Building and Environment 46 (2011) 2398–2412

Contents lists available at ScienceDirect

Building and Environment

journal homepage: www.elsevier.com/locate/buildenv

Climate change adaptation pathways for Australian residential buildings

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ARTICLE INFO

Article history:
Received 30 March 2011
Received in revised form
26 May 2011
Accepted 27 May 2011

Keywords:
Climate change adaptation
Adaptive capacity
Total energy consumption
Carbon emissions
Residential buildings
Modelling and simulations

ABSTRACT

Climate change can significantly impact on the total energy consumption and greenhouse gas (GHG) emissions of residential buildings. Therefore, climate adaptation should be properly considered in both building design and operation stages to reduce the impact. This paper identified the potential adaptation pathways for existing and new residential buildings, by enhancing their adaptive capacity to accommodate the impact and maintain total energy consumption and GHG emissions no more than the current level in the period of their service life. The feasibility of adaptations was demonstrated by building energy simulations using both representative existing and new housing in eight climate zones varying from cold, temperate to hot humid in Australia. It was found that, in heating dominated climates, a proper level of adaptive capacity of residential buildings could be achieved simply by improving the energy efficiency of building envelop. However, in cooling dominated regions, it could only be achieved by introducing additional measures, such as the use of high energy efficient (EE) appliances and the adoption of renewable energy. The initial costs to implement the adaptations were assessed, suggesting that it is more cost-effective to accommodate future climate change impacts for existing and new houses by improving building envelop energy efficiency in cooling dominated regions, but installing on-site solar PVs instead in heating and cooling balanced regions.

1. Introduction

Global warming is widely perceived to be one of the most important environmental issues facing the world today. The Intergovernmental Panel on Climate Change (IPCC) concluded that the observed temperature increase since the middle of the 20th century was very likely the result of increasing greenhouse gas concentration due to human activities such as the use of fossil fuel and deforestation [1]. Buildings account for 40% of the world's energy consumption and one third of global greenhouse gas emissions [2]. The IPCC identified that the reduction of energy consumption and greenhouse gas (GHG) emission from the building sector has one of the highest benefit-cost ratios among many possible mitigation measures across different sectors [3].

While buildings produce GHG emissions at all stages of their life-cycle including construction, operation, maintenance and demolition, the operation of a residential building generally accounts for 80–90% of the total emissions, mainly from space heating and cooling, hot water, lighting and other household appliances [4]. Therefore, GHG emissions from building operation may contribute considerably to the global warming. It should be noted that the warming climate may add more pressure on building energy consumption and subsequently GHG emissions. In particular, the increase in building cooling energy consumption and its related GHG emissions in a growing warm climate can further exacerbates global warming that leads to even higher cooling demands in the future [5–7].

Climate change mitigation and adaptation are two general approaches in response to global warming. Climate mitigation is designed to reduce GHG emissions and in return to reduce the global warming impact. Climate adaptation is designed to adjust actions in the society to cope with climate changes that are already happening or are the likely consequences of current GHG emissions [8].

In practice, climate adaptation is implemented by reducing exposures and vulnerability. Vulnerability is defined as the state of susceptibility to harm from exposure to changing environment and the absence of capacity to adapt [9]. While the exposure to potential climate change is unlikely avoided, the reduction of vulnerability can be achieved by the improvement in the adaptive capacity that is the ability to respond to climate variability and change, to reduce or moderate the likelihood and the magnitude of harmful outcomes, to cope with the consequences, or to take advantage of opportunities [10]. Considering vulnerability in building energy demand, climate adaptation can be implemented by increasing buildings' adaptive

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0360-1323/$ – see front matter
doi:10.1016/j.buildenv.2011.05.022