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## An analysis of problems with current indicators for evaluating carbon performance in the construction industry

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### Abstract

“Low-carbon” is well acknowledged as one of the key factors contributing to sustainable urban development, and also an effective approach for tackling climate change. Since the building sector accounts for a high proportion of carbon emissions, the construction is regarded as one of the most potential industry to reduce carbon emissions. However, there is no standardized indicator to measure carbon performance in the construction industry. As a result, the choice of various indicators may result in significantly different carbon performances which determine whether an industry is considered truly “low carbon”. In this paper, the current indicators for assessing carbon performance in the construction industry are reviewed. The pros and cons of the current indicators are also highlighted. The problems of using the current indicators are discussed, and these problems are often related to accuracy of indicator, data availability and definitions of specific terms. Suggestions are made to focus on carbon emissions at building operation stage first as it accounts for a significant amount of carbon emissions during the whole building life-cycle. It should be highlighted that embodied emissions of buildings are also important during the whole building life-cycle. However, due to the challenges in data acquisition for calculating embodied emissions, attention should be paid more to the operational stage first as smart meters can be used to facilitate data collection processes. The findings provide clues for industry practitioners to develop an indicator which is more practical in use to assess carbon performance in the construction industry.

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## 1. Introduction

Reducing carbon emissions in all sectors and the planning of low carbon cities have been regarded as a solution to tackle climate change. It is well known that the building sector is responsible for a large proportion of carbon emissions [1]. A number of studies indicated that buildings consume more than 40% of global energy and account for 36% of carbon emissions [2]. In addition, the construction of buildings consumes significant amounts of raw materials (e.g. 40% of stone, sand and gravel, 25% of the timber and 16% of the water in the world) [3]. Given the above figures, the building sector has great potential for significantly reducing carbon emissions. The carbon emissions in the construction industry mainly come from the construction process and its supply chain from emissions embodied in construction materials [4]. The industry produces substantial on-site emissions from electricity and fuel use, transporting workers, materials, deliveries, and waste [5].

The urgency to reduce the current level of carbon emissions through innovative technology in design and use of materials, regulations and setting energy and carbon rating standards has been increasingly advocated. However, a comprehensive and robust development of a set of low-carbon indicators, and in particular, a method for calculating carbon emissions is still lacking a consensus. Thus, it is difficult to determine whether a sub-sector in the construction industry is 'low carbon'. This paper aims to review the current indicators for assessing carbon performance in the construction industry, and provide future directions to develop a low-carbon indicator. The paper first discusses the pros and cons of current indicators. After that, the problems of using these indicators are highlighted. Future directions are also suggested to develop an indicator which is more practical in use to assess carbon performance in the construction industry.

## 2. Current Indicators

Indicators are defined as a tool for visualizing the current conditions in complex systems by expressing those conditions in numerical form, for example, environmental indicators for environmental systems. Low-carbon indicators play an important role in tracking progress towards meeting the increasingly urgent goal of a low-carbon future. Low-carbon indicators can be used by national, regional and local governments, non-governmental organizations and research institutions to measure the status of low-carbon development and outcomes of climate change policies. The indicators also enable policy makers to benchmark targets, strategies and policies to support policy improvements. In general, the current indicators for assessing carbon performance can be classified into two types, namely, macro-level indicators and micro-level indicators. Table 1 shows the current carbon indicators in the construction industry.

Table 1: Pros and cons analysis of current carbon indicators in the construction industry.

Indicator(s)		Pros	Cons	Observations
Macro-level	Economic-based indicators	<ul style="list-style-type: none"> <li>Provide a quick comparison among cities, regions, and province</li> </ul>	<ul style="list-style-type: none"> <li>Ignore the differences of economic structure</li> </ul>	<ul style="list-style-type: none"> <li>Commonly used in the international level</li> </ul>
	Population-based indicators	<ul style="list-style-type: none"> <li>Provide a quick comparison among cities, regions, and province</li> </ul>	<ul style="list-style-type: none"> <li>Not consider migrant/transient populations</li> </ul>	<ul style="list-style-type: none"> <li>May lead to over-accounting of energy use per capita</li> </ul>
Micro-level	CO <sub>2</sub> emissions in the construction of a single building	<ul style="list-style-type: none"> <li>Focus on carbon emissions during the construction and demolition stage</li> </ul>	<ul style="list-style-type: none"> <li>Not consider the operation stage</li> </ul>	<ul style="list-style-type: none"> <li>No standard method to calculate carbon emissions at different stages</li> </ul>

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