Reducing energy consumption cost and greenhouse gas emission for tropical low-income housing: Thailand contribution

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Abstract:
Recently, there is insufficient effort and insufficient body of studies into the issues of low-energy housing for low-income and medium income earners. Even fewer studies have touched on the issue of thermal comfort for low-income housing. Modern housing design does not adequately attempt to utilize daylight fully nor to provide sufficient but energy-efficient electric lighting during night time. This project is carrying out to study on reducing energy consumption cost and greenhouse gas emission for tropical low-income housing in Thailand. Recent progress is on the survey process in low-income housing to collect the data of electric appliances, building configurations and energy uses in household, and establish the baseline for each household type in low-income housing in Thailand.

Keywords: *Low income; housing; energy efficiency; greenhouse gas emission*

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1. Introduction

Thai vernacular houses were constructed from low-mass materials. Typically thatch was used for roofs. Walls were constructed from thatch or wood planks or even broad tree leaves. Roof eaves of such houses extend to provide shading of solar radiation. Windows and doors were open to allow good natural air flow for ventilation. Daylight from the sky provides sufficient lighting in the house during daylight hours. Floors were raised up by a full floor height, one consequence of which was the resultant upward flow of cool ventilation air from below. Such vernacular houses located among canals and water ponds were comfortable to live in. No heating or cooling was used. Embedded energy in the materials used for housing was low. Energy consumption to keep the interior environment comfortable was negligible. Artificial lighting was needed during night time only.

At present, electrification has reached over 99% of villages. Bottled liquefied petroleum gas (LPG) has become the most common cooking fuel. Electrical lighting, entertainment, and food preparation each accounts for about 15% of total electricity consumption of 2,680 kWh per annum of an average household. Amenities that include air-conditioning, use of electric fans, hot shower, and refrigeration account for the rest of over 50% of electricity consumption. Overall energy use per household is expected to increase by 2.5 times in 2030, while the number of households will increase by 25% and urbanization will increase from 43% to 64%.

Housing design has diversified greatly, in shape, size, configuration, and composition of materials. Materials for housing are now industrially produced. Low-to-medium income housing can be broadly classified into two category, individual detached house and condominium. In rural areas, low-income earners mostly dwell in detached houses. Most low-income earners also dwell in urban condominium. Most medium-income earners live in urban area and dwell in both types of housing. Medium-income earners will use air-conditioning in one or more rooms (such as the main bedroom and the living room). Low-income earners will use electric fan to achieve comfort. Present housing designs do not pay sufficient attention to ensure that daylight provides sufficient illumination during daytime.

Presently, there is insufficient effort and insufficient body of studies into the issues of low-energy housing for low-income and medium income earners (The Joint Graduate School of Energy and Environment, 2014). Even fewer studies have touched on the issue of thermal comfort for low-income housing. Modern housing design does not adequately attempt to utilize daylight fully nor to provide sufficient but energy-efficient electric lighting during night time. Even though a Building Energy Code for mandatory implementation on commercial building exists in Thailand, there is no such code for residential or other types of buildings. It is also perceived that a mandatory code for residential dwellings will not be accepted by the public at this point in time, but some schemes of voluntary energy labeling may be acceptable.

This project is carrying out to study on reducing energy consumption cost and greenhouse gas emission for tropical low-income housing in Thailand. It was supported by Engineering and Physical Sciences Research Council, UK, under the main project of Energy and Low Income Tropical Housing (ELITH). The ELITH partnership comprises two institutions in East Asian countries (Thailand and China), two in East African countries (Uganda and Tanzania) and two in UK with long-term involvement in technologies for international development. Five institutions are universities; one is a building research agency (Engineering and Physical Sciences Research Council, 2014). The active partners have skills in housing construction, architecture, town planning, and engineering and policy formulation (University of Cambridge, 2014).

3. Methodology

In the first part, criteria and energy performance indicators of building envelope, electric lighting system and air-conditioning system were firstly identified. Next study on housing designs, thermal comfort, efficiency of energy use for lighting and thermal comfort, and the level of use of daylight in existing sample detached houses and condominium for low-to-medium income earners in selected urban areas was conducted mainly by several surveys. Similar studies and surveys were made on sample detached houses in selected rural areas. The project is now in this stage. The results are being formed baseline information for formulating key performance parameters on energy performance of building envelope, lighting, cooling, and overall energy use of main spaces. The results of the studies will also be used to define adequate level of thermal comfort in the main spaces in each type of dwellings (Tummu et al., 2013). The overall results will be used to develop a scheme of rating or energy performance labeling of housing design for the two main types of dwellings studied.

In the second part, study on embodied energy of selected common construction materials was conducted. Alternative material composition or construction methods were then examined. The results of the study will be used to provide recommendation to industry on alternative composition, alternative construction method, or alternative low-embedded-energy materials.

In the last part, the results were disseminate: by publishing and providing assessment of energy performance levels of a number of housing designs in Thailand and other countries of same climate, providing training to building professionals, research networking and personnel exchanges (including students), and other means.

4. Preliminary Results

The survey in low-income housing to collect the data of electric appliances, building configurations and energy uses in household was carried out. Thermal and visual comforts of each household type, building enveloped materials, and energy uses during building construction process were surveyed also. This survey was done from August 2014 with the collaboration of National Housing Authority (NHA), Thailand. Questionnaire and instrumental monitoring were carried out during the survey.

Information that was collected and measured during the survey is shown in Table 1. Data of residents and houses, energy uses, changing trends in energy use, house configuration, and material types and quantities were obtained from questionnaire.

Table 1. Information from survey and monitoring

Required data	Detail	Questionnaire	Measurement
General information	General information of residents and houses	✔	
Energy uses	History of energy uses and energy uses for lighting, cooking, entertainment, convenient, small business or industry, and transportation	✔	
Changing trends in energy use	Changing trends in energy uses	✔	
House configuration	Configurations, size and material of roof, wall, glazing and interior walls	✔	
Material types and quantities	Types and materials of construction materials	✔	
Thermal and visual comforts	Thermal and visual comfort levels	✔	✔

A survey questionnaire was developed in order to answer all requirements in the survey. The survey staffs were the persons who ask questions to the low-income household owners, the household owners were not fill the form by themselves. In some case, the answers could not be obtained directly from the questions. The staffs estimated the information by experience without bias.

Four types of housing were surveyed, including detached house, twin house, townhouse, and condominium. The survey of NHA houses was divided to be 3 trips, according to the area of sites. The NHA houses in central, north, and east parts of Thailand were surveyed. NHA staffs were the persons who firstly contact to each house or juristic persons in the housing projects. Two trips of additional survey were done in the low-income houses those are not in the NHA projects. In each trip of surveys, 3-4 persons were in the team. One or two persons in the team asked questions in the questionnaire and took notes. At least 1 person took care for mobile equipment during the survey. NHA staffs also accompanied to the surveys. One trip was 2 days and 1 night. The survey target was 20 households a trip.

The information from the survey is using to establish the baseline for each household type in low-income housing in Thailand. In the next step, the results of the survey will be used to define adequate level of thermal comfort in the main spaces in each type of dwellings. The overall results will be used to develop a scheme of rating or energy performance labeling of housing design for the two main types of dwellings studied.

5. Conclusion

This project is carrying out to study on reducing energy consumption cost and greenhouse gas

emission for tropical low-income housing in Thailand. Recent progress is on the survey process in low-income housing. The final results will be used to develop a scheme of rating or energy performance labeling of housing design. Ultimate beneficiaries from this project are the low and medium income earners who will have access to low cost, comfortable, and low energy housing that contributes less to carbon emission. The academic institutions and housing design professionals will benefit from the results of research into low energy housing design that utilizes natural daylight and ventilation.

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