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# Factors Affecting Residential Energy Consumption from the Viewpoint of People's Lifestyle and Quality of Life: Case Studies of Thailand and Vietnam

Development of BELDA (Building Energy Structure and Lifestyle Database of Asia): Sequel 3

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Waseda University

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# *Introduction*

# Backgrounds & Objectives



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## ■ Background

- In Southeast Asian countries, **residential energy use increased annually** and will likely continue to rise due to higher living standards and economic growth.
- Nevertheless, **data collection** related to residential energy consumption **is lagging behind** in these countries, and understanding the state of consumption is challenging.

## ■ Research Objective

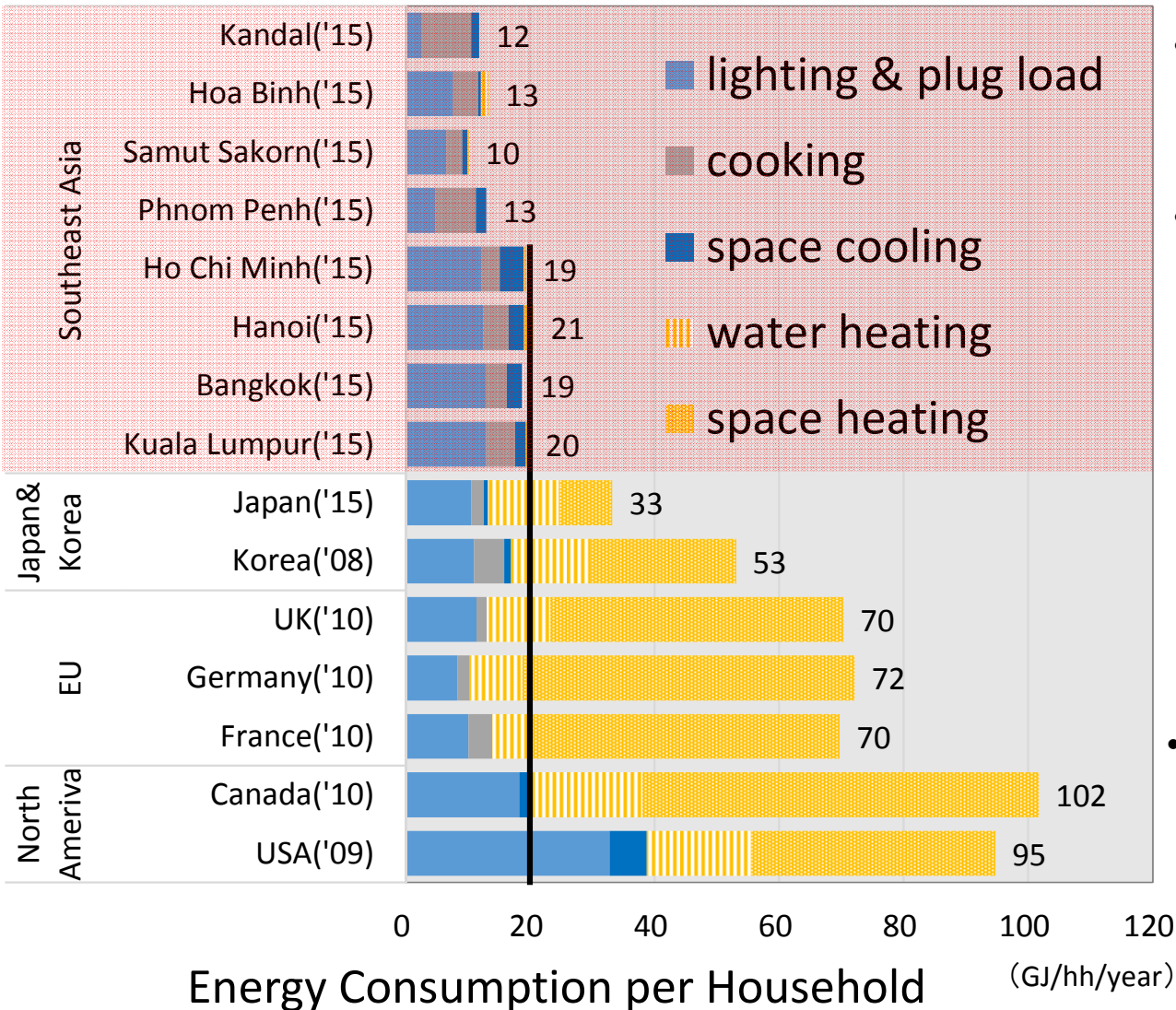
- In this study, we will **develop a database** of energy consumption of building sector in Southeast Asian countries, create scenarios for **reducing carbon dioxide emissions and build platform** that can evaluate of step-by-step measures in accordance with the development stage.
- At the same time, we are planning to **build an international academic & research network** in Asian countries.



# Backgrounds & Objectives

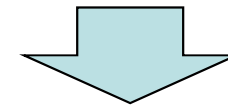


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- It is generally thought that residential energy consumption in Southeast Asia is lower than that in developed countries.

- However, this is due to the absence of heating demands like space heating and water heating, and when cooling, lighting and plug loads, and cooking demands are compared, households in urban areas in Thailand and Vietnam have already reached levels exceeding Japan and other developed countries.



- Therefore, the introduction and expanded adoption of energy efficient technologies in Southeast Asia is an urgent issue, as there is a need to curb the increase in residential energy consumption in the applicable countries.

Source) Chiharu MURAKOSHI, Ji XUAN, et al., *State of residential energy consumption in Southeast Asia: need to promote smart appliances because urban household consumption is higher than some developed countries*. Proc. of the ECEEE 2017 Summer Study (Belambra Presqu'île de Giens, France, 29-3 June 2017)



# Overview of Project



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1. Data collection and analysis of energy demand structure of the building sector (field survey for the database development) in Southeast Asia
  - Build database related to the “Quantity of Energy Use” and “Quality of Life”.
    - Field survey on annual energy consumption of residential sector (2015 year)
    - Measurement survey of housing and major home appliances (2016 year)
    - Interview survey on living style, behavior, use of home appliances and QOL (2016 year)
    - Field survey on energy consumption of commercial buildings (2016 year)
2. Study on development and utilization of the platform
  - Develop forecast model of future energy demand based on the database. And develop national emission reduction countermeasures in accordance with the development stage.
    - Specify a definition and rule making of joint utilization of the platform (2015 year)
    - Develop forecast model of future energy demand (2015/2016 year)
    - Build international academic & research network and transmit the information (2016 year)
    - Build Web-based database and the platform (2017 year)
    - Joint proposals of the national CO<sub>2</sub> emission reduction countermeasures by international academic & research network (2017 year)
3. Target countries: Residential sector in **Thailand, Vietnam, Cambodia**  
Commercial buildings in Thailand and Vietnam



# *Survey Overview*

# Overview of Project



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3. Target countries: Residential sector in Thailand, Vietnam, Cambodia  
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## Purpose

- Considering implementing an energy efficiency measure has a possibility to affect people's general Quality of Life (QOL), it is necessary to suggest and verify the effectiveness of policies and measures on energy saving without decreasing the level of people's QOL. Therefore, it is important to identify the factors that may influence peoples' QOL.
- Taking the above into consideration, this survey aims to seek for the factors (among household attributes, housing attributes, and energy consumption) that influenced on residents' QOL.

## Regions & Samples

- Vietnam (urban area): Hanoi (84 hhs), Ho Chi Minh (75 hhs)
- Vietnam (suburban area): Me Linh (70 hhs)
- Thailand (urban area): Bangkok (100 hhs)
- Thailand (suburban area): Ang Thong (104 hhs)
- Cambodia (urban area): Phnom Penh & other cities (110 hhs)
- Cambodia (suburban area): Phnom Penh & other cities (109 hhs)






**3 countries**  
**11 regions**  
**652 households**



# Local Partners



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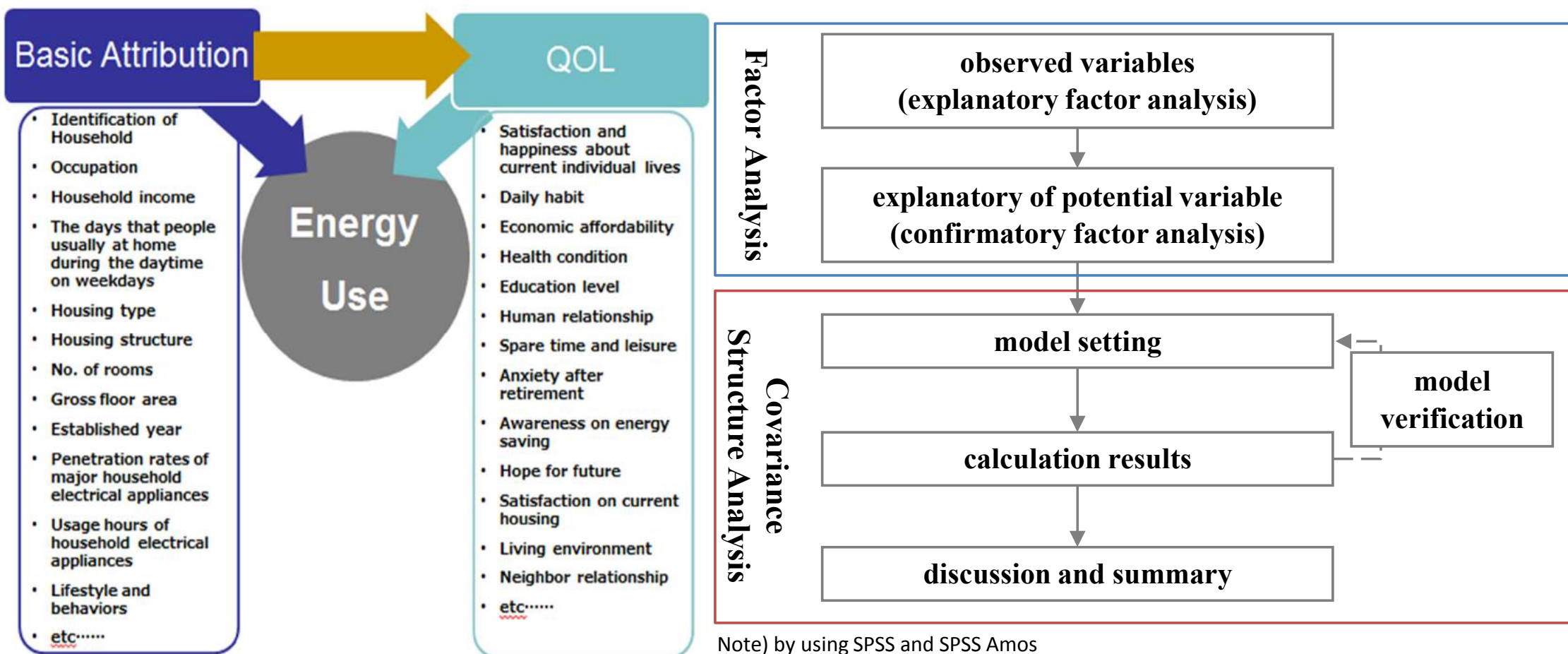
Country		Local Partner Organization
Thailand		Joint Graduate School of Energy and Environment (JGSEE), King Mongkut's University of Technology Thonburi (KMUTT)
Vietnam		Institute of Energy (IE)
Cambodia		Institute of Technology of Cambodia (ITC)

- Investigators conducted field interviews lasting one to two hours to narrow down the head of household or spouse who understood household expenditures and electricity usage for the past several months'.
- Snowball sampling (a method of at the time of recruiting subjects searching for other participants through relationships such as friends and acquaintances who meet participation conditions) was used.

# Survey Items & Methodology



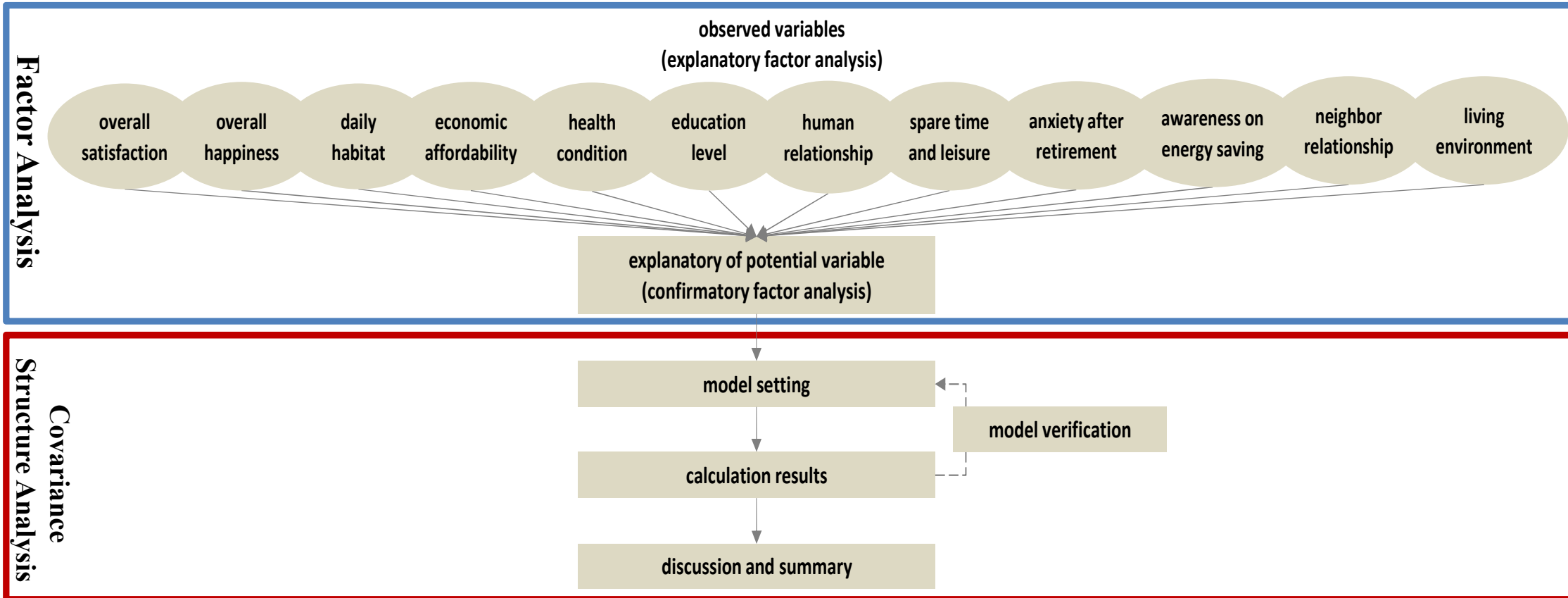
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# Survey Methodology



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Note) by using SPSS and SPSS Amos

- Factor Analysis: It is more efficient to explore common factor that hides behind on variety of observed variables.
- Covariance Structure Analysis: In order to define correlation between potential variable and observed variables, this research implements covariance structure analysis by SPSS Amos (structural equation modeling: SEM). The adaptation of model is finally decided by evaluate the value of comparative fit index (CFI), root mean square error of approximation (RMSEA), akaike's information criterion (AIC).



# Factor Analysis of QOL

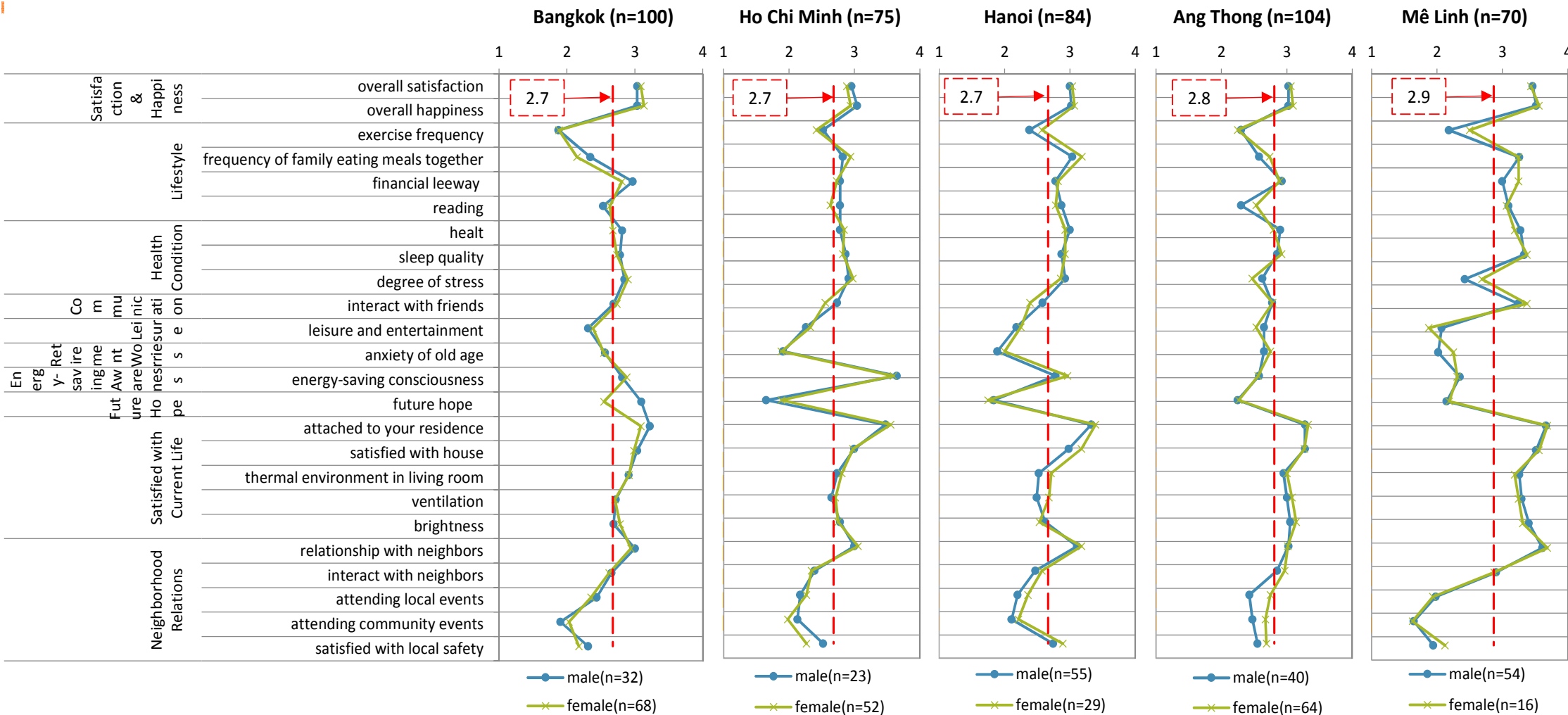
## Explanatory of potential variable from observer variables

Ho Chi Minh's case	Satisfied with Indoor Environment	Neighborhood & Events	Satisfaction & Happiness	Friends & Leisure	Health Condition	attach importance to family	hope & awareness	Cronbach's $\alpha$
satisfied with ventilation	0.904	0.068	-0.034	0.098	-0.145	0.061	-0.019	0.825
thermal environment in living room	0.835	-0.012	-0.097	-0.026	0.047	0.040	-0.091	
satisfied with house	0.712	-0.185	0.162	-0.065	-0.028	0.103	-0.019	
satisfied with brightness	0.586	0.117	0.089	-0.005	0.046	0.158	0.053	
interact with neighbors	0.079	0.796	0.006	-0.039	0.089	-0.117	-0.015	0.843
attending community events	-0.080	0.794	-0.049	0.093	-0.057	0.344	0.101	
interact with neighbors	0.084	0.787	0.061	-0.222	0.077	-0.211	-0.017	
relationship with neighbors	-0.068	0.741	0.000	0.115	-0.130	0.052	-0.071	
degree of satisfaction	0.084	0.087	0.898	-0.062	-0.020	-0.129	0.060	0.780
degree of happiness	0.131	-0.039	0.892	0.043	0.011	-0.004	0.000	
economic affordability	-0.156	-0.027	0.390	0.164	0.043	0.030	0.019	0.736
leisure and entertainment	0.152	-0.066	0.067	0.879	0.003	0.060	-0.082	
interact with friends	-0.104	0.007	0.018	0.736	0.097	-0.196	0.043	
frequency of using public facilities	-0.158	0.266	0.114	0.373	-0.006	0.158	-0.090	0.779
health condition	-0.051	-0.034	0.010	0.048	0.934	0.101	0.105	
sleep quality	-0.040	-0.003	0.028	0.047	0.695	0.048	-0.123	
frequency of having meal with family	0.173	0.243	-0.078	-0.025	0.002	0.674	0.064	0.511
frequency of reading	0.233	-0.102	-0.078	-0.012	0.242	0.638	0.045	
anxiety after retirement	0.217	0.194	-0.109	0.112	0.182	-0.561	0.005	
awareness on energy saving	-0.161	0.003	0.118	-0.167	0.065	0.194	0.748	0.627
future hope	0.129	-0.049	-0.092	0.176	-0.104	-0.182	0.741	

# Results & Discussions



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- Each category is evaluated based on the consumers' current situation by 4 point scales (very unsatisfied, unsatisfied, satisfied, and very satisfied) from very unsatisfied (1 point) to very satisfied (4 point). We evaluated the indicators by gender, age, occupation, education level, household size, household income, housing type and floor area.
- The overall satisfaction degree on daily lives shows that suburban areas are relatively higher than urban areas. In general, residents' comfort get higher under the situation that the level of public facilities about infrastructure and basic life component are high. However, urban lives with high population density, there is a possibility that the residents' comfort get lower due to the increase of residences' stress.

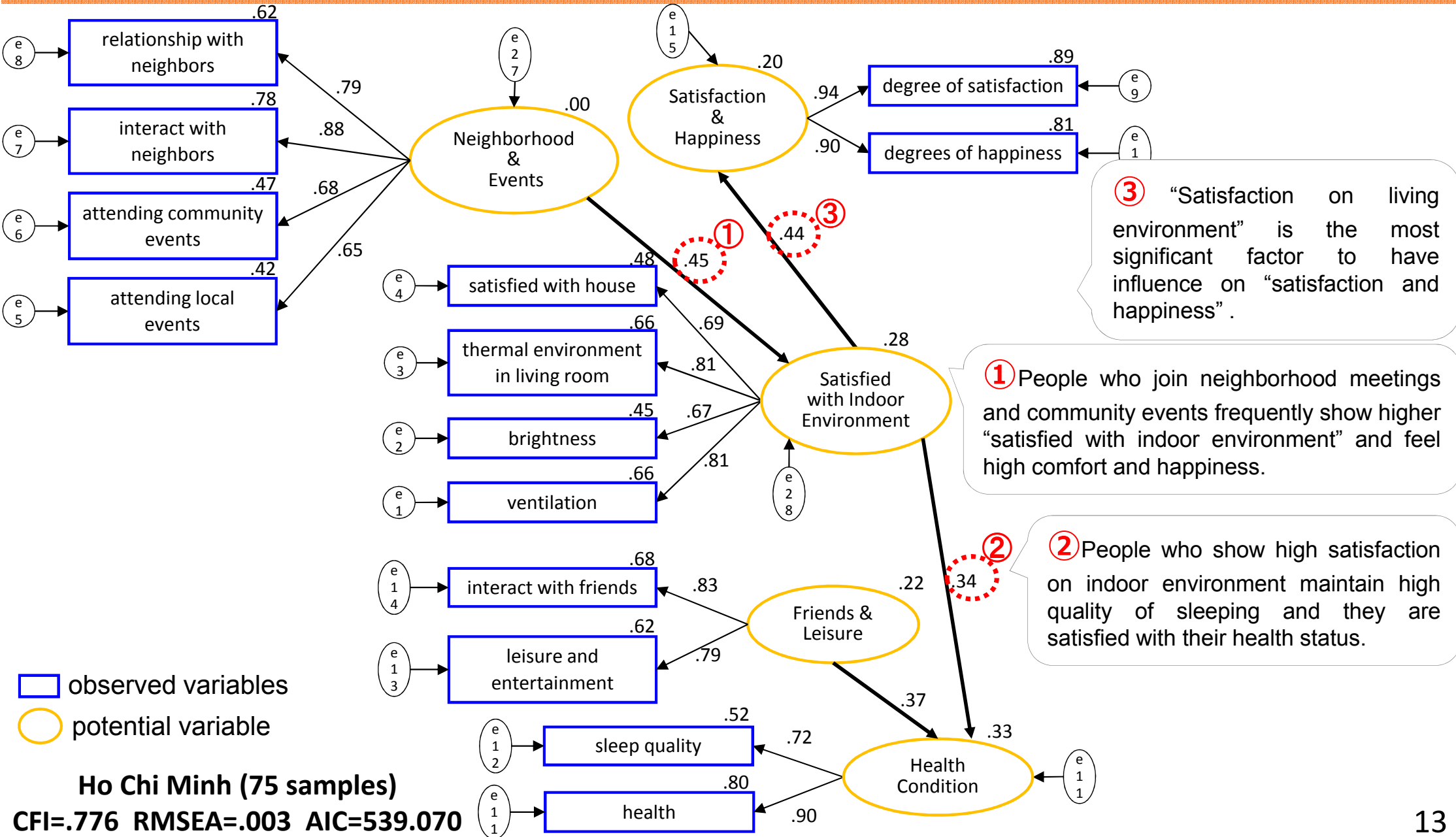


# Results & Discussions

## (1) Correlation among QOL indicators



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# Results & Discussions

## (2) Correlation between basic attribution and energy consumption



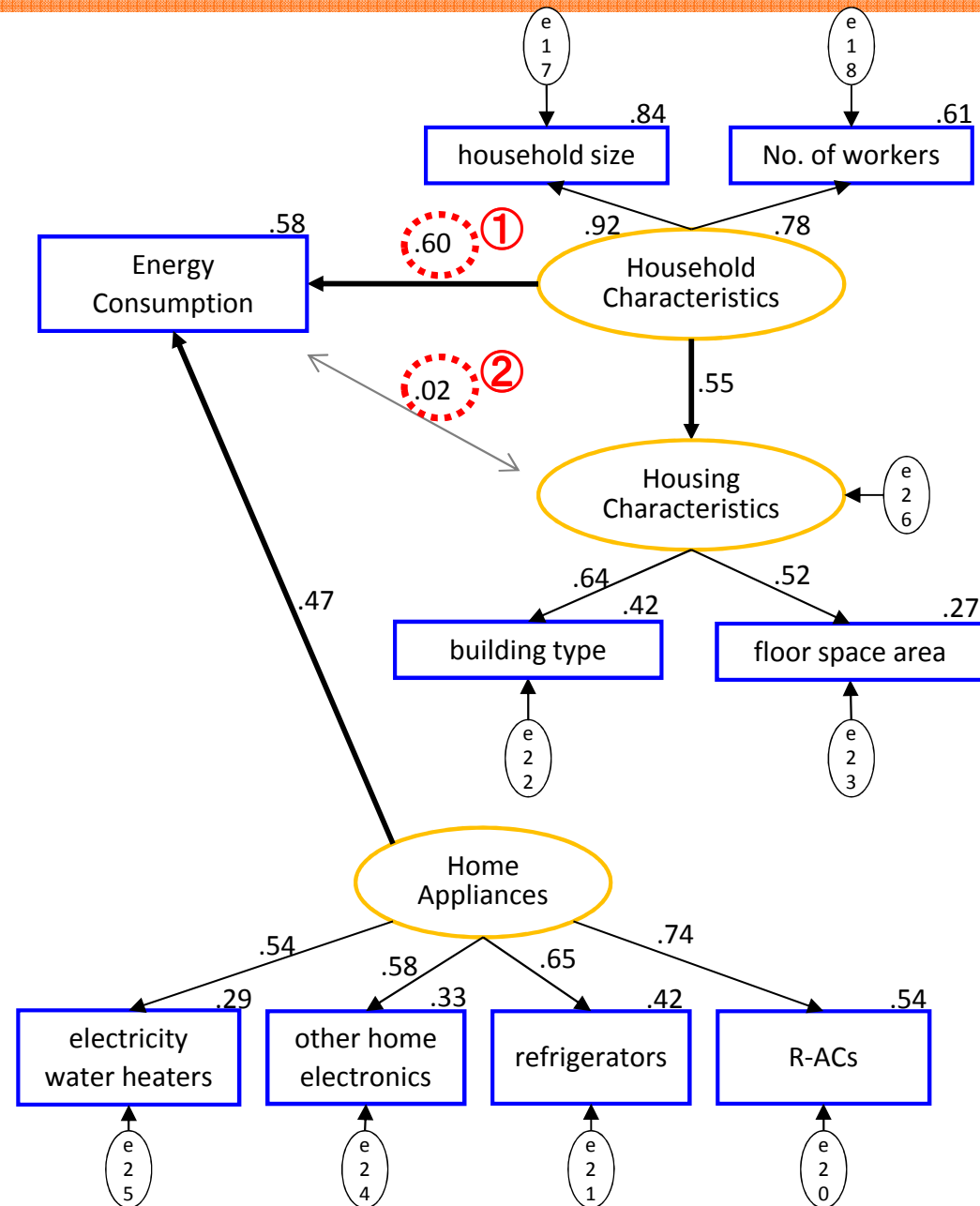
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① The most important factor on energy consumption is “household attribution.

② Correlation between housing characteristics and energy consumption is not obvious.

□ observed variables  
○ potential variable

Ho Chi Minh (75 samples)  
CFI=.776 RMSEA=.003 AIC=539.070

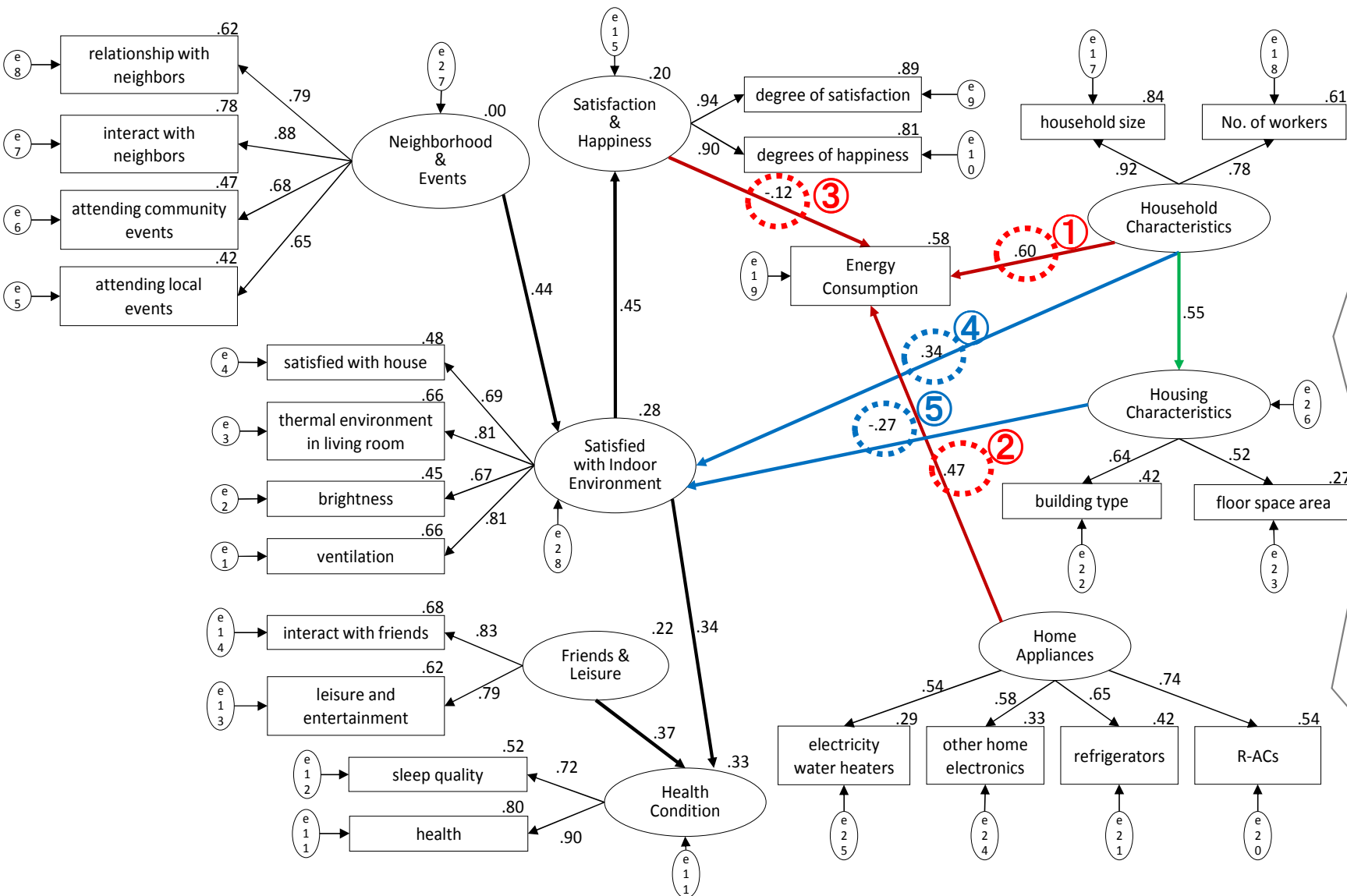


# Results & Discussions

## (3) Correlation between QOL & basic attribution & energy consumption



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①② “Household attribution” & “home appliance diffusion ratio” have influence on “energy consumption” .

③ QOL indicators and energy consumption are not obvious.

④⑤ In Ho Chi Minh, people living in apartment with higher income tend to show higher satisfaction on living environment, and show higher overall satisfaction and happiness.

Ho Chi Minh

CFI=.776 RMSEA=.003 AIC=539.070

# Conclusions



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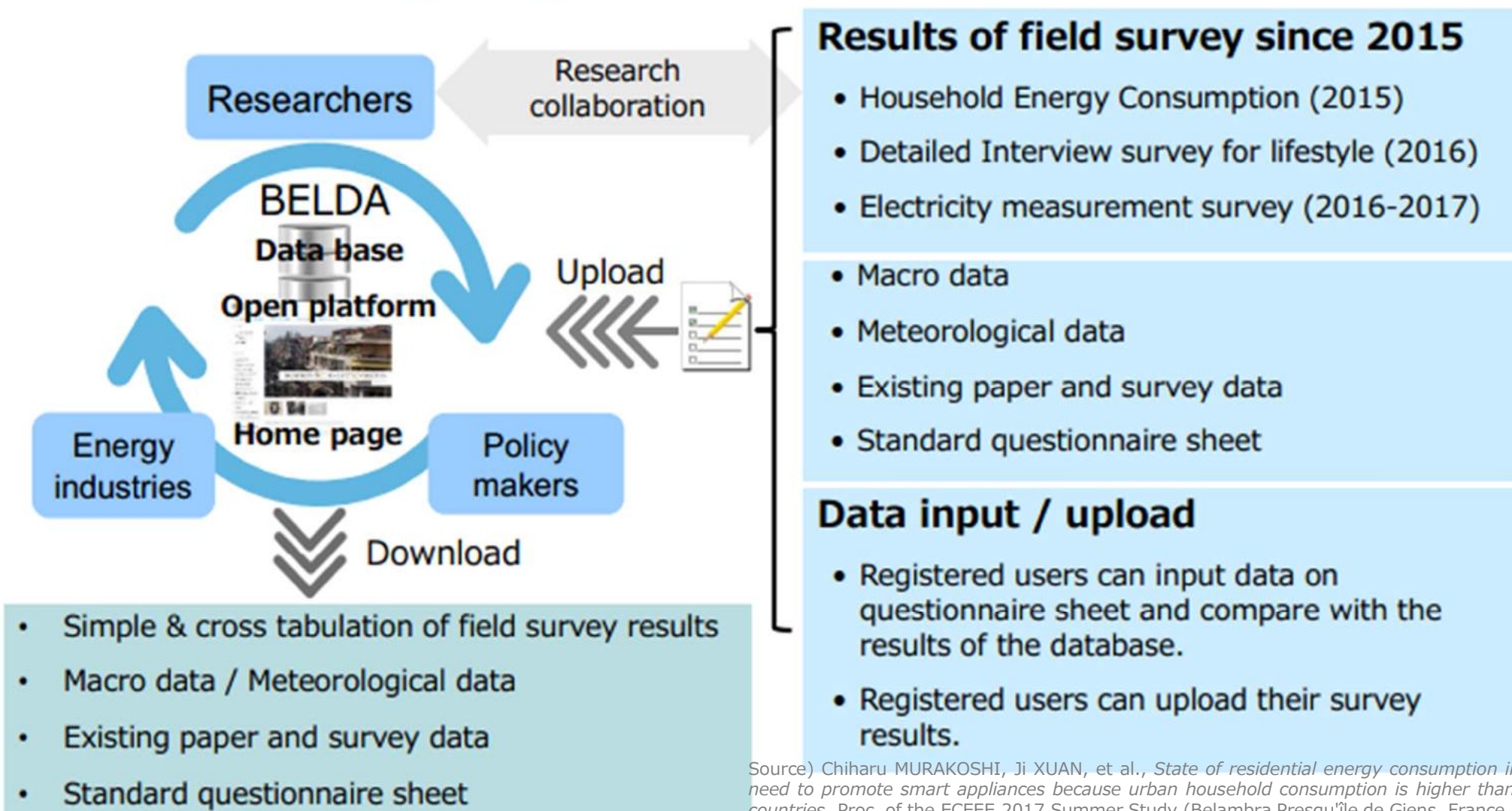
- In order to achieve and maintain a continuous energy efficiency improvement without affecting residents' comfort, satisfied and happiness levels is very essential.
- Taking the above into consideration, this survey aims to seek for the factors that influenced on residents' QOL in order to propose policies and measures on electricity conservation. To explore correlation between the three parties, such as QOL indicators, basic attribution as well as energy consumption, this research examined scenarios that influenced each other through structure equation modeling.
- “Satisfaction & happiness” shows significant relationship with “satisfaction on living environment”, and “housing characteristics” has influence on “satisfaction & happiness” relatively, but QOL indicators have no influence on “energy consumption”.
- For example, people living in big and new detached houses with many rooms show higher satisfaction on living environment in both two regions of Thailand, and they tend to show higher overall satisfaction and happiness.  
In Ho Chi Minh, people living in apartment tend to show higher satisfaction on living environment, and show higher overall satisfaction and happiness.

# Goals of Project



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## BELDA: Building Energy structure and Lifestyle Database of Asia



Source) Chiharu MURAKOSHI, Ji XUAN, et al., *State of residential energy consumption in Southeast Asia: need to promote smart appliances because urban household consumption is higher than some developed countries*. Proc. of the ECEEE 2017 Summer Study (Belambra Presqu'île de Giens, France, 29-3 June 2017)

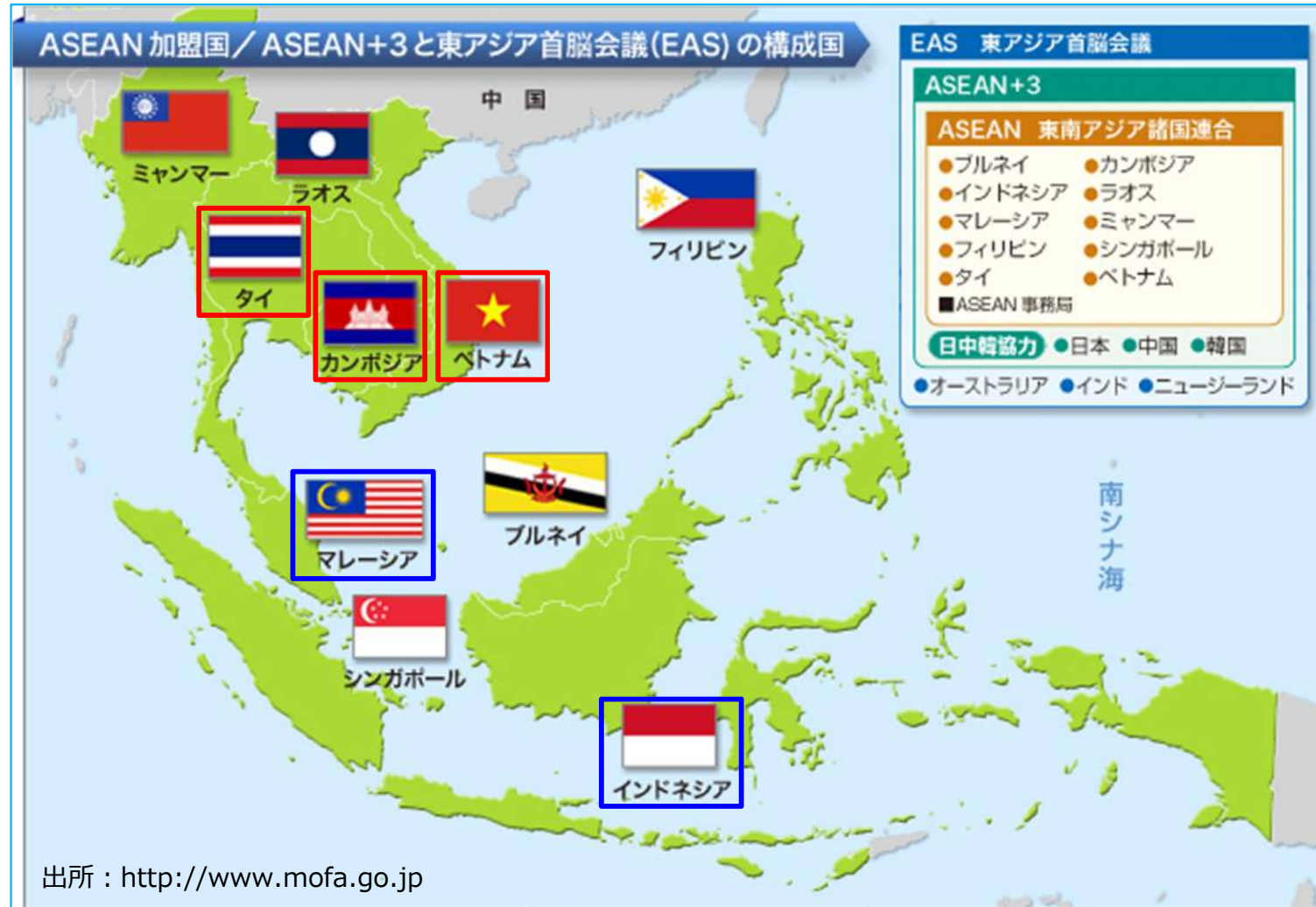
This research lays part of the groundwork, aiming to expand the research, to build a database platform, and deepen collaboration with local experts. Ultimately, by investigating measures that are appropriate for each country's actual conditions, it aims to make an effective international contribution.



# Database Expansion



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**5 countries : ca. 2,800 hhs**

# BELDA Home Page

## (Building Energy structure and Lifestyle Database of Asia)



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Building Energy structure and Lifestyle Database of Asia

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LANGUAGE

English (United States)  
 日本語

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- 「アジアの民生用エネルギー需要構造と将来予測に関するプラットフォーム構築」シンポジウム開催のご案内 12/15/2016
- ハノイ建築大学の先生方と打ち合わせ(事業系) 12/14/2016
- 2015年度 調査結果 12/13/2016
- Checking the situation of Measurement Survey at the targeted house 12/12/2016
- ベトナムエネルギー研究所との打ち合わせ 12/12/2016
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by belda  
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- Meeting with the staffs of Hanoi University of Architecture for commercial buildings 12/14/2016
- Result of the survey on Residential Energy in 2015 12/13/2016
- Meeting with Institute of Energy in Hanoi 12/12/2016
- We have started to BELDA platform finally! 12/08/2016



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This week, we discussed about the interview survey and measurement survey. Our staffs confirmed the problems each by each. Now we have started the...

English Ver.

# International Symposium



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## Symposium

- Symposium for “Development of the Platform on Energy Demand Structure and Forecasts in Asian Residential and Commercial Sector”
- 1<sup>st</sup> Symposium : 26<sup>th</sup> Jan. 2016, 2<sup>nd</sup> Symposium : 23<sup>rd</sup> Jan. 2017, 3<sup>rd</sup> Symposium : 24<sup>th</sup> Jan. 2018
- Venue : Waseda University, Nishiwaseda Campus, Tokyo
- Registration Fee : free
- Attendees : Chulalongkorn University, Thammasat University, Thailand  
Hanoi Architectural University, Vietnam  
Institute of Technology of Cambodia (ITC), Cambodia  
Tohoku University, National Institute for Environmental Studies  
Yokohama University, Yamaguchi University, The University of Kitakyushu, Tokyo University





Thank you for your attention