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Cycling mobility – a life cycle assessment based approach

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Abstract

Cycling brings advantages to the environment and is also an affordable transportation mode. The number of people using bicycles has been increasing in several European countries as well as the interest in manufacturing new types of bicycles with different materials.
The main objective of this paper is to evaluate the complete life cycle of a bicycle (cradle-to-grave analysis) and to quantify which components have the highest environmental impact. The production, maintenance, use and waste scenarios were modelled using the life cycle assessment software SimaPro. The use of bicycles in two different realities in terms of bicycle modal share (Portugal and The Netherlands) was considered. Then, some "what-if" scenarios were performed, in which some bicycles components were replaced with different materials, with the objective to decrease the environmental impact of the product itself. Aluminium, steel, wood and carbon fiber were tested in SimaPro. Results indicate that the components made in aluminium have the highest environmental impact. On the other hand, a bicycle with carbon fiber shows the lowest impact for the majority of the environmental categories. When evaluating the entire life cycle of the bicycle, the production phase has the highest negative impact.

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1. Introduction and Objectives

The efficiency of the transport network is a matter of concern to governments and other sectors of society, whether for economic or environmental reasons. In addition to high fuel prices, the externalities associated with the pollutants emissions are increasingly a source of global concern. Traffic congestion leads to high energy consumption and pollutant emissions as well as a significant economic damage. It is also known that each trip of European drivers has an average length of 9-22 km (EU, 2014).

As a consequence, cycling mobility becomes an increasingly attractive option, especially for short distances. Also, today there is a greater interest in biking and there is an attempt to introduce more attractive bikes on the market, including through the use of new and more sustainable materials, with the aim to improve well-being and the environment protection. However, it is important to understand the impact that causes the production of these new types of bicycles.

A study by Cherry et al. (2009) showed the materials used for the construction of different transport means. They also presented the energy consumption and the impact in terms of emissions and waste production associated with the production processes of various transport means with two wheels. The bicycle uses less material types and has smaller impacts associated with pollution. They analyzed the environmental impacts of electric bikes in China on its production and use. As for the phase-end life, they found some difficulties since this transport mean was new and there was no much information about it, but they highlighted the pollution caused by the lead present in the batteries. The lifetime of the batteries is, on average, 2 years or about 10,000 km and the pollution caused by lead is the biggest problem caused by the use of this bike, since a bike can use up to five batteries in its entire life.

Dave (2010) compares the life cycle of different transport means and concluded that electric bicycles consume less than 10% of the energy needed to power a light duty vehicle per km traveled and emit 90% less pollutants per passenger-kilometer than a bus. It was also found that an electric bike (compared to a conventional one) consumes more energy in the production and use phases; however, the conventional bicycle forces the user to breathe more intensively and to make more effort, which is reflected in the energy spent by the user.

There is some research regarding the use of life cycle assessment (LCA) applied to different transport modes and materials substitution in motor vehicles (Hakamada et al., 2007), but the amount of studies regarding bicycles is limited. Thus, the main objective of this paper was to perform a complete LCA of a bicycle, including its production (namely, the raw materials and the processes used in its design), use and end-of-life scenarios. The baseline scenario refers to a mountain bike with steel frame. Alternative scenarios considering different materials were developed, with the objective to quantify the energy and environmental impacts associated with these changes.

2. Methodology

This chapter includes an explanation of LCA main concepts and phases, as well as a description of the life cycle inventory for the analyzed bicycle.

2.1. Life Cycle Assessment

LCA is a technique to assess the environmental aspects and potential impacts associated with a product, process, or service (EPA, 2014), by:

- Compiling an inventory of relevant energy and material inputs and environmental releases;
- Evaluating the potential environmental impacts associated with identified inputs and releases;
- Interpreting the results to help the user to make a more informed decision.

The major stages in an LCA are raw material acquisition, manufacturing, use/reuse/maintenance, and waste management, as described in Figure 1. The four basic stages of conducting an LCA are indicated in Figure 2. Companies, federal facilities, industry organizations and academia can benefit from learning how to incorporate environmental performance based on the life cycle concept into their decision-making processes (EPA, 2014).

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