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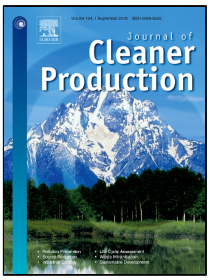

Assessing energy consumption and carbon dioxide emissions of off-highway trucks in earthwork operations: an artificial neural network model

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Assessing energy consumption and carbon dioxide emissions of off-highway trucks in earthwork operations: an artificial neural network model

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Highlights:

- A predictive tool for the energy use of and emissions from a truck is obtained by combining a discrete event simulation with ANN.
- The method allows assessment of the energy use and CO_2 emissions per unit volume of earth moved, which is important for mitigating the environmental impact in the initial stage.
- The utilization rate and loading time of a truck play a major role in reducing the environmental impact of earthmoving operations.

Abstract: Methods capable of predicting the energy use and CO_2 emissions of off-highway trucks, especially in the initial planning phase, are rare. This study proposed an artificial neural networks (ANN) model to assess such energy use and CO_2 emissions for each unit volume of hauled materials associated with each hauling distance. Data from discrete event simulations (DES), an off-highway truck database, and different site conditions were simultaneously analyzed to train and test the proposed ANN model. Six independent quantities (i.e., truck utilization rate, haul distance, loading time, swelling factor, truck capacity, and grade horsepower) were used as the input parameters for each model. The developed model is an efficient tool capable of assessing the energy use and CO_2 emissions of off-highway trucks in the initial planning stage. The results revealed that the grade horsepower and haul distances yield a significant increase in the environmental impact of the trucks. In addition, the results demonstrated that, for a given set of project conditions, the environmental impact of trucks can reduced by improving their utilization rate and reducing the loading time.

Keywords: Off-highway truck; energy consumption; CO_2 emission; Simulation; ANN prediction model; initial planning stage.

1. Introduction

The climate policy for Europe has set a high target of an 80-95% reduction in emissions by 2050. These levels are higher than the 1990 levels stipulated in the European Commission roadmap for moving to a competitive low-carbon economy (EEA, 2011). This high-level target is translated to goals and policies at the sectorial level by the European member states. Furthermore, national authorities procure the majority of the transport infrastructure in Europe and, nowadays, these targets and policies are included in the procurement requirements of infrastructure projects (Keijzer et al., 2015; Miliutenko et al., 2014). The Swedish Transport Administration (STA) has declared that emphasis should be placed on reducing both the energy use and carbon dioxide (CO_2) emissions of infrastructure construction projects. This would be achieved through increased understanding of the fuel consumption of construction machinery (Trafikverket, 2012), with incentives being provided for contractors to mitigate emissions during planning and construction. The STA has also demanded that, as of 2015, climate calculations should be performed in large projects, and has developed a template for the climate declaration they require from the contractors (Toller, 2018).

Regarding climate change, CO_2 is considered to be the major contributor to global warming. Greenhouse gas (GHG) emissions into the atmosphere showed an increase from about 60% in 2003 (Yamasaki, 2003) to about 65% in 2014 (WMO, 2015). As well as being a major reason for the increase in the concentration of GHG in the atmosphere (Oh et al., 2017; Yang et al., 2008), CO_2 is also a driver of man-made climate change (Oh et al., 2017).