The relationship between environmental load generation and demographic change

AIM International Workshop 2009 @NIES

National Institute for Environmental Studies
Researcher
Yuko KANAMORI

0. Introduction –Modeling a lifestyle-

☐ **What is a key factor which have a influence on consumption behavior?**

- **Economic situation**
  - ☐ How much money do you use for amusement?
- **Household composition/Age/Household size**
  - ☐ Single-person household or Other household
  - ☐ With children or not
  - ☐ With aged person or not
  - ☐ Young couple or elderly couple
- **Preference**
  - ☐ International travel or reading at home
- **Policy**
- **Technological change**

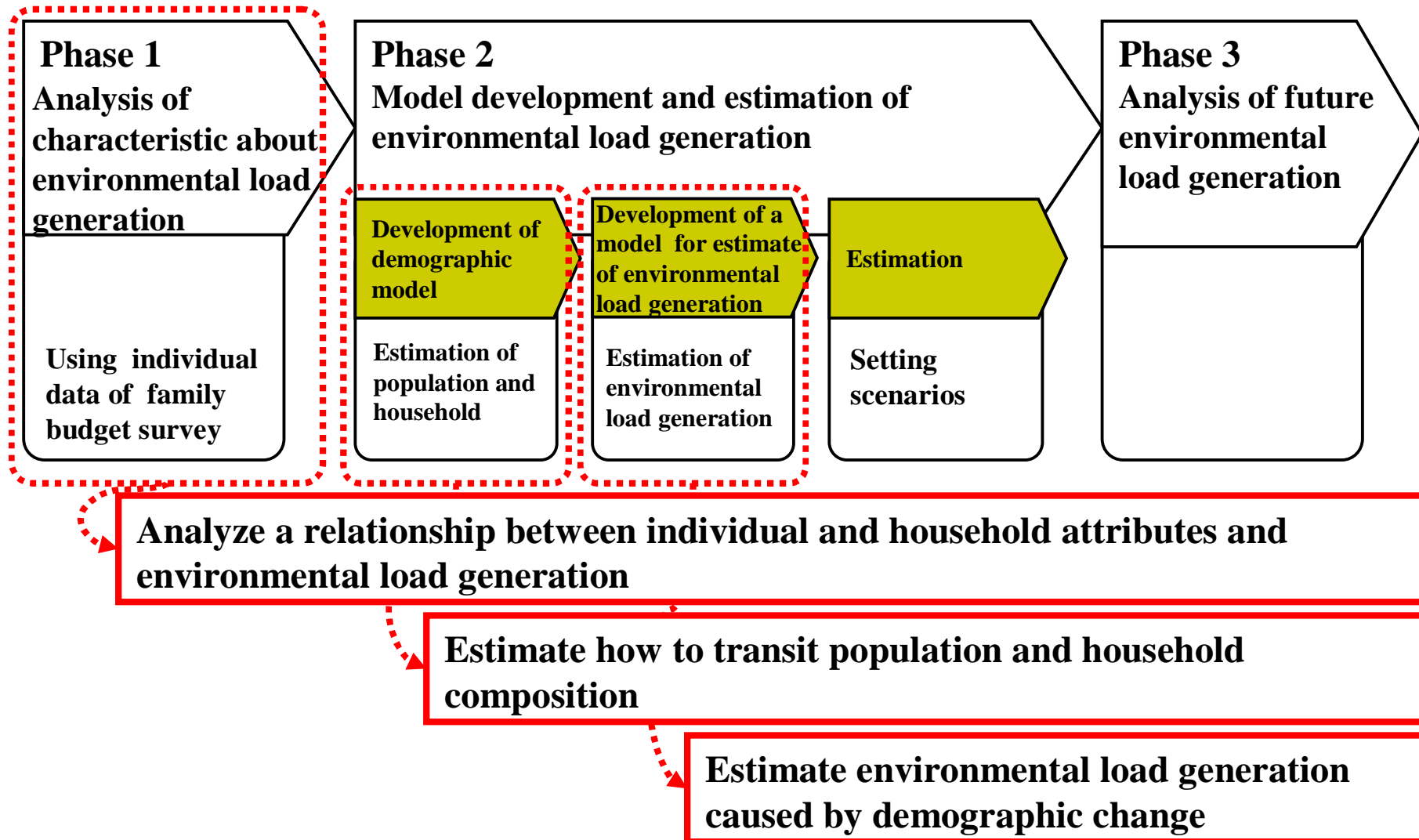# 1.   Objective

□ **To analyze a relationship between individual and household attributes and environmental load generation.**

□ **To estimate an impact on environmental load generation caused by demographic change (household composition change & population composition change).**

2. Framework

Phase 1
Analysis of characteristic about environmental load generation

Using individual data of family budget survey

Phase 2
Model development and estimation of environmental load generation

Development of demographic model

Estimation of population and household

Development of a model for estimate of environmental load generation

Estimation of environmental load generation

Estimation

Setting scenarios

Phase 3
Analysis of future environmental load generation

Analyze a relationship between individual and household attributes and environmental load generation

Estimate how to transit population and household composition

Estimate environmental load generation caused by demographic change

3.   Outline of this study (1)

■ **Country: Japan**   ■ **Period: 1985-2050**

■ **Environmental load**

Household garbage	Paper
	Plustic
	Textiles
	Glass/pottery
	Metal
	Wood/Plants
	Kitchen garbage
	Other
Energy consumption	Electricity
	City gas
	LPG
	Kerosene
	Gasoline
	Light oil
Household effluent	
CO_2 emission	

4. Outline of this study (2)

☐ **Data**
- **Individual data of family budget survey**
  - Period: 1985 – 2004 (20years)   monthly data
- **Others**
  - Annual report on the family income and expenditure survey
  - National survey of family income and expenditure
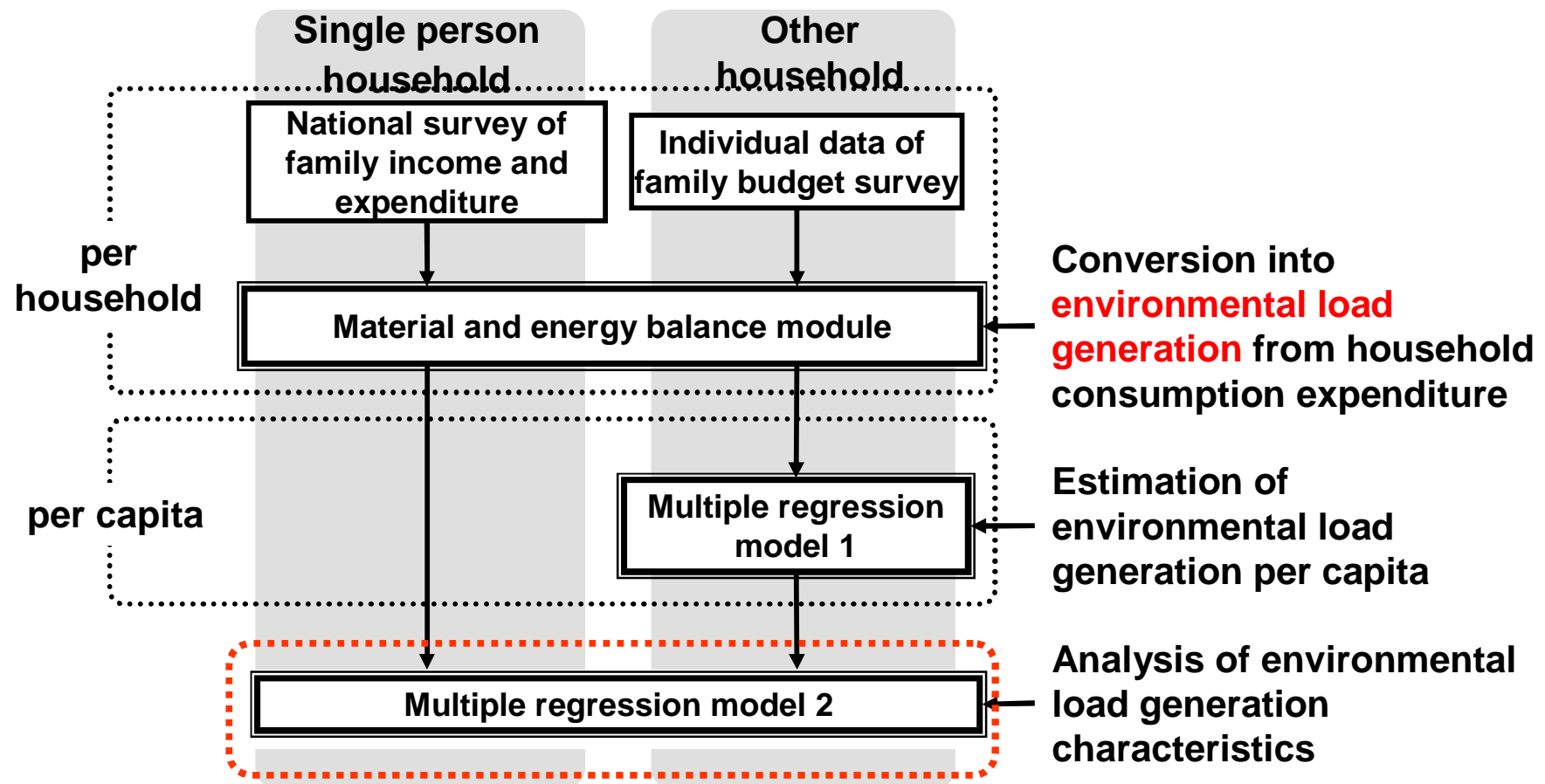   - ☐ and so on…

☐ **Definition of terms**
- **Individual attributes** are feature which characterize individual

  Ex)<u>Year of birth</u>, <u>Age</u>, and <u>Sex</u>
- **Household attributes** are feature which characterize household

  Ex)<u>Household size</u>, <u>household type</u>, and <u>household income</u>

5. Analysis of characteristic about environmental load generation (1)

☐ **Analyze characteristic about environmental load generation using multiple regression model**

Individual attribute

$$\ln\left(KAo^n_{t,s,jjo,HH,ICMo,NM}\right) = Kbo^n_s \cdot Dbo^n_s + Kco^n_{jjo} \cdot Dco^n_{jjo}$$

Environmental load generation per person

Sex — Dummy variable

Age — Dummy variable

$$+ Kdo^n_{HH} \cdot Ddo^n_{HH} + Keo^n_{ICMo} \cdot Deo^n_{ICMo} + Kfo^n_{NM} \cdot Dfo^n_{NM} + Co$$

Household type — Dummy variable

Household income — Dummy variable

Household size — Dummy variable — Constant term

Household attribute

□ **Result(1)** Ex) **Electricity consumption**

■ **Individual attribute**
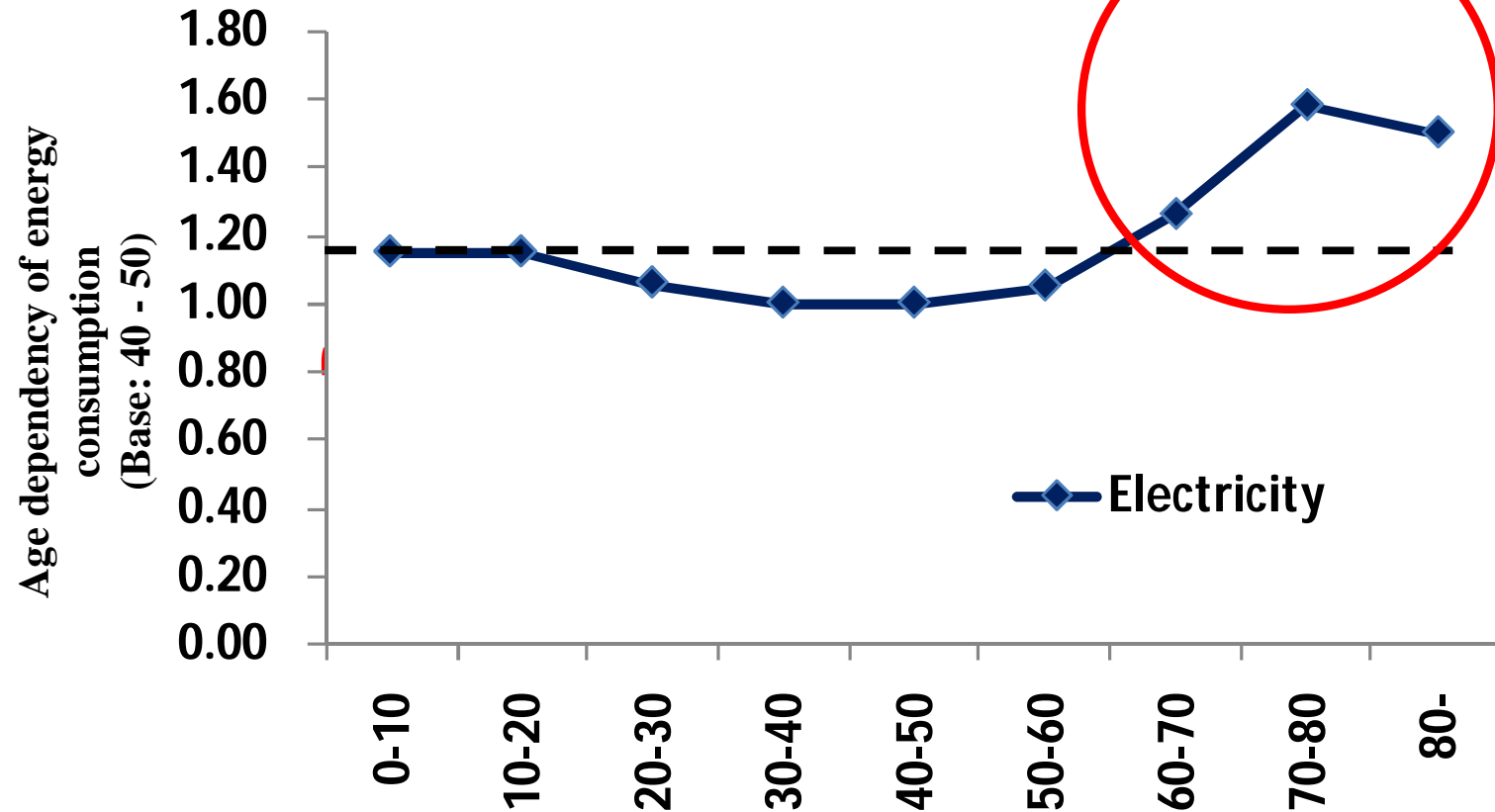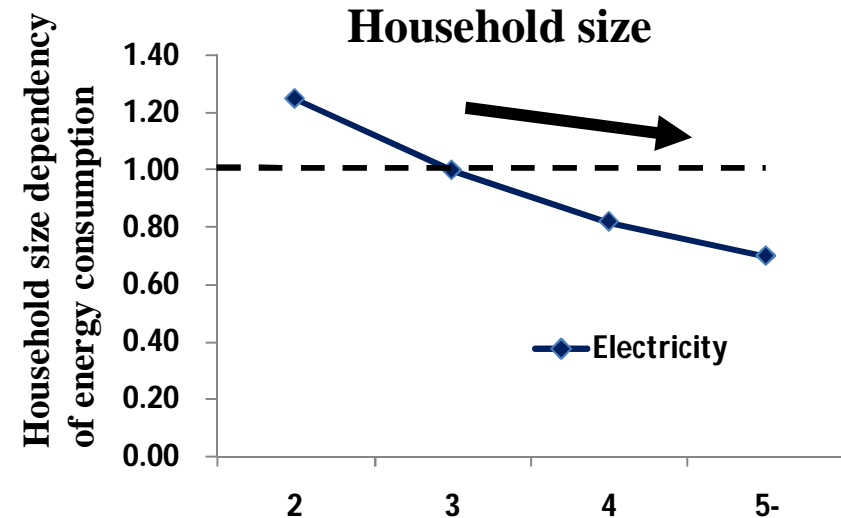

Old generations tend to consume **much** electricity

☐ **Result(2) Ex) Electricity consumption**

■ **Household attribute**
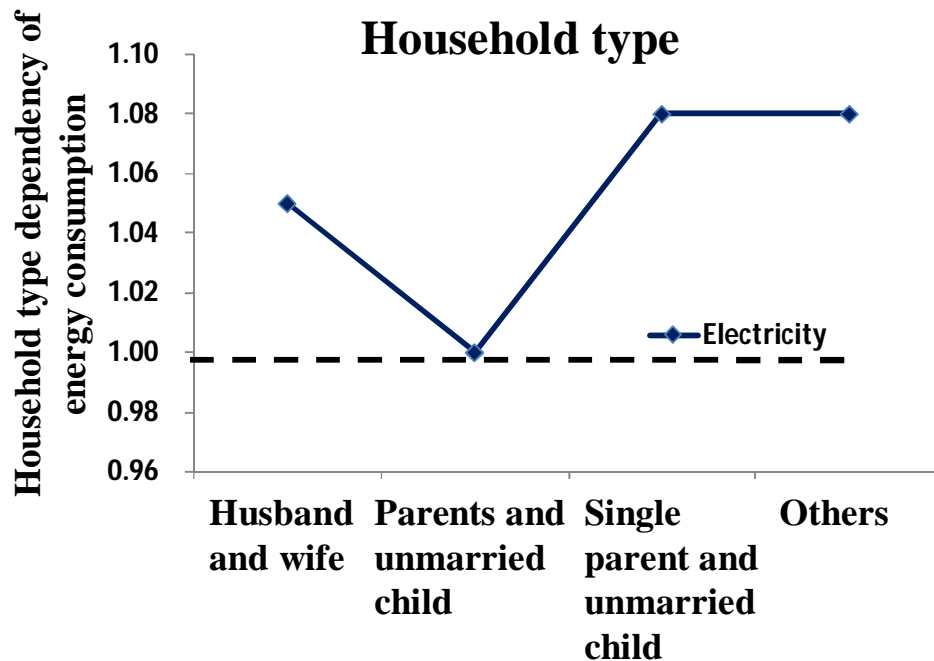
Household with parents and unmarried child tend to consume less electricity
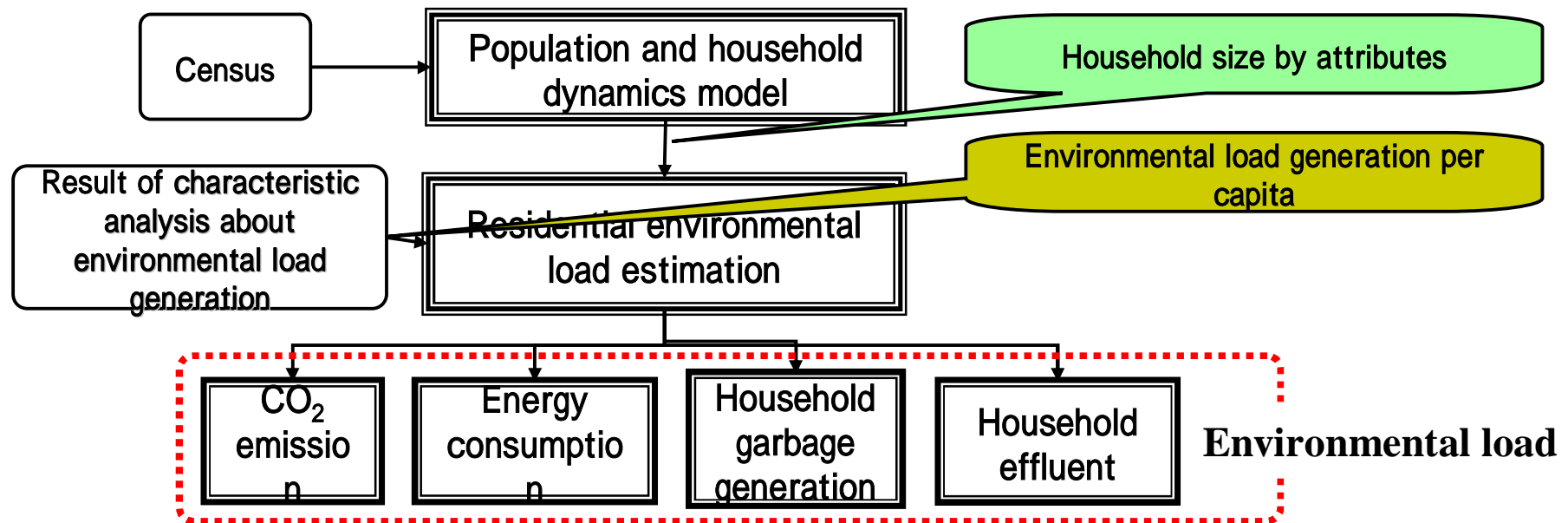
Larger the household size is, Less the electricity consume

9. Model development

☐ Outline

- **Population and household dynamics model**
- **Residential environmental load estimation**

☐ Estimation flow

```
Census  →  Population and household        Household size by attributes
            dynamics model

Result of characteristic              Environmental load generation per
analysis about      Residential environmental         capita
environmental load        load estimation
generation
```

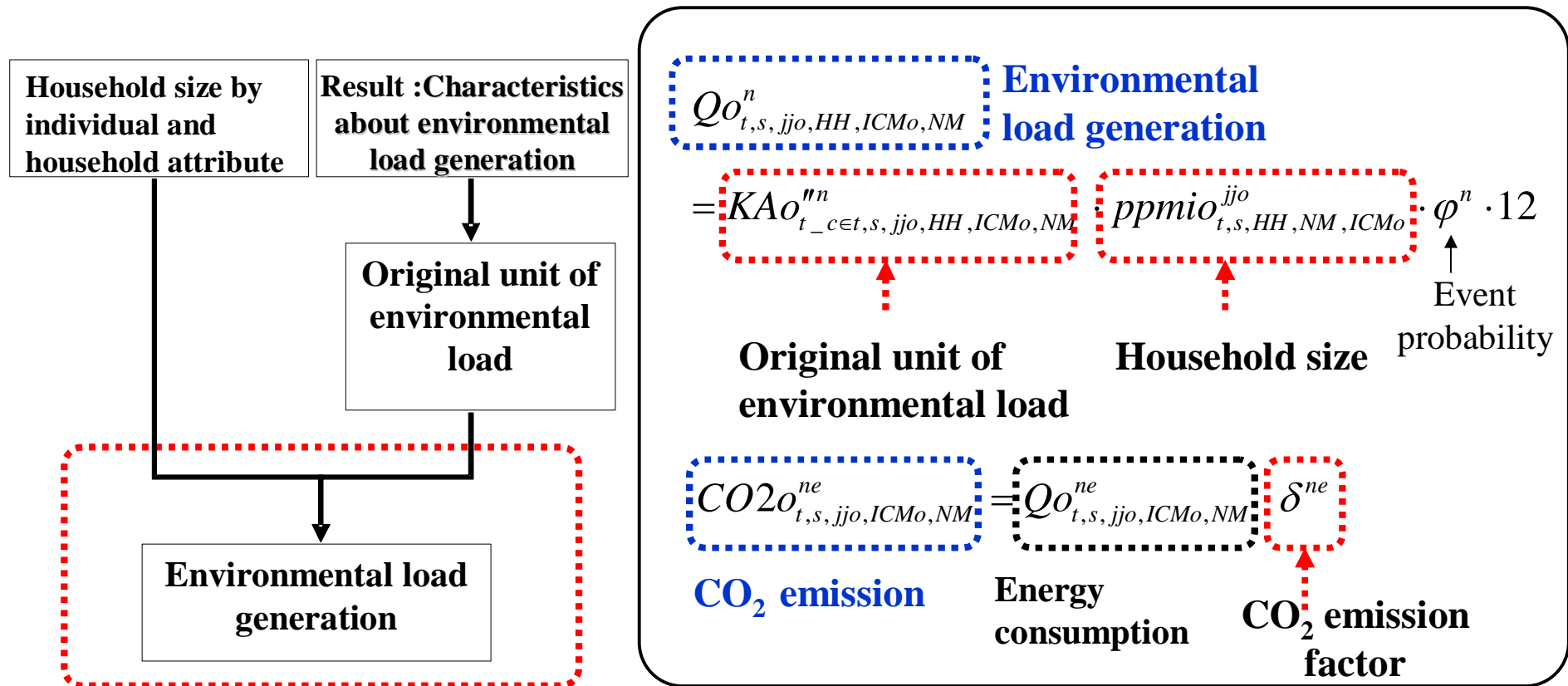| CO_2 emission | Energy consumption | Household garbage generation | Household effluent | **Environmental load** |

10. Population and household dynamics model

- **Input: Base year population and 5 parameters**
  - Rate of married
  - Rate of first marriage
  - TFR
  - Mortality rate
  - Immigration rate

- **Output: Population by age and household type**

- **Method: Model is based on Japan's official estimation method by National institute of population and security research**

11. Residential environmental load estimation

■**Bottom-up type**

■**To estimate energy consumption, household garbage, Household effluent, CO_2 emission**

Household size by individual and household attribute	Result :Characteristics about environmental load generation

Original unit of environmental load

Environmental load generation

$$Qo_{t,s,jjo,HH,ICMo,NM}^{n}$$ **Environmental load generation**

$$= KAo_{t\_c\in t,s,jjo,HH,ICMo,NM}^{\prime\prime n} \cdot ppmio_{t,s,HH,NM,ICMo}^{jjo} \cdot \varphi^{n} \cdot 12$$

Original unit of environmental load   **Household size**   Event probability

$$CO2o_{t,s,jjo,ICMo,NM}^{ne} = Qo_{t,s,jjo,ICMo,NM}^{ne} \cdot \delta^{ne}$$

CO_2 emission   **Energy consumption**   **CO_2 emission factor**

12. Model verification (1)

☐ Population and household dynamics model

■ Population

| year | Population (10^4 people) | | error |
	Reported value	Estimated value	(%)
1985	121101	12097	-0.03
1990	12328	12383	0.44
1995	12544	12571	0.21
2000	12670	12670	0.00

■ Household

| year | Household (10^4 household) | | error |
	Reported value	Estimated value	(%)
1985	3791	3849	1.50
1990	4067	4129	1.51
1995	4390	4300	-2.09
2000	4659	4765	2.21

Population
Error is **less that 1%**

Household
Error is **about 2%**

| Housheold type | Household (2000) | | Error |
	Reported Value	Estimated value	(%)
Single-person	13257	12911	-2.60
Husband and wife	8837	8835	0.00
Parents and unmarried child	15171	14919	-1.66
Single parent and unmarried child	3657	3578	-2.17
Others	6724	6347	-5.60

13. Model verification(2)

□ **Residential environmental load estimation**

Environmental load		1985 R/E	2000 R/E
Energy consumption	Kitchen garbage	0.78	0.78
	Electricity	0.76	0.83
	City gas	0.77	0.62
	LPG	0.76	0.85
	Kerosene	0.69	0.92
	Gasoline	0.77	0.82
	Light oil	0.75	0.47
Housheold effluent		1.04	1.37
CO_2 emission		-	0.86

R: Reported value

E: Estimated value

Comparison reported value and estimated value is almost **0.75-1.00**

14. Demographic scenario(1)

	Scenario B	Scenario A	Scenario C
TFR by 2050	**1.54**	**1.26**	**1.06**
	Household composition change to **large family**	Household composition change keep the **current trend** (Small family)	Household composition change to **small family quickly** (Increase the tendency of smaller family)
Population (million person)	**122.3**	**94.0**	**87.3**
Household (million household)	**35.3**	**44.2**	**51.1**
Average household size	**2.90** person/household	**2.13** person/household	**1.71** person/household

15. Demographic scenario(2)

"Base scenario"

| Scenario B | Scenario A | Scenario C |

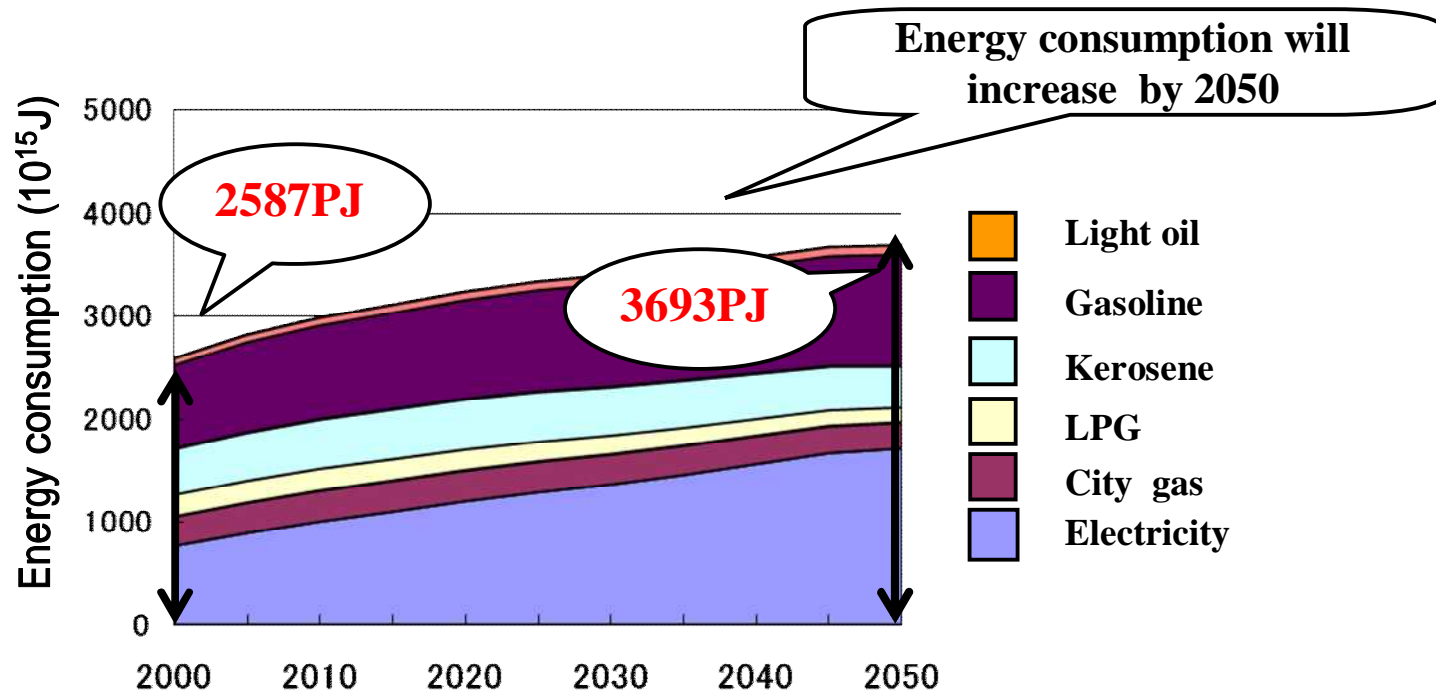## Ratio of household by household type
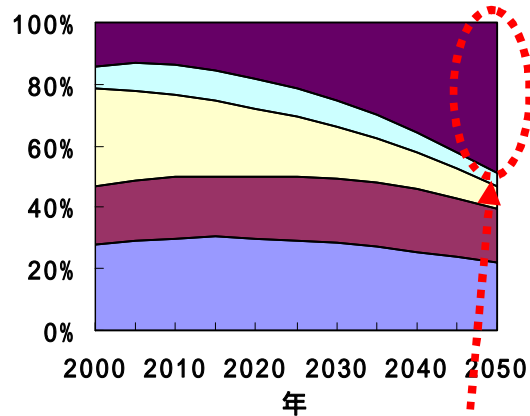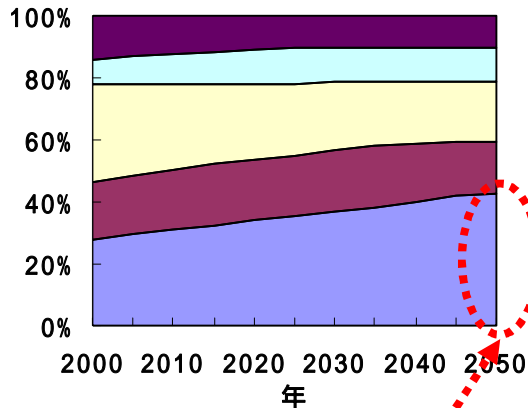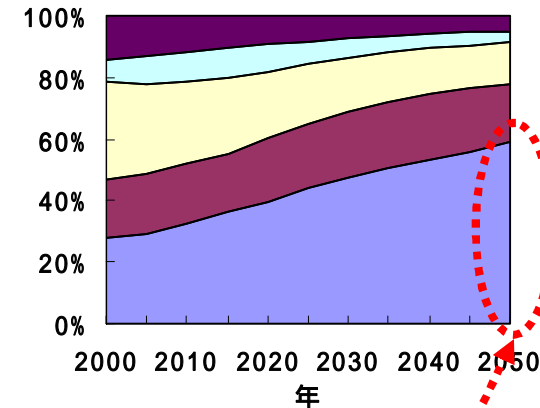
48.6% **42.6%** **59.0%**

Others

Household with husband and wife

Household with single parent and unmarried child

Single-person

Household with parents and unmarried child

□ **Energy consumption (Scenario A)**

Energy consumption will
increase by 2050

2587PJ

3693PJ

Light oil

Gasoline

Kerosene

LPG

City gas

Electricity

Energy consumption (10^{15}J)

Energy consumption will be increasing, and reach to **3693PJ** in 2050.
Especially, **electricity consumption** will be increasing drastically, and reach
to1716PJ in 2050 (2.2 times compared to 2000)
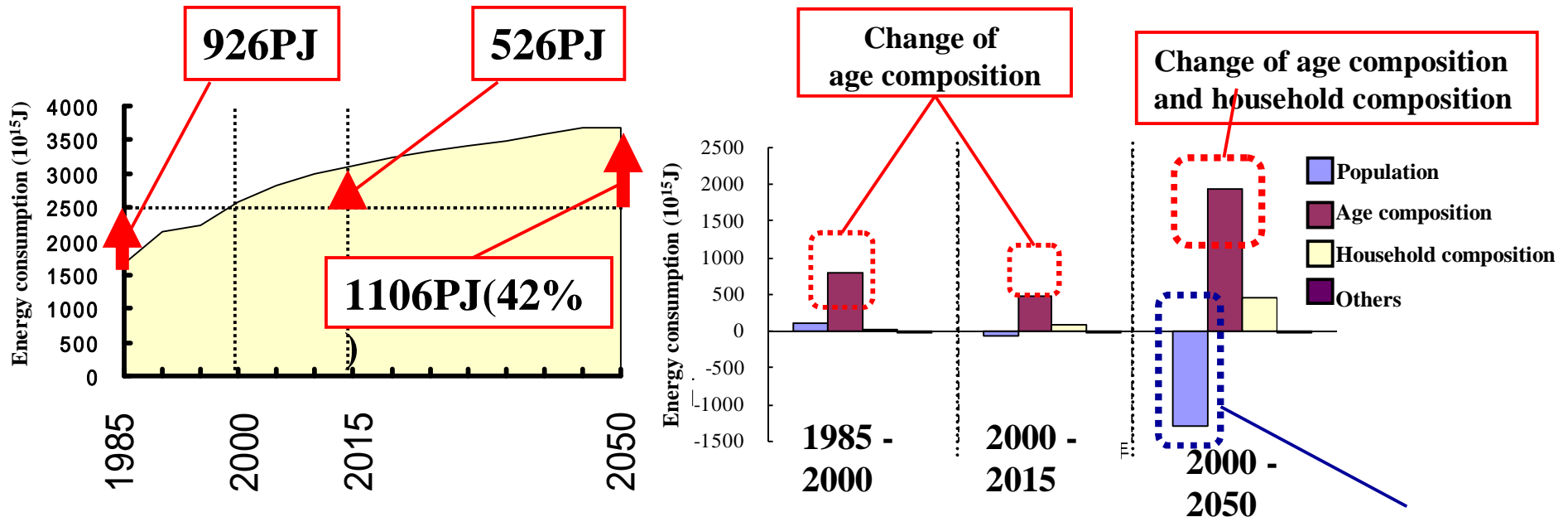
17. Result(2)

- ❑ **Factor analysis**
  - ■ **3 factors**
    - ❑ **Population**
    - ❑ **Age composition**
    - ❑ **Household composition**

$$\Delta Q^n_{t_2-t_1} = \Delta P^n_{t_2-t_1} + \Delta AG^n_{t_2-t_1} + \Delta H^n_{t_2-t_1} + OTH^n_{t_2-t_1}$$

Change of environmental load generation

By population change

By age composition

By household composition

By others

☐ **Ex) Energy consumption**

926PJ   526PJ   1106PJ(42%)

Change of age composition

Change of age composition and household composition

- Population
- Age composition
- Household composition
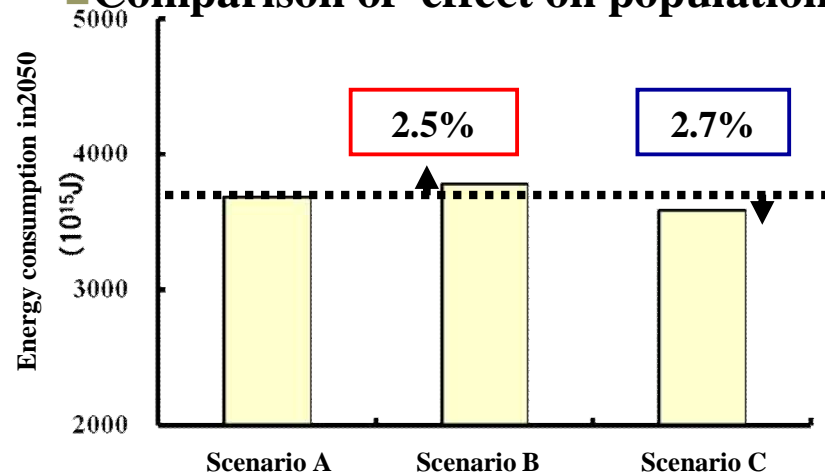- Others

1985 - 2000   2000 - 2015   2000 - 2050

➤1985 - 2000: **Change of age composition** have an effect on energy consumption **increase**

➤2000 - 2050: **Change of age composition and household composition**
energy consumption **increase**
**Population change** energy consumption **decrease**

Ex) Energy consumption

■ Comparison of effect on population change (Fix household transition)
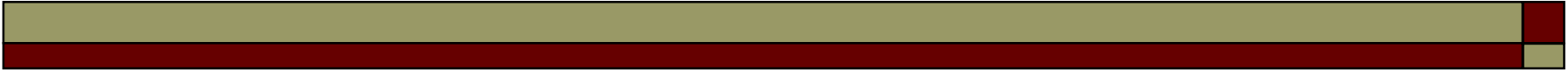

> In scenario B, energy consumption is **2.5%(92 10^{15}J) greater** than scenario A.
> In scenario C, energy consumption is **2.7 (99 10^{15}J) less** than scenario A.

■ Comparison of effect on household composition change(Fix population transition)
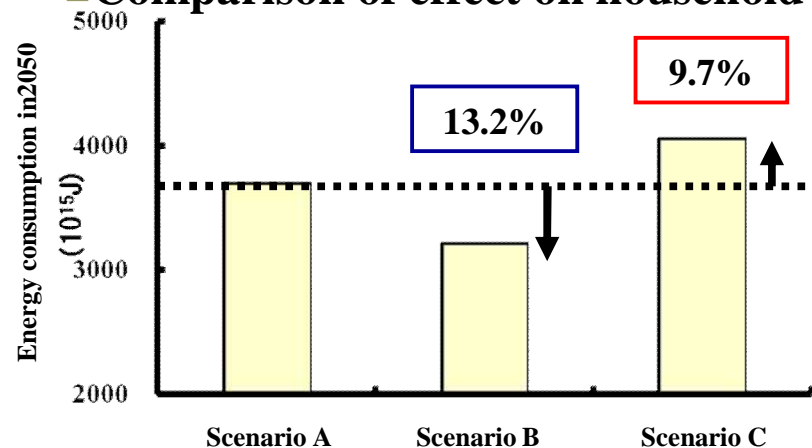
> In scenario B, energy consumption is **13.2%(486 10^{15}J) less** than scenario A.
> In scenario C, energy consumption is **9.7 (357 10^{15}J) greater** than scenario A.

Thank you for your attention!

10.

Phase

Phase

Phase

Phase

2000

15
2000

2000

CE cross entropy)

**Phase
Population**

**Phase
Household**