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# A global review of energy consumption, CO<sub>2</sub> emissions and policy in the residential sector (with an overview of the top ten CO<sub>2</sub> emitting countries)



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## ABSTRACT

Climate change and global warming as the main human societies' threats are fundamentally associated with energy consumption and GHG emissions. The residential sector, representing 27% and 17% of global energy consumption and CO<sub>2</sub> emissions, respectively, has a considerable role to mitigate global climate change. Ten countries, including China, the US, India, Russia, Japan, Germany, South Korea, Canada, Iran, and the UK, account for two-thirds of global CO<sub>2</sub> emissions. Thus, these countries' residential energy consumption and GHG emissions have direct, significant effects on the world environment. The aim of this paper is to review the status and current trends of energy consumption, CO<sub>2</sub> emissions and energy policies in the residential sector, both globally and in those ten countries. It was found that global residential energy consumption grew by 14% from 2000 to 2011. Most of this increase has occurred in developing countries, where population, urbanization and economic growth have been the main driving factors. Among the ten studied countries, all of the developed ones have shown a promising trend of reduction in CO<sub>2</sub> emissions, apart from the US and Japan, which showed a 4% rise. Globally, the residential energy market is dominated by traditional biomass (40% of the total) followed by electricity (21%) and natural gas (20%), but the total proportion of fossil fuels has decreased over the past decade. Energy policy plays a significant role in controlling energy consumption. Different energy policies, such as building energy codes, incentives, energy labels have been employed by countries. Those policies can be successful if they are enhanced by making them mandatory, targeting net-zero energy building, and increasing public awareness about new technologies. However, developing countries, such as China, India and Iran, still encounter with considerable growth in GHG emissions and energy consumption, which are mostly related to the absence of strong, efficient policy.

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## Contents

1. Introduction	844
2. Global status of residential energy consumption	845
2.1. Traditional biomass	846

**Abbreviations:** ASHRAE, American Society of Heating, Refrigerating and Air Conditioning Engineers; BEC, building energy code; CO<sub>2</sub>, carbon dioxide; EPA, Environmental Protection Agency (of the US); EPBD, Energy Performance of Buildings Directive; EJ, exajoule (10<sup>18</sup> J); GHG, greenhouse gas; HPwES, home performance with ENERGY STAR; HVAC, heating, ventilation, and air conditioning; IEA, International Energy Agency; IECC, International Energy Conservation Code; IPCC, Intergovernmental Panel on Climate Change; LED, light-emitting diode; LEED, Leadership in Energy and Environmental Design; LNG, liquefied natural gas; LPG, liquefied petroleum gas; MEPs, minimum energy performance requirements; MNECB, Model National Energy Code of Canada for Buildings; MOHURD, Ministry of Housing and Urban–Rural Development of China; Mtoe, Million ton oil equivalent (equal to 0.041868 EJ); nZEB, nearly zero energy buildings; OECD, the Organization for Economic Cooperation and Development; PV, photovoltaics; RdSAP, reduced standard assessment procedure; SAP, standard assessment procedure; TFC, total final consumption; USGBC, the U.S. Green Building Council

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2.2. Fossil fuels . . . . . 846  
 2.3. Electricity . . . . . 846  
 3. Interaction between global CO<sub>2</sub> emissions and residential energy consumption . . . . . 847  
 4. Energy policies in the residential sector . . . . . 847  
 4.1. Transition from prescriptive to performance-based BEC . . . . . 848  
 4.2. The potential of current energy policies to mitigate future global warming . . . . . 848  
 5. The status of residential energy consumption, CO<sub>2</sub> emissions and policy in the top ten emitters . . . . . 849  
 5.1. China . . . . . 849  
 5.2. The US . . . . . 850  
 5.3. India . . . . . 851  
 5.4. Russia . . . . . 852  
 5.5. Japan . . . . . 853  
 5.6. Germany . . . . . 853  
 5.7. South Korea . . . . . 855  
 5.8. Canada . . . . . 856  
 5.9. Islamic Republic of Iran . . . . . 856  
 5.10. The UK . . . . . 857  
 6. Discussion and summary . . . . . 859  
 6.1. Energy consumption . . . . . 859  
 6.2. CO<sub>2</sub> emissions . . . . . 859  
 6.3. Energy policies . . . . . 859  
 7. Conclusions . . . . . 860  
 Acknowledgments . . . . . 860  
 References . . . . . 860

**1. Introduction**

Buildings account for approximately 40% of global energy consumption and play an important role in the energy market. Buildings' energy demand is predicted to continue growing worldwide in the coming decades [1,2]. In addition, the buildings sector has a significant influence on natural resource utilization [3,4]. Hence, while buildings provide facilities for human needs and their countless benefits to the society cannot be ignored, buildings have also had destructive influences on the environment during last decades [5].

Since forty years ago, the energy demand from buildings (including residential and commercial buildings) has grown by 1.8% per year [6], and it is predicted to grow from 2790 Mtoe (116.8 EJ) in 2010 to over 4400 Mtoe (184.2 EJ) by 2050, with most of this increase being from developing countries [7,8].

Three-quarters of total energy consumption in the buildings sector is residential, where there is great potential to improve energy efficiency [9]. Fig. 1 demonstrates the percentage of total consumption that is residential in different regions of the world,

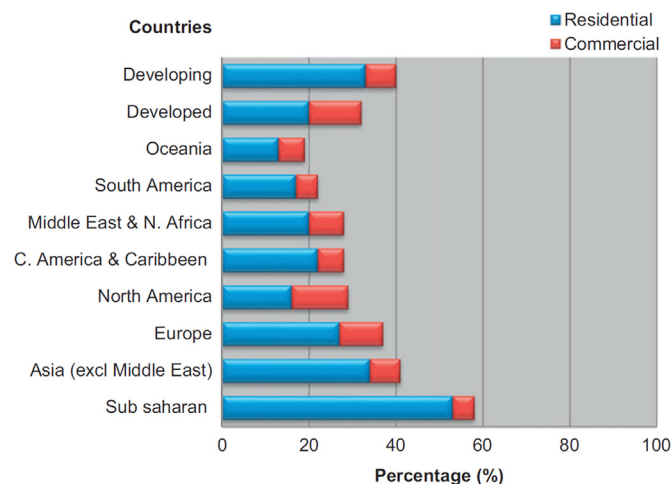


Fig. 1. Percentage of energy consumption in the buildings sector globally [10].

which fluctuates from an average of 20% in the developed countries to more than 35% in the developing countries [10]. Residential energy demand is prominent both for its present size and potential growth [11].

In addition, buildings are also responsible for one-third of global energy-related GHG emissions [12]. Carbon dioxide (CO<sub>2</sub>) emissions are believed to account for approximately three-quarters of global greenhouse gas (GHG) emissions, and CO<sub>2</sub> is seen as the main gas responsible for climate change [13]; thus, this paper focuses solely on CO<sub>2</sub> emissions. According to the above, the residential sector can play a pivotal role in decreasing global total energy-related CO<sub>2</sub> emissions [14].

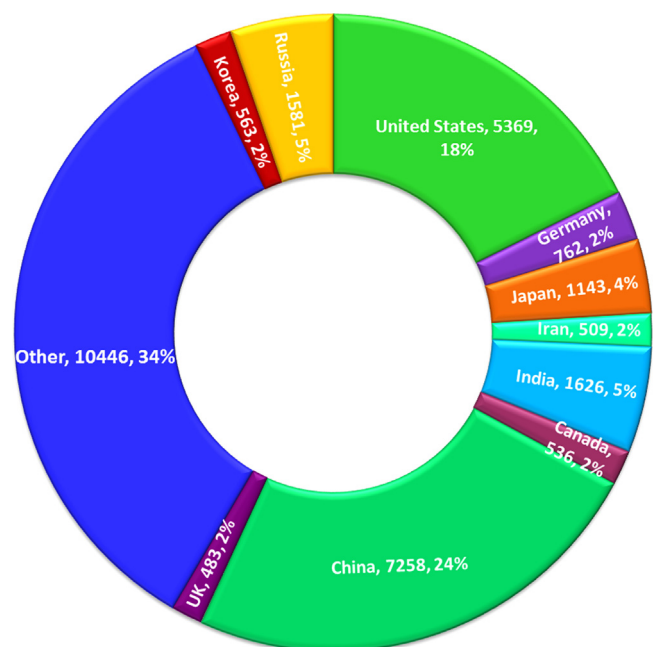


Fig. 2. Shares (in millions of tons) and percentages of top ten countries in global CO<sub>2</sub> emissions in 2010 [15].

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