Available online at www.sciencedirect.com
ScienceDirect
Procedia Engineering 198 (2017) 1007 – 1017
Procedia Engineering
www.elsevier.com/locate/procedia

Urban Transitions Conference, Shanghai, September 2016

Carbon Footprint and Carbon Emission Reduction of Urban Buildings: A Case in Xiamen City, China

Wei Huang[a, b], Fei Li[a, b], Sheng-hui Cui[a, b,]*, Fei Li[a, b], Lizhen Huang[c], Jian-yi Lin[a, b]

[a]*Key Lab of Urban Environment and Health, Institute of Urban Environment, Chinese Academy of Sciences, 1799 Jimei Road, Xiamen 361021, China*
[b]*Xiamen Key Lab of Urban Metabolism, 1799 Jimei Road, Xiamen 361021, China*
[c]*Department of Civil and Transport Engineering, Norwegian University of Science and Technology, Høgskoleringen 7A, NO-7491, Trondheim, Norway*

Abstract

The building sector is one of the largest contributors to greenhouse gas emission in urban areas. Quantitative assessment of the carbon footprint of urban buildings is needed to advance research and policy debates on building carbon emission reduction and sustainable architectural planning. This study develops a calculation methodology for carbon footprint accounting of urban buildings by taking Xiamen as a case study. Also, a scenario analysis is performed for examining emission reduction potential. It is shown that the carbon footprint of urban buildings increased from 8.95 million tons in 2005 to 13.57 million tons in 2009 in Xiamen, with an average annual growth rate of 12.87%. The carbon emissions from building material production and building energy use contributed 45% and 40% of building carbon footprint respectively. With the implementation of low-carbon strategies in building sector, such as increased energy efficiency design for new buildings and energy-saving retrofit for existing buildings, there would be a significant influence on carbon emission reduction. The growth rate of energy consumption from urban buildings would decrease 2.98% by 2020, with an energy saving of 1.66 million tce and a carbon emission reduction of 3.15 million tCO_2e, in a low-carbon development scenario.

Peer-review under responsibility of the organizing committee of the Urban Transitions Conference

Keywords: carbon footprint; life cycle analysis; urban building; Xiamen city

1. Introduction

Global warming is expected to continue and even increase within the next 100 years, and to have a more significant negative impact on both natural and socio-economic systems (Solomon, S., et al, 2009). Hence, how to effectively reduce carbon emissions has become the focus of international political, economic and environmental research.

Peer-review under responsibility of the organizing committee of the Urban Transitions Conference
doi:10.1016/j.proeng.2017.07.146

Energy consumption in urban areas accounts for about 75% of the global total, and more than 80% of the total carbon emissions (Stern, N. H., 2007). In addition, the construction sector consumes over 40% of the raw materials, and contributes 40% to 50% of the greenhouse gas emissions. In the European Union, the energy demand of construction sector has accounted for more than 40% of the total demand (Mistretta A., Fulvio B., 2011), and in China this proportion has reached nearly 30% and is expected to increase by 2.6% each year until 2020 (Wiel S., et al, 1998).

The energy consumption of buildings in urban areas is much larger than that in rural areas, and its electric power consumption accounts for 22-24% of the total power generated in China (Jiang Y., 2005). With the rapid urbanization and urban development of recent years, the total area of China's urban building construction increased from 6.2 billion square meters to 20.4 billion square meters during the past 13 years. By the end of 2010, the land area devoted to housing construction reached approximately 50 billion square meters. Indirect energy consumption and greenhouse gas emissions for building materials production, transportation, and building waste disposal have been growing accordingly.

Research on carbon emissions has been concerned primarily with the mechanism of carbon emissions, the relationship between carbon emissions and economic growth, and between carbon emissions and energy consumption (Lim H. J., et al, 2009, Li F., et al, 2011). The process of carbon emission can be calculated based on carbon footprint analysis, from the perspective of life cycle analysis, taking into account greenhouse gas emissions of personal or corporate activity, so as to study further the nature of the process of carbon emission and plan for carbon reduction (Christopher L., Weber, H. S., 2008). Research on carbon footprints, therefore, is of special significance in dealing with global climate change (Wiedmann, T., et al, 2007).

The concept of a carbon footprint is derived from that of the ecological footprint (Rees, W. E., 1992; Wackernagel M., Rees, W E., 1996). Calculating the carbon footprint involves analyzing products' life cycle, including both direct and indirect carbon emissions of the related activities, and comparing the results with other carbon emission studies. However, the exact definition and scope of carbon footprint is still under discussion (Carbon Trust, 2007; GFN, 2007; Grubb E., 2007; Hammond G., 2007; POST, 2006; Wiedmann T., Minx J, 2007).

The carbon footprint has become a hot topic in environmental science and related academic fields in recent years. The methodology for determining the carbon footprint has been studied for several years (Wiedmann T., Minx J., 2007; Carbon Trust, 2007), at various scales—personal, household, company, and region (Burnham A., et al, 2006; Carbon Trust., 2007; Giurcoa D, Petrie J G., 2007; Liu Q, et al., 2008; Kenny T., Gray N. F., 2009; Marilyn A, et al., 2009; Sovacool B K, Brown MA, 2010), and including industrial, transportation, water supply, medical, and other sectors (Burnham A., et al, 2006; POST, 2006; Cole A., 2009). However, there is relatively few research on the urban scale in the developing world, especially on the urban building sector. Existing studies were mainly concentrated on energy consumption and carbon emissions associated with production of building materials, building construction process, or a single building (Gong Z. Q., Zhang Z. H., 2004; Nassen J., et al, 2007; Upton B., et al, 2008).

At present, China is the largest contributor of carbon emissions in the world. As one of the China's low-carbon pilot cities, Xiamen is dedicated to explore the ways towards low-carbon transition, within which building is one of the important sectors that should be given enough attention. In this study, we develop a methodology for calculating the carbon footprint of urban buildings from a life-cycle perspective, by taking Xiamen city as an example. On this basis, we analyze energy saving and carbon emission reduction potential of urban buildings under different scenarios, aiming to provide decision supports for low-carbon building designs.