Energy Consumption and CO_2 Emissions Evaluation for Electric and Internal Combustion Vehicles using a LCA Approach

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Abstract. The demand for Electric Vehicles (EVs) has increased during the last years, especially after the peak oil prices experienced in the year 2008. In spite of, in general, EVs being associated to a cleaner and more efficient mobility, the benefits of substituting conventional Internal Combustion Vehicles (ICVs) by EVs must be evaluated. In this regard, in the present paper, it is compared the energy consumption and CO2 emissions of two different vehicles technologies, an EV equipped with lithium-ion battery and a gasoline ICV. The evaluation is performed according to a Life Cycle Assessment (LCA) approach, making use of a parametric model developed in a Microsoft Excel platform.
The results of the evaluation performed show that, for the different scenarios assumed, the EV is the one that presents the lower LCA energy consumption and CO2 emissions.

Key words

Electric vehicle, internal combustion vehicle, energy consumption, CO2 emissions, life-cycle assessment.

1. Introduction

The demand for Electric Vehicles (EVs) has increased during the last years, especially after the peak oil prices experienced in the year 2008. In spite of the technology that supports the EVs been well known since many years, vehicle manufactures have presented some reluctance to introduce it in the market [1]. However, the oil prices increase associated to the present pressure introduced by some national and regional authorities to reduce the environmental impacts of the transportation sector, is acting as a driver for vehicle manufactures changing the status-quo and start a regular production of EV models.

Regardless, in general, EVs being associated to a cleaner and more efficient mobility, the benefits of substituting conventional Internal Combustion Vehicles (ICVs) by EVs must be evaluated. In this regard, the information provided by the vehicle manufacturers may not be enough. For instance, vehicle manufacturers assume EVs as zero emission vehicles, disregarding the Dioxide Carbon (CO2) emissions associated to the electricity consumed by the vehicle.

In literature, there is a diversified broad of vehicle evaluation models, not always consensual. Some authors use the Tank-to-Wheel approach, in which only the powertrain efficiency is included [2]. Some studies are only dedicated to fuel cycle, including all the energy consumptions since the primary energy extraction to the transport for the gas station [3]. Other authors integrate the vehicles efficiency with the fuel cycle, resulting in the approach usually known as Well-to-Wheel analysis [4].
In spite of the vehicle use being one of the main responsible for the energy consumption and CO2 emissions during its life, vehicle materials production, assembly and disposal can not be disregarded. As so, some authors evaluate the vehicles in a perspective of the body and powertrain life-cycle, accounting all the energy consumption and CO2 emissions associated to the materials production, assembly and disposal [5], [6]. However, a most comprehensive approach to evaluate the different vehicle technologies should integrate the both cycles, the body and powertrain cycle and the fuel cycle [7], [8]. That complete Life Cycle Assessment (LCA) of the vehicles is the one adopted in the present paper.

2. Objectives and Methodology

The main objective of the paper is to compare the energy consumption and CO2 emissions of different vehicle, assuming its complete life-cycle since the materials manufacture to the vehicle disposal, including all the production chain of fuel consumed during the vehicle use.

In order to attain the objective of the paper, a dedicated framework was developed in a Microsoft Excel platform. The framework corresponds to a parametric model, in which the user can choose or supply a set of inputs in order to best characterize the case study.

The vehicle LCA framework developed includes two different models: the EV and the ICV. Both models are detailed below.