

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

Mardiana A^{1*} and Riffat SB²

¹Environmental Technology Division, School of Industrial Technology, Universiti Sains Malaysia, 11800 USM, Pulau Pinang, Malaysia

²Department of Architecture and Built Environment, Faculty of Engineering, University of Nottingham, NG7 2RD University Park, Nottingham, United Kingdom

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

***Corresponding author:** Mardiana A, Environmental Technology Division, School of Industrial Technology, Universiti Sains Malaysia, 11800 Pulau Pinang, Malaysia, Tel: +604 653 2214; E-mail: mardianaaidayu@usm.my

Received December 26, 2014; **Accepted** January 02, 2015; **Published** January 12, 2015

Citation: Mardiana A, Riffat SB (2015) Building Energy Consumption and Carbon dioxide Emissions: Threat to Climate Change. J Earth Sci Climat Change S3:001. doi:[10.4172/2157-7617.S3-001](http://dx.doi.org/10.4172/2157-7617.S3-001)

Copyright: © 2015 Mardiana A, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

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) CO₂ equivalent (e) in 2004, and expected to grow to 26% by 2030, reaching 15.6 billion t CO₂e 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.

Acknowledgment

This research is funded by Exploratory Research Grant Scheme Ministry of Education Malaysia (203/PTEKIND/6730116) and RUI Universiti Sains Malaysia Grant (1001/PTEKIND/811229).

References

1. IPCC (2007) Fourth Assessment Report: Climate Change (AR4).
2. Moss RH (2010) The next generation of scenarios for climate change research and assessment. *Nature* 463: 747-756.
3. Tang CF, Tan BW (2014) The impact of energy consumption, income and foreign direct investment on carbon dioxide emissions in Vietnam. *Energy* 79: 447-454.
4. Boon E, Ahenkan A (2011) Assessing Climate Change Impacts on Ecosystem Services and Livelihoods in Ghana: Case Study of Communities around Sui Forest Reserve. *J EcosystEcogr* S3:001.
5. Htut AY, Shrestha S, Nitivattananon V, Kawasaki A (2014) Forecasting Climate Change Scenarios in the Bago River Basin, Myanmar. *J Earth SciClimat Change* 5: 228.
6. UNEP (2009) Buildings and Climate Change. Summary for Decision-Makers, France.
7. United Nations Framework Convention on Climate Change (2009) Adapting to

- climate change: towards a european framework for action. Commission of the European Communities, UK.
8. OECD (2010) Cities and Climate Change. OECD publications, ISBN: 978- 92-64-09137-5, France.
 9. United Nations Framework Convention on Climate Change (2006) Background paper on impacts, vulnerability and adaptation to climate change in Africa for the African Workshop on Adaptation Implementation of Decision 1/CP.10 of the UNFCCC, Accra, Ghana.
 10. Khajuria A, Ravindranath NH (2012) Climate Change Vulnerability Assessment: Approaches DPSIR Framework and Vulnerability Index. J Earth Sci Climat Change 3: 109.
 11. Liao H, Huai-Shu Cao (2013) How does carbon dioxide emission change with the economic development? statistical experiences from 132 countries. Global EnvironChange 23: 1073-1082.
 12. Cloy JM, Smith KA (2013) Greenhouse gas emissions. In: Reference Module in Earth Systems and Environmental Sciences.
 13. Macknick J (2009) Energy and Carbon Dioxide Emission Data Uncertainties. International Institute for Applied Systems Analysis, Laxenburg, Austria.
 14. Mardiana A, Riffat SB (2013) Review on physical and performance of heat recovery system for building applications. Renewable Sustainable Energy Rev 28:174-190.
 15. Yau YH, Hasbi S (2013) A review of climate change impacts on commercial buildings and their technical services in the tropics. Renewable Sustainable Energy Rev 18: 430-441.
 16. Gul MS, Patidar S (2015) Understanding the energy consumption and occupancy of a multi-purpose academic building. Energ Buildings 87: 155-165.
 17. EIA (2014) International Energy Outlook 2014, U.S Energy Information Administration, Washington DC, USA.
 18. Lior N (2008) Energy resources and use: The present situation and possible paths to the future. Energy 33: 842-857.
 19. Reinders AHME, Vringer K, Blok K (2003) The direct and indirect energy requirement of households in the European Union. Energy Policy 31: 139-153.
 20. Liu Z, Geng Y, Lindner S, Zhao H, Fujita T, et al. (2012) Embodied energy use in China's industrial sectors. Energy Policy 49: 751-758.
 21. Mardiana, A, Riffat SB (2012) Review on heat recovery technologies for building applications. Renewable Sustainable Energy Rev 16: 1241-1255.
 22. IEA (2012) Energy Policies of IEA Countries, UK.
 23. Wu Y (2003) Chinese building energy conservation: Existing situation, problems and policy, presentation. In: International Conference on Sustainable Development in Building and Environment, China.
 24. Kwok AG, Rajkovich NB (2010) Addressing climate change in comfort standards. Building Environ 45: 18-22.
 25. Khan N, Su Y, Riffat SB (2008) A review on wind driven ventilation techniques. Energ Buildings 40: 1586-1604.
 26. Besant RW, Simonson CJ (2000) Air-to-air energy recovery. ASHRAE J: 31-42.
 27. Juodis E (2006) Extracted ventilation air heat recovery efficiency as a function of a building's thermal properties. Energ Buildings 38: 568-573.
 28. Lazzarin RA, Gasparella A (1998) Technical and economical analysis of heat recovery in building ventilation systems. Appl Thermal Eng 18: 47-67.
 29. Roulet CA, Heidt FD, Foradini F, Pibiri MC (2001) Real heat recovery with air handling units. Energ Buildings 33: 495-502.
 30. Gong G, Zeng W, Wang L, Wu C (2008) A new heat recovery technique for airconditioning/ heat-pump system. Appl Thermal Eng 28: 2360-2370.
 31. Wang S, Fang C, Guan X, Pang B, Ma H (2014) Urbanisation, energy consumption, and carbon dioxide emissions in China: A panel data analysis of China's provinces. ApplEnergy 136: 738-749.
 32. Kılış B (2014) Energy consumption and CO₂ emission responsibilities of terminal buildings: A case study for the future Istanbul International Airport. Energ Buildings 76: 109-118.
 33. Alshehry AS, Belloumi M (2015) Energy consumption, carbon dioxide emissions and economic growth: The case of Saudi Arabia. Renewable Sustainable Energy 41: 237-247.
 34. Zhu J, Chew DAS, Lv S, Wu W (2013) Optimization method for building envelope design to minimise carbon emissions of building operational energyconsumption using orthogonal experimental design (OED). Habitat Int 37: 148-154.
 35. Emeakaroha A, Ang CS, Yan Y, Hopthrow T (2014) A persuasive feedback support system for energy conservation and carbon emission reduction in campus residential buildings. Energ Buildings 82: 719-732.
 36. Ng ST, Chen Y, Wong JMW (2013) Variability of building environmental assessment tools on evaluating carbon emissions. Environ Impact As Rev38: 131-141.
 37. Alhorr Y, Eliskandarani E, Elsarrag E (2014) Approaches to reducing carbon dioxide emissions in the built environment: Low carbon cities International J Sustainable Built Environ.
 38. Shao L, Chen GQ, Chen ZM, Guo S, Han MY, et al. (2014) Systems accounting for energy consumption and carbon emission by building. Commun Nonlinear Sci 19: 1859-1873.
 39. Biswas WK (2014) Carbon footprint and embodied energy consumption assessment of building construction works in Western Australia. Int J Sustainable Built Environ (In Press).
 40. Pacala, S, Socolow R (2004) Stabilization wedges: Solving the climate problem for the next 50 years with current technologies. Sci 305: 968-972.
 41. Rezaie B, Esmailzadeh E, I. Dincer I (2011) Renewable energy options for buildings: case studies. Energ Buildings 43: 56-65.
 42. Pollack HN, Hurter SJ, Johnson JR (1993) Heat flow from the Earth's interior: Analysis of the global data set. Rev Geophys 31: 267-280.
 43. Smeets EMW, Faaij APC, Lewandowski IM, Turkenburg WC (2007) A bottom-up assessment and review of global bio-energy potentials to 2050. P Energ Combust 33: 56-106.
 44. Kaygusuz K (2007) Energy for sustainable development: Key issues and challenges. Energ Sour 2: 73-83.
 45. Zafirah MF, Mardiana A (2014) Design, efficiency and recovered energy of an air-to-air energy recovery system for building applications in hot-humid climate. Int J Sci Res 3: 1803-1807.
 46. Nyboer J, Sathaye J (2010) Renewable energy costs, potentials, barriers: Conceptual issues. Energy Policy 38: 850-861.

Citation: Mardiana A, Riffat SB (2015) Building Energy Consumption and Carbon dioxide Emissions: Threat to Climate Change. J Earth Sci Climat Change S3:001. doi:10.4172/2157-7617.S3-001

This article was originally published in a special issue, **Environmental Challenges** handled by Editor(s). Dr. Hari K. Pant, University of New York, USA

Submit your next manuscript and get advantages of OMICS Group submissions

Unique features:

- User friendly/feasible website-translation of your paper to 50 world's leading languages
- Audio Version of published paper
- Digital articles to share and explore

Special features:

- 400 Open Access Journals
- 30,000 editorial team
- 21 days rapid review process
- Quality and quick editorial, review and publication processing
- Indexing at PubMed (partial), Scopus, DOAJ, EBSCO, Index Copernicus and Google Scholar etc
- Sharing Option: Social Networking Enabled
- Authors, Reviewers and Editors rewarded with online Scientific Credits
- Better discount for your subsequent articles

Submit your manuscript at: www.omicsonline.org/submission