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A holistic low carbon city indicator framework for sustainable development

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HIGHLIGHTS

- Assessment of the criteria for a range of low-carbon city (LCC) indicators at global level.
- Establishment of an LCC indicator system covering the holistic perspectives of sustainable development.
- The indicator system benchmark values for the standardization of cities.

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ABSTRACT

Many cities are pursuing the low-carbon practices to reduce CO₂ and other environmental emissions. However, it is still unclear which aspects a low-carbon city (LCC) covers and how to quantify and certify its low carbon level. In this paper, an indicator framework for the evaluation of LCC was established from the perspectives of Economic, Energy pattern, Social and Living, Carbon and Environment, Urban mobility, Solid waste, and Water. A comprehensive evaluation method was employed for LCC ranking by using the entropy weighting factor method. The benchmark values for LCC certification were also identified. The framework was applied to 10 global cities to rank their low-carbon levels. The comparison of cities at different levels of economic, social, and environmental development enhances the holistic of the study. The results showed that Stockholm, Vancouver, and Sydney ranked higher than the benchmark value, indicating these cities achieved a high level of low-carbon development. São Paulo, London, and Mexico City are still in the slow transition towards LCC. Beijing and New York each has much lower LCC level than the benchmark value due to the poor environmental performance and infrastructure supports caused by intensive human activities. The proposed indicator system serves as a guideline for the standardization of LCC and further identifies the key aspects of low-carbon management for different cities.

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1. Introduction

Since the inception of “low-carbon economy” by the UK white paper “Our Energy Future: Creating a Low-Carbon Economy” in

2003, low-carbon practices had been widely conducted and international cooperation was further emphasized. In recent years, the outcome of the landmark United Nation (UN) conference on climate change held in December 2009 in Copenhagen was a step forward with the agreement of Copenhagen Accord by setting an objective of limiting the increase in global temperature to 2 °C above pre-industrial levels. However, a study published in the journal of Environmental Research Letters found that the Accord's voluntary commitments would probably result in a dangerous increase in the global average temperature of 4.2 °C over the next century [1]. The 2 °C goal can only be achieved by vigorous implementation of commitments in the period until 2020 and much

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stronger action thereafter [2]. To achieve the 2 °C goal, a far-reaching transformation of the global energy system and lifestyle are required. Specifically, low-carbon development strategies should focus on the holistic perspective of economic, institutional and technological aspects.

Cities are responsible for 70% of global CO₂ emissions [3]. Cities are the basic unit of economic development and growth engines of the future should play a great role in the low-carbon development. The changing climate would also cause severe impacts on city, as they hold the increasing majority of the population and productive assets. The term “Low-carbon City” (LCC) emerged in response to the growing demand of carbon reduction and climate change alleviation of cities. Now, low-carbon practices have been widely conducted at a city level. It was reported that approximately 1050 cities in the United State, 40 cities in India, 100 cities in China, 83 cities in Japan established an objective of low-carbon development under their city’s development blueprint [4,5]. In a report of The C40 Cities Climate Leadership Group (C40), a network of the world’s megacities taking action to reduce greenhouse gas (GHG) emissions, estimated that about 93% of C40 Cities seat climate change responsibility at the highest level, 62% of C40 Cities had developed a climate change action plan, 50% of C40 Cities had a dedicated council or steering committee, and 57% of C40 Cities had specific GHG reduction targets for citywide emissions [3]. Table 1 shows the low-carbon goals and actions set by the representative mega cities.

Despite of aggressive low-carbon targets have been established, there are remaining issues to be solved. Low-carbon development takes in diversified forms, for instance, Copenhagen focused on the promotion of renewable energy applications while London emphasized on energy efficiency programs. Regardless, the concept of LCC refers to not only GHG emissions but also development of economic, environmental and social aspects. Thus, a comprehensive understanding of LCC is the first step of low-carbon development. In addition, long-term low-carbon goals of various cities have been set. However, is the city low-carbon goal reasonable? To justify its feasibility, the low-carbon development status should also be well

acknowledged. Hence, it is desirable to develop a standard LCC indicator framework capable of evaluating the low-carbon level of cities under different socio-economic situations. Apart from that, the applicability and implementation of an indicator tool or method should be addressed. Many indicator systems have been developed to analyze the sustainable development of a city, but it requires a complicated set of input data that are often difficult to collect. Although this approach seems comprehensive and complete in principle but faces the difficulties for the application or uncertainties due to lack of input data.

Therefore, this study aims to present a comprehensive indicator system for the evaluation, implementation and standardization of LCC. The low-carbon levels of 10 world cities are measured and compared using the proposed indicator system. In addition, the benchmark value of the LCC provides a goal and lower limit of each indicator and is defined to identify the low-carbon level of a city. It can thereby shed light on the certification of LCC. The paper is organized as follows: Section 2 reviews the definition of LCC and the current progress of the LCC indicator system. Section 3 describes the framework and methodology of LCC evaluation and certification, with the discussion on the selection of case cities and data sources. It is followed by the results of LCC ranking in term of comparison and low-carbon certification. The conclusions are given in Section 5.

2. Literature review

2.1. LCC definition

Although many countries and regions are already taking action to address the carbon emission issue, the term LCC is so new that a consensus has not yet been reached on how to define it. LCC is always related to the ultimate goal of sustainability. The concept of “sustainable development” which emphasizes the “development that meets the needs of the present without jeopardizing the ability of future generations to meet their own needs” was identified as the concept of LCC in earlier research [6]. Therefore, LCC is within

Table 1
Low carbon targets of typical megacities (Author’s compilation).

| City | Region | Targets | Actions |
|-------------------|----------------------------|---|--|
| New York | North America | To reduce GHG emissions by 30% by 2030 compared with the 1990 level | Improved the energy efficiency of building through high performance standards for new construction |
| Chicago | North America | To reduce GHG emissions by 25% by 2020 and 80% by 2050 compared with the 1990 level | Launched the Chicago Climate Action Plan (CCAP) in September 2008 with 5 strategies and 35 actions for GHG emissions mitigation |
| Copenhagen | Europe | To reduce GHG emission by 20% in 2015 compared with the 2005 level | Integrated climate adaptation into all aspects of planning – from overall municipal planning to both local and sectoral plans |
| London | Europe | To reduce 60% GHG emission by 2025 compared with the 1990 level | A range of programs and investing unprecedented amounts in climate change programs within London |
| Rotterdam | Europe | To reduce 50% GHG emissions by 2025 | Launched the Rotterdam Climate Initiative (RCI) to offer a platform for governments, organizations, companies and citizens to work together on the goals |
| Seoul | East Asia | To reduce GHG emissions by 40% by 2030 compared with the 1990 level | Addressing climate change issues through projects such as establishment of climate monitoring system; development of Seoul climate & energy map; development of GHG inventory; and launch of the Seoul Emission Trading System |
| Tokyo | East Asia | To reduce GHG emissions by 25% by 2020 from the 2000 level | Specific policy directions were delineated in the Tokyo Climate Change Strategy and the Tokyo Metropolitan Environmental Master Plan, which marked a dramatic departure from the past and made progress toward achievement of the announced target |
| Iskandar Malaysia | East Asia | To reduce GHG levels by 50% by 2025 | It not only addresses the social and economic needs of burgeoning populations, but also the environmental challenges they face |
| Johannesburg | Africa | – | Climate Change Programs are reviewed every quarter as part of the Environmental Departmental Balance Scorecard and are discussed in Sub Mayoral Committee on Climate Change |
| Sydney | Southeast Asia and Oceania | To reduce GHG emissions by 20% by 2012 and 70% by 2030 below 2006 levels | Launched the Sustainable Sydney 2030, which provides a long-term strategic vision of Sydney as Green, Globally Connected |
| São Paulo | Latin America | To reduce GHG emissions by 30% by 2012 from 2005 levels | Launched the first comprehensive Climate Bill in Brazil and is under final discussions for creating its guidelines for a Climate Change Action Plan |

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