Development of BELDA, Building Energy structure and Lifestyle Database of Asia

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Abstract

Carbon dioxide emissions of the world are still increasing, and it is said that 40% of them are come from the building sector. Also this sector is expected to significantly grow in the future. In order to reduce carbon dioxide emissions in the building sector, it is necessary to propose specific measures after understanding the actual energy supply and demand in accordance with each development stage.

In Japan, the Architectural Institute of Japan (AIJ) developed a nation-wide database on energy consumption in housing in 2003[1]. For commercial buildings, a DECC[2] database has been developed since 2007 by the Institute of Building Environment and Energy Conservation (IBEC) with the support of the Japanese government. Both databases have been published and are available on its website. These databases have helped in the formulation of an environmental policy at national and local levels, and also been used in the design of buildings and related products.

However, the information on energy demand in most Asian countries are poor.

In this paper, we have outlined the components of a database of energy consumption for the building sector in Asia, which can create scenarios for reducing carbon dioxide emissions and help build platforms that can evaluate step-by-step measures that can be used, depending on the development stage of the country. We have called this database "BELDA", Building Energy structure and Lifestyle Database of Asia. We also report the results of an interview based survey, aimed at clarifying the position regarding monthly energy use in housing in both urban and rural areas that was conducted for the purpose of establishing a seed database in Hanoi, Ho Chi Minh, Phnom Penh and Bangkok.

Introduction

We set three goals for this study. First, to develop database of energy consumption of building sector in Southeast Asia. Second, to establish a Web-based platform that can evaluate policy and measures in accordance with the development stage. Third, to build international academic and research network to take advantage of it.

We suppose 5 types of users of BELDA; Non-registered user, General user, Research user, Cooperate user, Co-worker. Table 1 shows conditions to be each user and availabilities.

Development of Database

BELDA database is composed by 3sections; Data Registration, Building and Analyzing database, and Using Database (Fig.1). BELDA will finally include the data collected by cooperate researcher in addition to data collected in BELDA research. Basic information in BELDA is divided by 5 categories as shows in Table 2. Also we made work process of data registration, input format, and definition of related term.

And we determined the duty of confidentiality and contents about privacy protection. The database is generally available on the website.

Table 1 User types

Types of user	Availability	Condition
Non-registration users	Browsing default data on the website	-
Registered users	Browsing processed data on the website	To enter minimum user information
Research users	Downloading anonymous individual data	To enter researcher information (Affiliation, Research subject etc.)
Collaborative user	Downloading anonymous individual data with some incentives	To offer research result
Collaborator	Accessing all individual data through research company	Co-working agreement with [b]JYURI, [a]WU

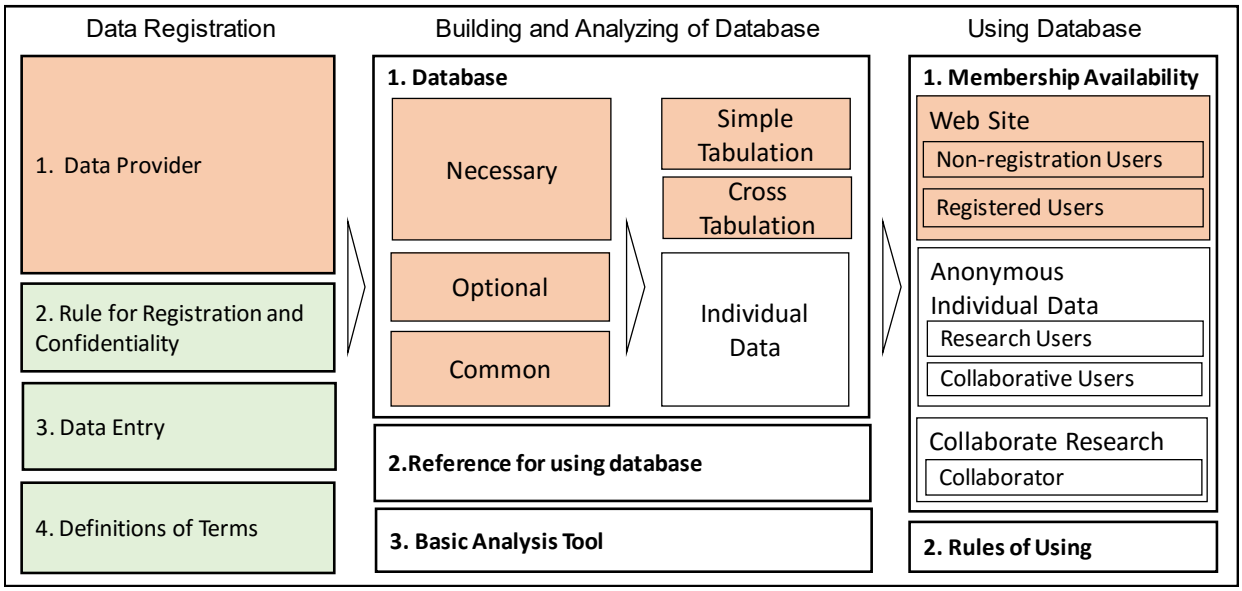

Fig. 1 Composition of BELDA

Table 2 Information in BELDA

Category	Contents
Survey data	Result of BELDA survey, (2015 survey, 2016 survey at this moment)
Previous data	Previous research data done in each countries, Search results on internet, etc.
Macro data	Macro statistic data, such as population, GDP, etc.
User data	Registration information (name, affiliation, bio, e-mail address, specialty etc.)
Master	All master data

This paper presents a survey we conducted in 2015 on energy consumption data and other significant information of resident in Southeast Asia which constitute the Database.

Sample Survey (Household Energy Consumption Survey)

This survey aims to collect detailed information about energy use as well as carbon dioxide emissions per household in the urban and rural areas of Vietnam, Thailand and Cambodia based on personal interview survey. We collected 300 data for each country in total of urban area and rural area.

- Vietnam (urban area): Hanoi (100 samples), Ho Chi Minh (100s)
- Vietnam (rural area): Hoa Binh (100s)
- Thailand (urban area): Bangkok (200s)
- Thailand (rural area): Samutsakorn (100s)

Table 3 Survey items

Category	Contents
Household Information	Constitution of household, Occupation, Number of workers, Household income,
Residential Information	Building type, Structure, Number of stories, Number of rooms, Total floor area, Construction year, Ownership
Facility	Cooling, Heating, Water heating, Kitchen, Home appliances
Facility use	AC/Home appliance/Shower using period
Vehicle	Number of vehicles, How to use
Lifestyle	Way of control room temperature Satisfaction for thermal/humid environment Energy saving action, Important points when buying home appliance
Energy Consumption	Yearly and monthly Energy consumption (Electricity, LPG, Kerosene, Coal, Charcoal, Firewood, Firewood)
Expense for Energy	Yearly and monthly utility bills by energy type

- Cambodia (rural area): Kandal (100s)

We conducted questionnaire survey as shown in Table 3, and estimated energy consumption by use, based on energy consumption by type and other information. Heat conversion factor used in this study are as follows.

Electricity:3.6MJ/kWh
LPG:47.3MJ/kg
Kerosene: 40.4MJ/kg
Coal:26.9MJ/kg
Charcoal:30.5MJ/kg

Firewood:14.4MJ/kg
Gasoline:32.78MJ/l

Energy consumption by energy type and use

Fig.2 shows yearly energy consumption per household. The outer circle is divided by type of energy source, and the inner circle is divided by energy use. In Bangkok, Ho Chi Minh, Hanoi, Yearly total energy consumption per household is around 20 GJ for each area. Electricity occupies 80 to 90 % of total energy consumption. In Phnom Penh, energy consumption is less than other urban areas, 13.3 GJ. And electricity occupies half of that. Bangkok consumes electricity as much as Ho Chi Minh, and it is 7% bigger than Hanoi. Hanoi uses the largest amount of LPG and other fuels in 4 urban areas. It is 2.2 times larger than Bangkok, and 1.4 times larger than Ho Chi Minh. In all areas electricity is the largest part of energy consumption, but the percentage is different area by area. In rural area of Thailand and Vietnam, total energy consumptions are about half of urban area, especially, electricity use is less than half of urban area. In rural area of Vietnam, they uses more LPG and other fuels than other areas. In the rural area in Vietnam, and Cambodia, "other" energy consumption such as charcoal and firewood is larger than other countries.
Focusing on the using, cooling occupies 12% to 19% in urban area, 4% to 11% in rural area. Ho Chi Minh consumes most. According to the interview survey in Hanoi, cooling period is less than half of other areas (Hanoi: 5 months, Bangkok and Ho Chi Minh: 12 months), but prevalence of air conditioner is 90%, and average number of holdings is 1.5. This is much higher than Bangkok, Ho Chi Minh, Phnom Penh.

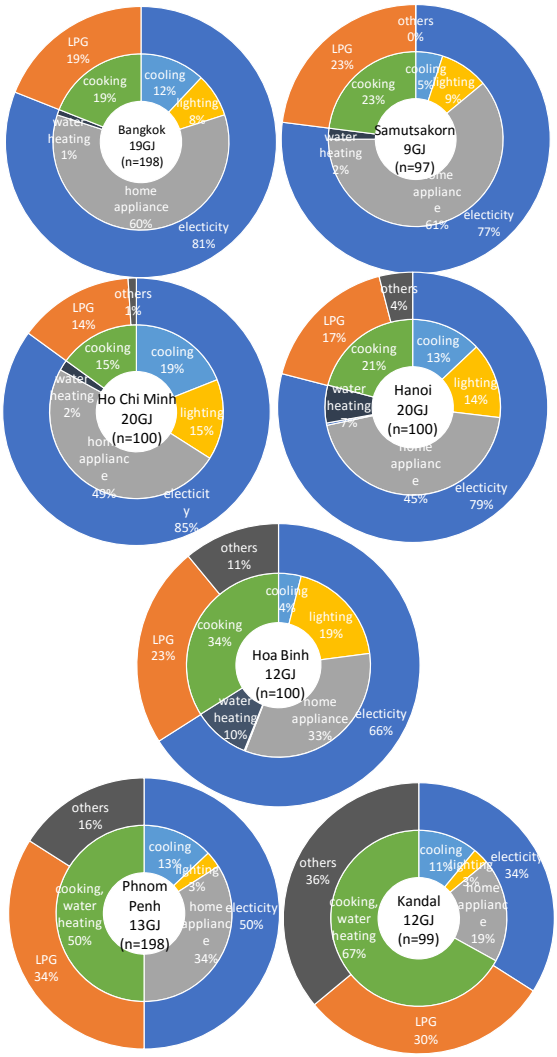

Fig. 2 Yearly energy consumption per household

Energy consumption by family group

Income

The more income increases, the more energy consumption increases. Especially, in high income household uses more electricity by cooling and appliance. It shows strong relationship between income and energy consumption.

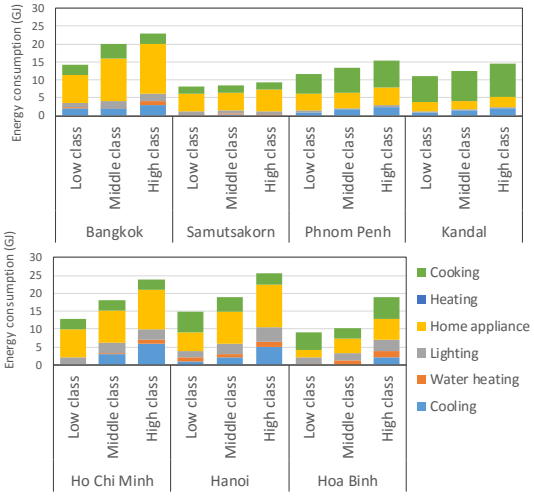

Fig. 4 Energy consumption and income

Ownership of Air Conditioner

Air conditioned household consume 60% to 90% larger than non-Air conditioned household. It shows that using air conditioner strongly influence electricity consumption.

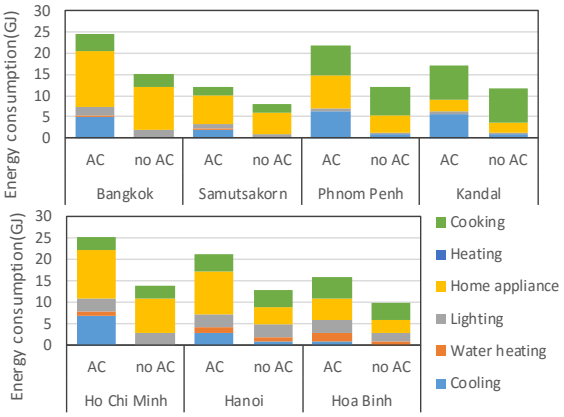

Fig. 5 Energy consumption and ownership of AC

Adopted Energy saving action

We defined 15 energy saving action as follows. The rate of energy saving action shows the percentage of household which answered "We do this" for each action.

(a)Reduce the brightness of the television

(b)Switch off the power of the television when not using

(c)Do not leave the refrigerator door open

(d)Try not to put too many things in the refrigerator

(e)Refrain from using the air conditioner

(f)Keep the temperature setting of the air conditioner higher than the comfortable level

(g)Try to turn lights off when leaving a location, even for a short time

(h)Use a water saving shower head

(i)Shorten the time of using showers

(j)Try to take cold instead of hot showers

(k)Reduce the number of times to run the washing machines

(l)Try not to use the keep-warm function of the electric rice cooker

(m)Turn off power of PC or switch to low-power mode when not in use

(n)Fill pots and kettles with the optimal amount of water when boiling

(o)Try to drive in a fuel efficient manner in ways such as accelerating automobiles and motorcycles slowly

Relationship between energy-saving action rate and energy consumption is in Fig. 6. Except for Bangkok, there is no relationship between energy-saving action rate and energy consumption.

Utility costs

Fig. 7 shows the monthly utility costs. The average of monthly utility costs in rural area is about half of urban area in each country. Table4 shows the percentage of utility costs in family income. As can be seen here, in Cambodia, the percentage is 9.8 % in urban area, and 7.6% in rural area. This is the highest compared with the other two countries. Possible reasons for this are; firstly, high electric bill in Cambodia because of the imports of electricity. Secondly, when they use LPG, they often use more cassette bomb because of the convenience although the unit price is higher than gas cylinder.

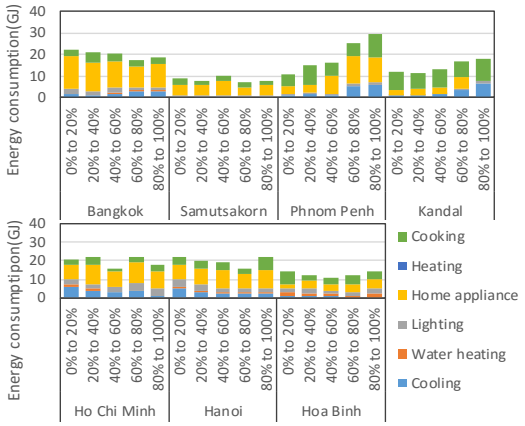

Fig. 6 Energy consumption and energy saving action

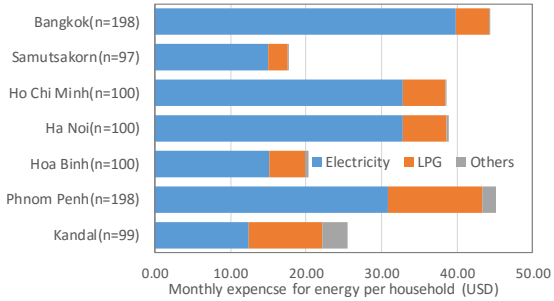

Fig. 7 Monthly utility costs

Table 4 Percentage of utility in the income

Region	Monthly Income(USD)	Monthly Utility(USD)	%
Thailand(urban)	1,258	44	3.5
Thailand(rural)	733	18	2.4
Vietnam(urban)	546	39	7.1
Vietnam(rural)	367	20	5.5
Cambodia(urban)	458	45	9.8
Cambodia(rural)	400	25	7.6

Monthly energy consumption

Fig.7 shows the monthly energy consumption and temperature. In Vietnam, monthly fluctuation of energy consumption is the largest in the three countries. The reason is the big change in temperature, especially in Hanoi. In Thailand, the climate is basically hot all through the year, and it has three seasons: rainy season (June to October), Dry season (November to February) and Hot season (March to May). In Bangkok, electricity consumption is few in January and February when temperature and humidity are relatively low. And same tendency in Phnom Penh. In Ho Chi Minh, electricity consumption increase from hottest April, and May is the highest. During the dry season (November to March), energy consumption gradually decreases, and February is the fewest. The reason why the energy consumption in February is the smallest is many people go their home villages because of Tet (the lunar new year). Also in Hanoi, February is the smallest energy consumption month excluding heating consumption. In general, the energy consumption is smallest in dry season, and biggest in rainy season.

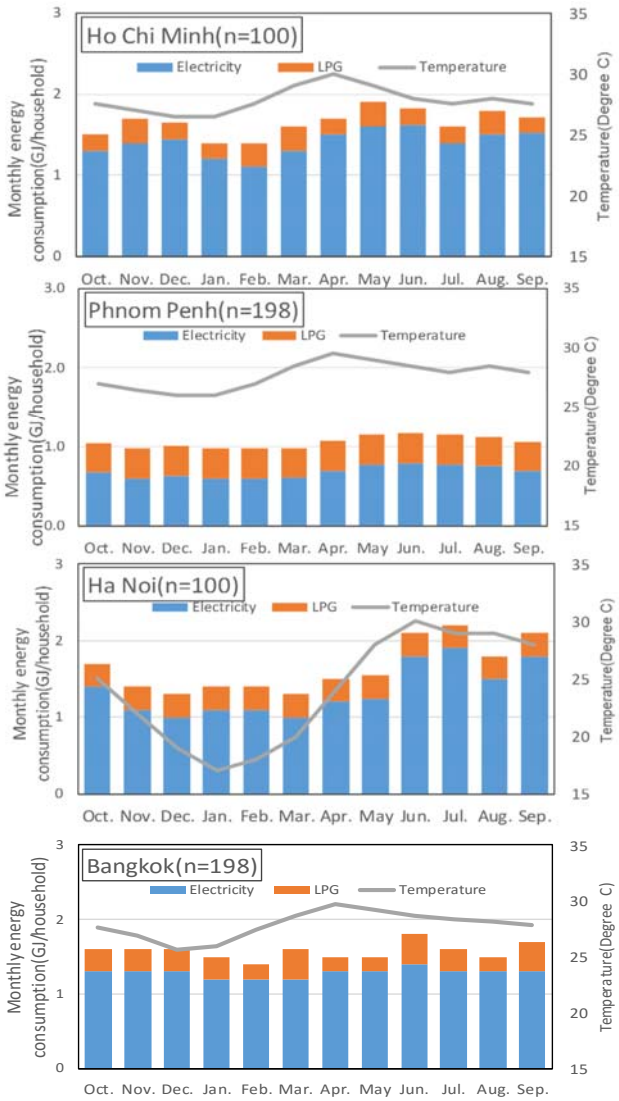

Fig. 7 Monthly energy consumption and temperature

Satisfaction for thermal environment

Except for rural area of Thailand (Samutsakorn), 60% to 90% of people are satisfied with their room temperature (Fig.). In generally, the household with AC have a tendency to be satisfied with their room environment. In Samutsakorn, many people are not satisfied no matter how they have air conditioner. In Cambodia, having AC strongly influence on satisfaction for thermal environment.

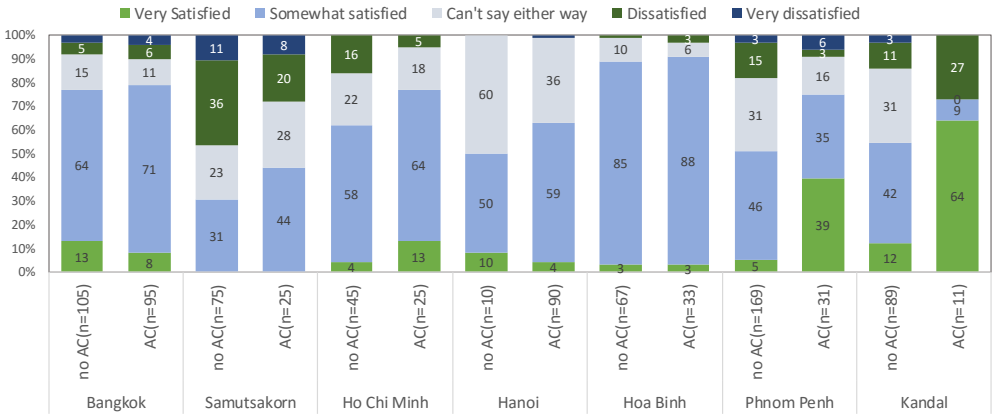

Fig. 8 Satisfaction for thermal environment

Conclusion

This paper reported overview of the environmental database, BELDA. Energy consumption data and other significant information were collected from 900 households of three Southeast Asian countries, Thailand, Vietnam, and Cambodia. And the number of the valid data is 892. This report is a first brief analysis of using BELDA. We are going to pay more effort to find an evidence it works for making a good measure and policy for each countries.

In 2016, we are going to do two kinds of survey in these countries. One of them is a detail measuring survey for electric home appliances. And another one is an interview survey that is focused on lifestyle and future prediction.

These result will be opened in BELDA soon. We are hoping that many researchers and policy makers will access our database, and provide their own data and information to share for sustainable future.

Acknowledgement

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