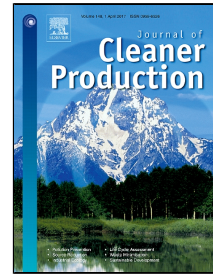


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Building Information Modeling-based Model for Calculating Direct and Indirect Emissions in Construction Projects

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2 **Building Information Modeling-based Model for Calculating** 3 **Direct and Indirect Emissions in Construction Projects**

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11 **Abstract**

12 The construction industry is considered as one of the most dynamic sectors that have upstream and
13 downstream economic links and has been growing rapidly in the last few decades. On the other hand, it is
14 considered as one of the main sources of greenhouse gases where construction projects represent a huge
15 portion of sources producing carbon dioxide gases (CO₂). Furthermore, greenhouse gases (GHG) are one
16 of construction emissions that should be investigated to calculate the overall emissions. Therefore,
17 estimating construction emissions is very important in order to keep emissions at an acceptable level. This
18 paper presents a building information modeling (BIM)-based model that enables the estimation of six types
19 of emissions including: greenhouse gases, sulfur dioxide, particular matter, eutrophication particles, ozone
20 depleting particles and smog. As such, the total direct and indirect emissions can be calculated where these
21 emissions are produced from construction activities during the overall project life cycle phases which are:
22 manufacturing phase, transportation phase, construction phase, operation phase, maintenance phase, and
23 deconstruction/demolition phase. The methods of calculating direct and indirect emissions are extensively
24 described in the paper. A case study is presented to illustrate the use of the proposed BIM-based model.

25 **Keywords:** Construction projects, construction emissions, building information modeling, direct emission,
26 indirect emissions, project life cycle phases.

27 **1. Introduction**

28 Climate change is compulsory. Environmental pollution contributes significantly to climate change. A
29 major portion of environmental pollution is greenhouse gases. Eleven of the last twelve years (1995-2006)
30 are ranked as the twelve warmest years in the instrumental record of global surface temperature since 1850
31 (Intergovernmental Panel on Climate Change, 2007). Carbon dioxide emissions should be decreased by
32 50% to 85% in order to keep the global increase in mean temperature within 2°C-2.4°C (Intergovernmental
33 Panel on Climate Change, 2007). Environmental pollution is considered one the main concerns of
34 construction industry. This concern has significantly increased in the recent few years. Environmental
35 pollution became a major constraint of construction process alongside with time and cost. There are various
36 types of environmental pollution that are produced from construction projects. Each type of pollution has a

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