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Energy efficiency and energy savings in Japanese residential buildings—research methodology and surveyed results

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Abstract

Worldwide energy consumption has risen 30% in the last 25 years. Fossil fuels exploitation is causing depletion of resources and serious environmental problems. Energy efficiency improvement and energy savings are important targets to be achieved on every society as a whole and in residential buildings in particular. In this article, results of a survey and questionnaire on energy consumption and thermal environment held in Kansai area, Japan are reported. Energy savings potential was analyzed for the surveyed 13 houses focusing on certain electrical appliances e.g. TV, rice cooker and refrigerator. Residents' environmental awareness towards energy consumption was clarified through questionnaire. An energy information session towards residents was held, and the resulting changes in lifestyle and their implications on energy consumption were evaluated.

Keywords: Energy savings; Energy efficiency; Residential buildings; Lifestyle

1. Introduction

1.1. Energy consumption

Worldwide energy consumption has risen 30% in the last 25 years. Industrialized countries consume ca. four times more than the world average. As economic growth is being pursued in countries such as China, India and Brazil, the energy consumption is expected to increase further. In this scenario, improvements in energy efficiency are regarded as the guarantor of economic growth, without increasing the energy consumption further.

In that context, the Japanese economy is the most energy efficient in the industrialized world as can be seen in Fig. 1. It has faced an urgent need for the improvement of its overall efficiency at the time of oil shocks in 1970s. Energy savings regulations for the industry were extremely important to achieve that aim, which enabled the Japanese industry to increase its output 40% by spending the same energy in 2001 as in 1973 [2].

On the other hand, the residential sector has shown an opposite trend, thus, energy savings achieved at industry level may be surpassed by the households spending. Therefore, energy efficiency/savings in the residential sector is strongly required in Japan. Moreover, a specific approach will be necessary since it has specific problems, namely the willingness of residents to achieve energy savings or not, their environmental consciousness and their ability to understand the close relationship between energy and environmental issues.

1.2. Energy conservation programs and energy labeling

Since the first oil shock in 1973, several measures like improving the building/equipment standards or marketing solutions with higher energy efficiency have been taken worldwide. In order to promote energy conservation and to provide consumers with information about energy efficiency, energy labels have been proposed. There are two

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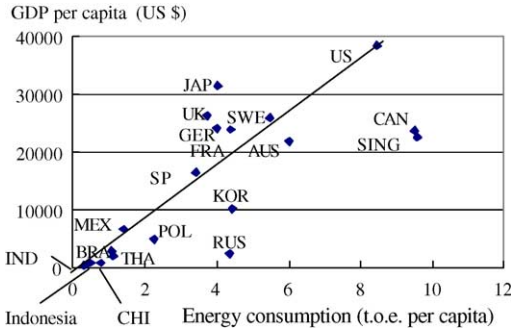

Fig. 1. GDP vs. energy consumption per capita [1].

Fig. 2. Japanese Energy savings label.

main types: endorsement labels, which simply identify appliances that are particularly energy efficient (e.g. 'Energy Star'), and comparison labels, which provide information that enables consumers to compare the energy efficiency of a specific product with the rest of appliances within the same category. Some examples of comparison labels are the Australian 'Energy Rating', the US 'Energy Guide' and the European 'Energy label'. 'Energy label' is conceived for a variety of electrical appliances, like refrigerators/freezers, washing machines, dish washers and lamps.

In Japan, a specific energy conservation program was introduced, the 'Top-Runner Program' [3]. Parallel to the program, a voluntary energy-saving labeling system has also been developed for five household appliances categories: refrigerators, freezers, AC, TV and fluorescent lamps. The label specifies the equipment's energy-saving standard achievement ratio as a percentage (e.g. refrigerator; Fig. 2) thus helping consumers select products with high-energy conservation performance.

1.3. Global environmental issues and awareness of residents

In the 1970s, CFCs emitted to the atmosphere were found to be destructing the ozone layer at an accelerated rate. After years of research, an international agreement on the phase out of substances that deplete the ozone layer, known as 'Montreal Protocol', was adopted in September 1987. After implementation, CFCs production was reduced to one-tenth in 10 years. In 1997, climatic changes related to the emissions of the so-called greenhouse gases, led to a new agreement on the reduction in emissions of greenhouse gases, the Kyoto Protocol. Electricity production, mainly if generated in thermal power plants, presents a significant environmental burden. However, residents do not necessarily associate the use of electricity to the pollution it stands for, since there are no perceptible emissions when using electricity in opposition to the emissions of their private cars. Hence, awareness to the close link between environmental problems and energy issues should be raised among dwellers.

2. Research approach

When analyzing energy consumption in housing, several factors are interrelated. In this research, a graphical way, the '3-star' concept is proposed (Fig. 3). It presents three main axes, representing the surrounding environment, resident's action and technology matters.

Axis 1 corresponds to the environment where a house is built. The surrounding environment is very important since it is possible to design a house that interacts better with its surroundings by taking into account the natural air, water and energy flows. The focus is put on achieving a suitable thermal environment by using local resources, e.g. use of locally available building materials, implementation of heating and cooling passive strategies, hence reducing the energy input needs. Axis 2 corresponds to occupants' interaction with housing. The way people use the house can have a significant influence on its energy consumption. Just to mention a few examples: use of curtains to reduce heat load, making use of natural ventilation, appliance usage among others. The usage depends on the number of dwellers, their income, age and even on their culture. Economic issues and regulations regarding energy consumption are aspects included in axis 2 since they influence directly the residents' way of spending energy at home.

Axis 3 corresponds to the technical features, that is, the characteristics of the housing materials and of the equipment installed. Improved characteristics mean that the input of external work/energy will be smaller for the same service

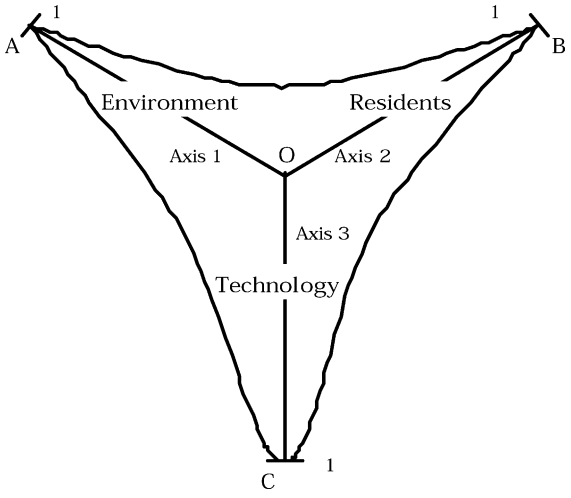

Fig. 3. Environment, Residents and Technology interrelationship: '3-star' concept.