adopt a life-cycle perspective: Green Score (US), Ecoscore (Belgium), Green Car Rating (UK) and EcoTest (Europe), while VCD (Germany), Eco vehicles rating (Mexico) and Green Vehicle (Australia) only consider the fuel in-use stage. Fuel in-use stages methodologies are good indicators of air quality rankings but would rank a fuel cell hydrogen vehicle on top along with the electric vehicles which does not reflect the carbon footprint of the overall fuel pathways and side effect pollutants. Therefore life cycle based methodologies are worth being further explored.

Between the more complete life cycle based methodologies, Green Score and Ecoscore differ in terms of the impact categories considered, stages of the life cycle taken into account, weighting system and geographical application, but both use environmental economics and translate the results into a single indicator 0–100 (best). For this relevant variability of aspects they were selected to be applied to a set of seven real vehicles, comprising internal combustions engines and alternative vehicles, including the alternative fuels hydrogen and biodiesel.

The application of methodologies shows that the position of the commercial vehicles obtained in the ranking for both methodologies differs. Internal combustion engine (ICE) has the higher impact in the environment and electric vehicle (EV) scores between the best positions; the position of the fuel cell hybrid electric vehicle (FCHEV) and the biodiesel ICE vary significantly.

A sensitivity analysis shows that the US rating has high sensitivity to variations, namely in damage costs and fuel pathway.

Contents

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1. Introduction

The transportation sector is the center of rising concerns with energy consumption, air pollution, global warming and noise. The ability to environmentally score and rank light-duty vehicles allows manufactures and consumers to take environmental friendly decisions. Environmental ranking schemes potentially represent a useful tool for governmental and non-governmental organizations in the promotion of less pollutant technologies and fuels.

The sustainability debate, originally confined to academics and experts, has captured the attention of public opinion, prompting consumers to change their purchasing patterns [1]. Frequently we have seen some aspects being measured and communicated, some because of the regulations and others on a voluntary basis. Between known aspects there are the classes of tailpipe emissions, fuel consumption, percentage of recycled materials included and CO_2 emissions. Such fragmented approaches to communicate greenness are unlikely to compare vehicles and facilitate more environmental friendly choices [2].

Usually the comparison of different vehicle technologies/transportation fuels is based on direct application of life cycle principles on comparable power to weight vehicle [3,4]. The life cycle approach (LCA) regards to fuel indirect ("well-to-tank" approach, WTT, also called "well-to-pump" or "seed-to-tank") and direct in-use ("tank-to-wheel" approach, TTW) emissions boundaries. This "well-to-wheel" (WTW) assessment refers to the consideration of emissions from the fuel production to its use [5,4]. Most WTW studies typically include Greenhouse Gases (GHG) emissions (contributions from CO_2, N_2O and CH_4) and an energy (efficiency) indicator. Other studies consider an embodied material emissions life cycle in addition to the fuel WTW [3,4,6–8]. It is important to have a broader range of impact categories not only in terms of fuels depletion and global warming but also air quality and noise level.

The Life cycle assessment (LCA) methodology can contribute to support environmental based decisions, since considers cradle-to-grave life cycle phases and considers a wide range of environmental dimensions; however LCA can be too complex, time consuming and expensive to be applied to vehicle rating [1]. That is why different environmental rating methodologies appeared in some regions of the world, which allow evaluating the environmental performance of the vehicles in a life cycle approach but in a simplified way with normalizing, weighting and establishing a score for each vehicle.

Main existing environmental rating methodologies consider climate change, air quality as main impact categories, as described in the next section, and also use external monetized costs.

The main objectives of this research are: to perform a literature review of existing methodologies for rating the environmental performance of vehicles worldwide covering different continents and life cycle stages; apply the ones using a life-cycle approach to a set of commercial vehicles representative of different technologies and energy sources (pure electric_EV, hybrid_HEV, plug-in hybrid_PHEV, fuel cell_FCHEV, conventional internal combustion_ICE) and compare its scores; and finally, assess their sensitiveness to external costs, impact categories weighting, fuel pathways and embodied material cycle. Based on the results some recommendations are derived.

2. Vehicle environmental rating methodologies

There are several environmental rating methodologies for vehicles, which are designed for vehicle comparison and are generally specific for a country. Documents useful in this matter are the CleanVehicle Research:LCA and Policy Measures (CLEVER) ReportTask1.2 Over-view of environmental vehicle assessments [9] and the recent presentations of the Green Global NCAP Workshop —IEA, Paris, 30th April 2013, published in the IEA website: [10,11]. This paper presents an overview of seven environmental rating methodologies that were found worldwide and are currently in operation in the respective countries; to the best of the author's knowledge no other exists but this sample covers multiple continents and life cycle boundaries that is in line with the goal of this research. Four considering a life cycle approach: Green Score (US) [12,13], Ecoscore (Belgium) [14,15], Green Car Rating (UK) [16] and EcoTest (European context, life cycle approach only regarding CO_2) [17]; and three considering only the in-use phase: Verkehrsclub Deutschland (VCD) from Germany [18] (used in Topten.eu and in Austria, Switzerland and in Quercus Environmental Portuguese association), Mexico Eco vehicles rating and Australian Green Vehicle (AGV).

The European Ecoscore, Green Car Rating, VCD and Australian (AGV) methodologies use the New European Driving Cycle (NEDC) roll test bench to determine the fuel consumption and the emissions. EcoTest methodology, rely on real-life testing of cars, based on the NEDC and Allgemeiner Deutscher Automobil-Club (ADAC) motorway cycle. United States methodology and Mexican based on EPA rating uses Federal Test Procedure (FTP)-75 for roll test bench and different emission limits according to US Tier2 or California LEV and CAFE for fuel consumption. [9,12,14,17,19,20].

The environmental performance has multiple dimensions, in the methodologies reviewed only the atmospheric emissions and in some of them noise, are considered. Table 1 summarizes the main characteristics of the reviewed methodologies regarding: Impact categories; Weighting System; Stages of the Life Cycle; GHG considered; Pollutants considered in in-use TTW emissions; Characterization of air quality damage; Air quality cost (health/ecosystems) and Characterization of GHG damage.

The three methodologies, Belgium Ecoscore, UK Green Car Rating and US Green Score, make an inventory and apply based monetary costs in the internalization process. Another way of internalize costs is a non-monetary method. Among the common approaches for estimating environmental externalities are the use of control/abatement costs and use of damage costs. Control/Abatement costs are based on observations of the costs incurred to reduce pollution such as the cost of clean-up devices. Damage costs are based on observations of the harm caused by pollution [12]. US ACEEE and UK Green Car Rating methodologies use damage costs; Ecoscore methodology use both, damage cost for human health affected by air quality and control costs regarding ecosystems.