Role of occupancy and indoor temperature on energy efficiency of tiny housing

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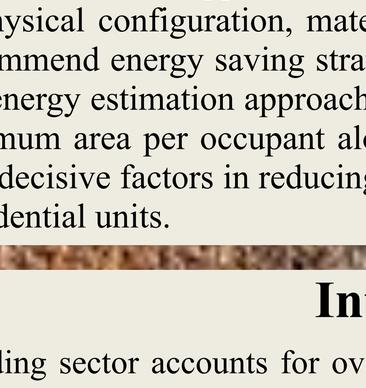
Abstract

With focus on urbanization, population, and sustainable housing, tiny house movement have gained momentum in recent years. In high-density populated regions such as Hong Kong, non-existence of standards on minimum amount of living space per capita and chronic housing shortage have led to rise in tiny residential units with size less than 18m^2. As we perceive a future in tiny affordable homes, it is necessary to implement strategies that make it more sustainable. This study utilizes a hybrid model that integrates the physical simulation method with data driven approaches to comprehend key relationships within buildings physical configuration, material specifications and operational conditions to recommend energy saving strategies at a minimal time compared to conventional energy estimation approaches. The study results indicate that establishing a minimum area per occupant along with indoor set-point temperature control can be decisive factors in reducing the annual cooling energy consumption of tiny residential units.

Introduction

- Building sector accounts for over 38% of energy-related carbon dioxide emissions in the world.
- Residential buildings alone constitute 70% of the total building energy demand.
- Space conditioning is one of the major sources consuming energy in residential building segment of Hong Kong.
- In regions with lack of buildable land, shortage of public housing and high housing prices, tiny residential spaces could be an alternative housing facility to improve housing affordability and alleviate the housing needs of its population.
- Tailoring the building characteristics and operational conditions with hybrid simulation model would be a time efficient and cost effective strategy compared to employing conventional methods to achieve building energy efficiency.
- This study embarks on strategizing sustainability measures for tiny living spaces in Hong Kong by analysing the impact of floor area per occupant and building operational conditions on the annual space cooling energy use.



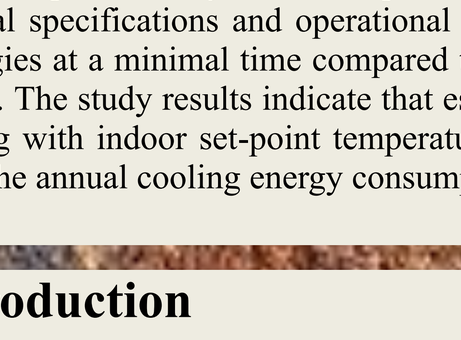
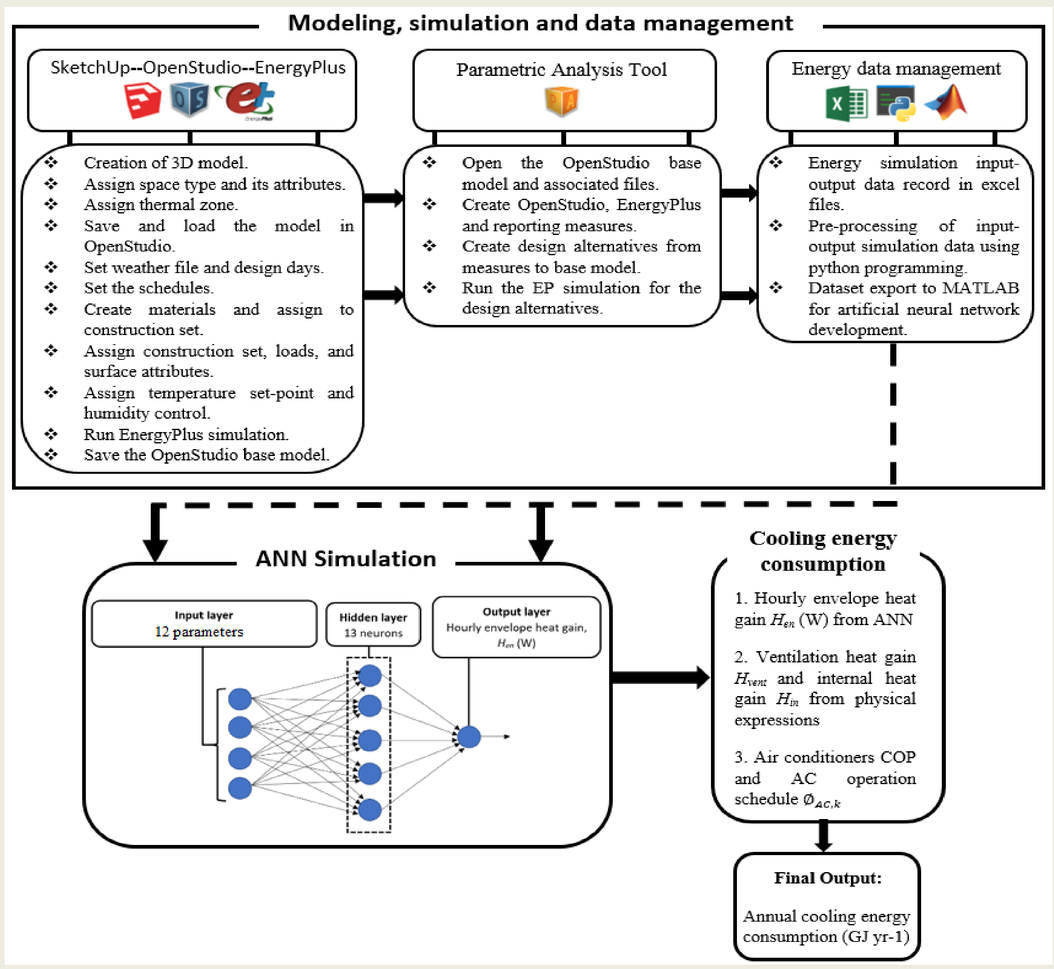


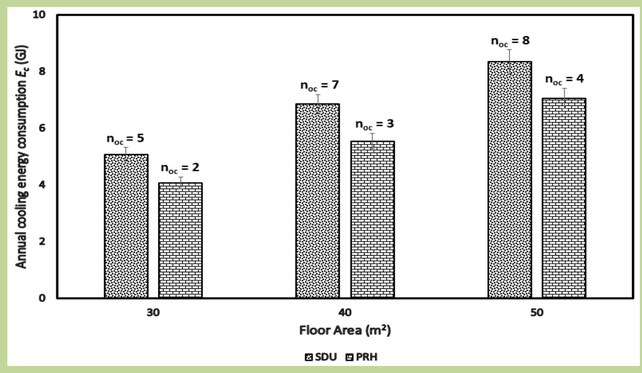
Figure 1. Example model (a) Residential apartment (b) Residential apartment sub-divided into four tiny residential units (SDUs) (c) Median per capita floor area of accommodation by type of housing

Methodology

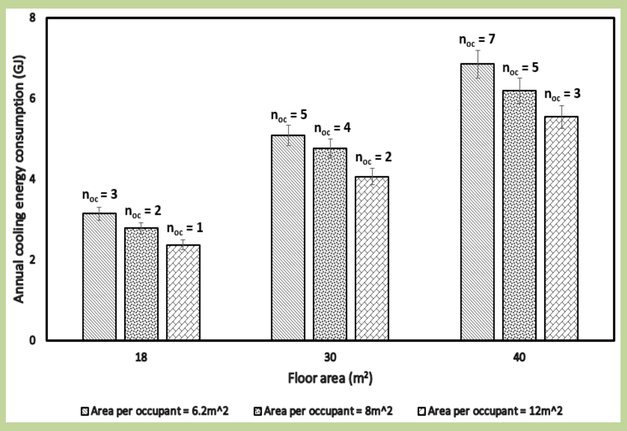


Results and discussion

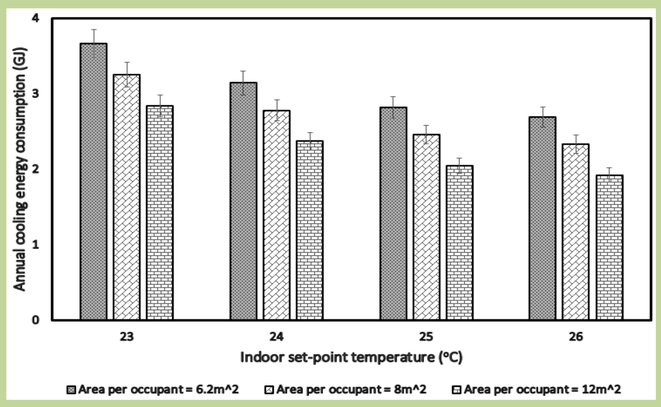
Based on the average area per occupant in a sub-divided unit (SDU), annual cooling energy consumption is noted to increase with floor area.



It is observed that the number of occupants within a household especially SDUs can be quite energy intensive in comparison to public housing sharing same floor area.



The variation in annual cooling energy consumption with change in area per occupant is estimated and it is found that area per occupant is a potential parameter influencing energy consumption.



The impact of indoor set-point temperature along with area per occupant is analysed and it is found that both can be crucial parameters that would impact energy consumption.

Conclusions

- Due to lack of minimum standards of living space per person in cities such as Hong Kong, a lot of people are often cramped into spaces resulting in more discomfort and energy consumption.
- Increasing the average area per occupant in an apartment of size 18m^2 from 6.2m^2 to 8m^2 resulted in a cooling energy reduction of 11.5% whereas a reduction of 24.6% was achieved when it is raised from 6.2m^2 to 12m^2.
- Along with area per occupant, the indoor set-point temperature is also noted to play a vital role in reducing the energy consumption.

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