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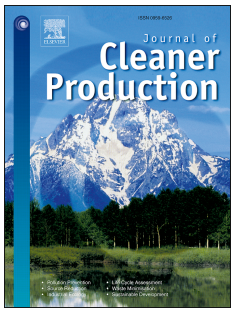

A genetic algorithm with exact dynamic programming for the green vehicle routing & scheduling problem

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A genetic algorithm with exact dynamic programming for the green vehicle routing & scheduling problem

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Abstract: Traffic congestion significantly increases CO_2 (a well-known greenhouse gas) emissions of vehicles in road transportation and causes other environmental costs as well. A road-based delivery company can reduce its CO_2 emissions through operational decisions such as efficient vehicle routes and delivery schedules by considering time-varying traffic congestion in its service area. In this paper, we study the time-dependent vehicle routing & scheduling problem with CO_2 emissions optimization (TD-VRSP-CO_2) and develop an exact dynamic programming algorithm to determine the optimal vehicle schedules for given vehicle routes. A hybrid solution approach that combines a genetic algorithm with the exact dynamic programming procedure (GA-DP) is proposed as an efficient solution approach for the TD-VRSP-CO_2. Computational experiments on 30 small-sized instances and 14 large-sized instances are used to study the efficiency and effectiveness of the proposed hybrid optimization approach with promising results. Contributions of this study can help road-based delivery companies be ready for a low-carbon economy and also help individual vehicle drivers make better vehicle scheduling plans with lower CO_2 emissions and fuel consumption.

Keywords: CO_2 emissions; green logistics; sustainability; dynamic programming; hybrid optimization

1. Introduction

The 2014 National Climate Assessment report (Melillo et al, 2014) unambiguously reaffirms that the global warming of the past 50 year has been caused by the human activity, particularly burning of coal, oil, and gas that leads the concentration of heat-trapping gases, mainly the carbon dioxide (CO_2), in the atmosphere. The keeling curve in (http://keelingcurve.ucsd.edu/), which has been perpetually measuring the concentration of CO_2 in Earth's atmosphere since 1958, has reached the highest, a record setting level and indicates an accelerated increase in the past decade. If the World continues along a business-as-usual energy path, the Intergovernmental Panel on Climate Change predicts that there is a fifty-fifty chance that the temperature will exceed 5 degrees by the end of this century, and many species, including Humans, will have a hard time in adapting to the changing climate (Chu, 2009). The world economic development should be steered towards a more sustainable model.

According to a report published by the International Energy Agency (IEA, 2015), the transportation sector was the second-largest contributor of CO_2 emissions, counting for 23% of the global CO_2 emissions in 2015, road transportation sector was responsible for almost three-quarters of the total emissions due to transportation activities. In urban areas, traffic congestion is one of the factors that substantially increase CO_2 emissions by vehicles. Based on the results of an empirical study to investigate the impact of traffic congestion on CO_2 emissions in Southern California, Barth and Boriboonsomsin (2008) point out that CO_2 emissions can be reduced by up to 20% through congestion mitigation strategies. Supply chain researchers suggest that commercial vehicle emissions can be significantly reduced by implementing operation research techniques to avoid traffic congestion and cooperation