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Building Energy Consumption and Carbon dioxide Emissions: Threat to Climate Change

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Abstract

Climate change has become an undoubted environmental challenge in last couple of decades in every continent and all sectors across the world. It occurs due to increase in temperature of atmosphere by burning of fossil fuels and releasing of greenhouse gases. These days, vast quantities of fossil fuels have been used for energy source to power the economy of a country. This scenario significantly contributes to a large percentage of carbon dioxide emissions. By comparing with other economic sectors, it was reported in the literature that the consumption of energy in buildings accounts for about one third of the total consumption and responsible for an equal portion of carbon dioxide emissions in both developed and developing countries. In order to have a deeper understanding into existing knowledge concerning this area, this paper presents a review on building energy consumption and its related carbon dioxide emissions as threat to climate change.

Keywords: Building energy consumption; Carbon dioxide emissions; Climate change

Introduction

Since the Industrial Revolution started in the mid-19th century, human activities have contributed significantly to climate change by adding more carbon dioxide and other heat-trapping gases to the atmosphere [1] and consequently disturb the natural processes to reach equilibrium. With rapid industrialisation, increased population, urbanisation density and significant change in lifestyle, the burning of coal, oil and natural gas has emitted approximately 500 billion tons of carbon dioxide, around half of which remains in the atmosphere [2]. The impact of these additional carbon dioxide emissions in the atmosphere contributes to the increasing level of global temperature and greenhouse gases leading to human-induced global warming effect. As a result, threat of global warming and climate change is escalating for the last two decades [3].

Global warming and climate change are the contemporary threats to ecosystem services and biodiversity [4] that has a huge impact on the environment, livelihood of communities and economics across the world [1,5-10]. In response to this scenario, recently, there is a plethora of research examining influencing factors and the historical linkage between global warming and climate change [11]. This linkage is also closely related to the relationship between energy consumption and carbon dioxide emissions, in which it is reported that if energy consumption has increased extremely then carbon dioxide emissions would increase intensely [12,13]. It was reported that concentrations of carbon dioxide in the atmosphere continued to grow to approximately 390 ppm or 39% above pre-industrial levels in 2010 with the global average temperature increased by 0.76 °C (0.57 to 0.95°C) between 1850 to 1899 and 2001 to 2005 [1]. Therefore, it is observed the coordination of economic sectors, energy consumption, and carbon dioxide emissions forms an important issue as one of environmental challenges that will have a huge impact on a country's future. This paper presents a review on energy consumption and related carbon dioxide emissions in buildings that lead to a better understanding of relationship between these scenarios as threat to climate change.

Building Energy Consumption

It is well recognised that world energy consumption is divided into three major economic sectors: i) buildings; ii) transportation and; iii) industrial. Amongst these three sectors, buildings including residential, commercial, light commercial and institutional signify for about one third of the total energy consumption compared to other energy-using sectors [14-16]. It was reported that about 35 to 40% of total energy was consumed in buildings in the developed countries with 50 to 65% of electricity consumption [17]. The rate of building energy consumption in developing countries is also predicted to increase as the nations keep improving their standard of living and quality of life [18].

United Nations Environment Programme (UNEP) reported that approximately 80 to 90% of the energy in buildings is utilised during the operational phase of a building's life-cycle, while the other 10 to 20%, is used during extraction and processing of raw materials, manufacturing of products and construction [6]. This trend of energy consumption in buildings is influenced by several key factors. These factors include population growth, urban density, spatial organisation, economic growth, building size, building operation, building life, occupant behaviour, geographic location, climatic conditions and service demands [19,20]. Thus, in depth studies of the underlying mechanisms that lead to a deeper understanding of the aspect and impact of energy consumption in buildings should be established in the future that will help in finding new strategies and approaches for the overall energy reduction, creating more sustainable energy consumption patterns and realising the low-carbon economic development.

From the building energy consumption percentages, the demanded services of building in terms of Heating, Ventilation and Air-Conditioning (HVAC) systems account for a substantial amount

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of energy consumption in buildings which is more than 60% of total consumption [21,22]. Whilst, lighting accounts for approximately 11 to 20% of total building energy demand [17]. In the UK, energy consumption for space heating contributes to about 50% of the service sector energy consumption as reported by IEA [22]. In China, the air-conditioning and heating system account for 65% of the total building energy consumption [23]. Kwok and Rajkovich [24] reported that the building sector accounted almost 39% of the total primary energy requirements in the US of which almost 35% was used for HVAC systems. Furthermore, energy consumption in buildings due to ventilation and infiltration accounts for approximately 30 to 50% of total energy consumption [25]. In Europe for instance, with the consolidation of the demand for thermal comfort and IAQ, the energy demand for heating from ventilation air tends to reach about 60 to 70% of the total annual energy demand for the building [26]. Since the envelope of building equipped with HVAC systems is becoming tighter, the energy consumption resulted by the ventilation can be much higher than that caused by the heat transfer through the building shell [27,28]. Besides, in modern building, the ventilation losses may become more than 50% of total thermal loss [29]. By and large, it can be seen that energy consumption for HVAC systems in developing and industrialising countries accounts for half of the energy use in buildings and one fifth of the total national energy use. With the rapid pace of changes in lifestyles and technology, combined with economic prosperity, it is expected that energy consumption in buildings will continuously to take a large amount of total energy consumption in the future [30,31].

Carbon dioxide Emissions from Building Energy Consumption

As a result of energy consumption, the building sector contributes as much as one third of greenhouse gas emissions, primarily through the use of fossil fuels during their operational phase, both in developed and developing countries. The 4th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) projected that building-related greenhouse gas emissions reached 8.6 billion metric tons (t) CO_2 equivalent (e) in 2004, and expected to grow to 26% by 2030, reaching 15.6 billion t CO_2e under their high-growth scenario [1]. From this portion, carbon dioxide emissions from buildings account for 30 to 40% of the total greenhouse gas emissions which have been rising steadily since the 1950s [22]. Over the next 25 years, these emissions are estimated to grow faster than any other economic sectors [32,33].

The carbon dioxide emissions from energy consumption in buildings can be divided into two types which are: i) direct emissions from on-site combustion of fuels for heating and cooking and; ii) emissions from the end use of electricity utilised to heat, cool and provide power to buildings. The relation between these two types of carbon dioxide emissions and building service demands can fluctuate significantly year-on-year depending on their influencing factors [34]. To comprehend this, several approaches are used to analysis the association between the energy consumption and carbon dioxide emissions, leading to energy conservation and carbon dioxide emissions reduction [35-37]. The approaches of system accounting for overall energy consumption and carbon dioxide emissions induced by buildings are exemplified in terms of a combination of process and input-output analyses [38]. In addition, carbon dioxide emissions and energy consumption also can be assessed using life cycle assessment which takes into account all stages in production and operation of buildings [39]. Based on the approaches, further improvements in environmental and energy management can be made with a concrete procedure to cover various materials, manpower input, equipment and operational cost.

There are multiple options for reducing carbon dioxide emissions from the energy system while still providing energy services in buildings [1,40]. This includes the deployment of renewable energy technologies such as biomass, solar, geothermal, hydro, ocean and wind, in a sustainable manner that can aid the full range of energy services required in buildings [41-43]. Most forms of these renewable energy technologies unlike fossil fuels produce little or no carbon dioxide emissions [41,44]. Furthermore, significant reduction in energy consumption and carbon dioxide emissions from buildings can be attained through a range of measures including, energy efficient technologies, smart design, low carbon appliances and high efficiency HVAC systems that are already well established and extensively used [1,11,45]. Despite the capability to reduce carbon dioxide emissions, the contribution of these technologies relies heavily on the economic competition between these technologies and society aspect and varies substantially by country and region [46]. Thus, the role of these technologies in reducing carbon dioxide emissions and mitigating climate change specifically for energy service in buildings should be further examined by taking into account the total cost; end-use efficiency measures; economic analysis; and socio-cultural benefits and barriers.

Conclusion

Today's building sector utilises a significant percentage of energy and contributes to almost equal portion of carbon dioxide emissions. This percentage is predicted to increase in the coming year as a result of rapid changing in lifestyles and technologies. It was also highlighted that energy consumption in buildings is influenced by several key factors such as urban density, spatial organisation, economic growth, building size, building operation, building life, occupant behaviour, geographic location, climatic conditions and service demands. Thus, to overcome this issue and minimise the impact of climate change, new strategies and approaches by taking into account these factors and the adoption of renewable energy technologies should be ventured in the future for reduction of energy consumption in buildings.

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