# Energy service supply-demand structure in residential sector

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# My research interest

- Why / what do people purchase goods and services?
- How long do people spend for working or recreation?

■How do and will people decide their budget and time allocation ?

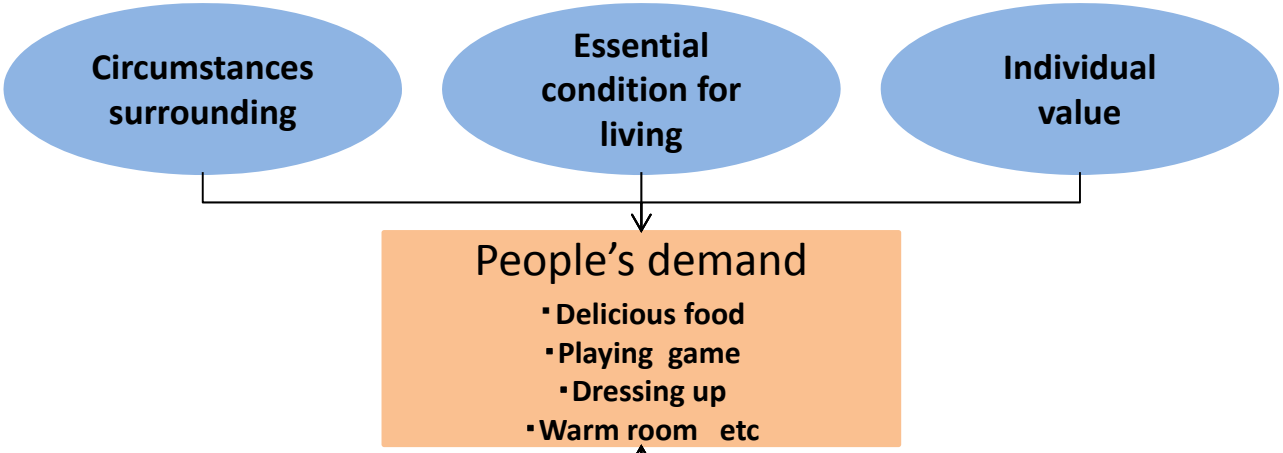
■ How will these lifestyle changes give impacts on the environment?

**- Develop model and tool and estimate relationship between lifestyle change and environmental load generation.**

# Today's presentation

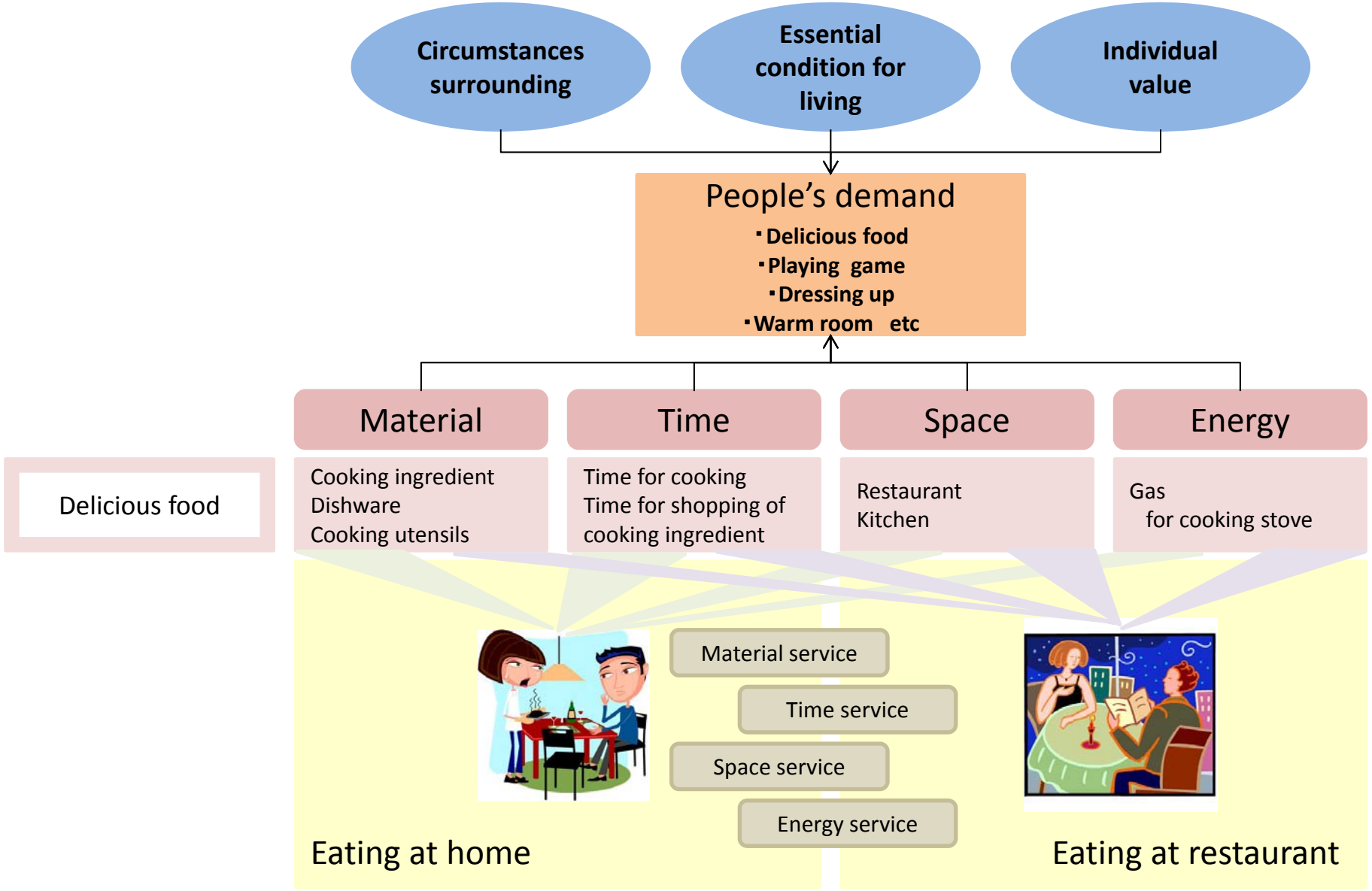
- 1. People's demand structure
  - Relationship between people's want and energy service demand
- 2. What is "Energy service"
  - Definition of energy service demand
- 3. Future energy service demand
- 4. Future works

# People's demand (1)

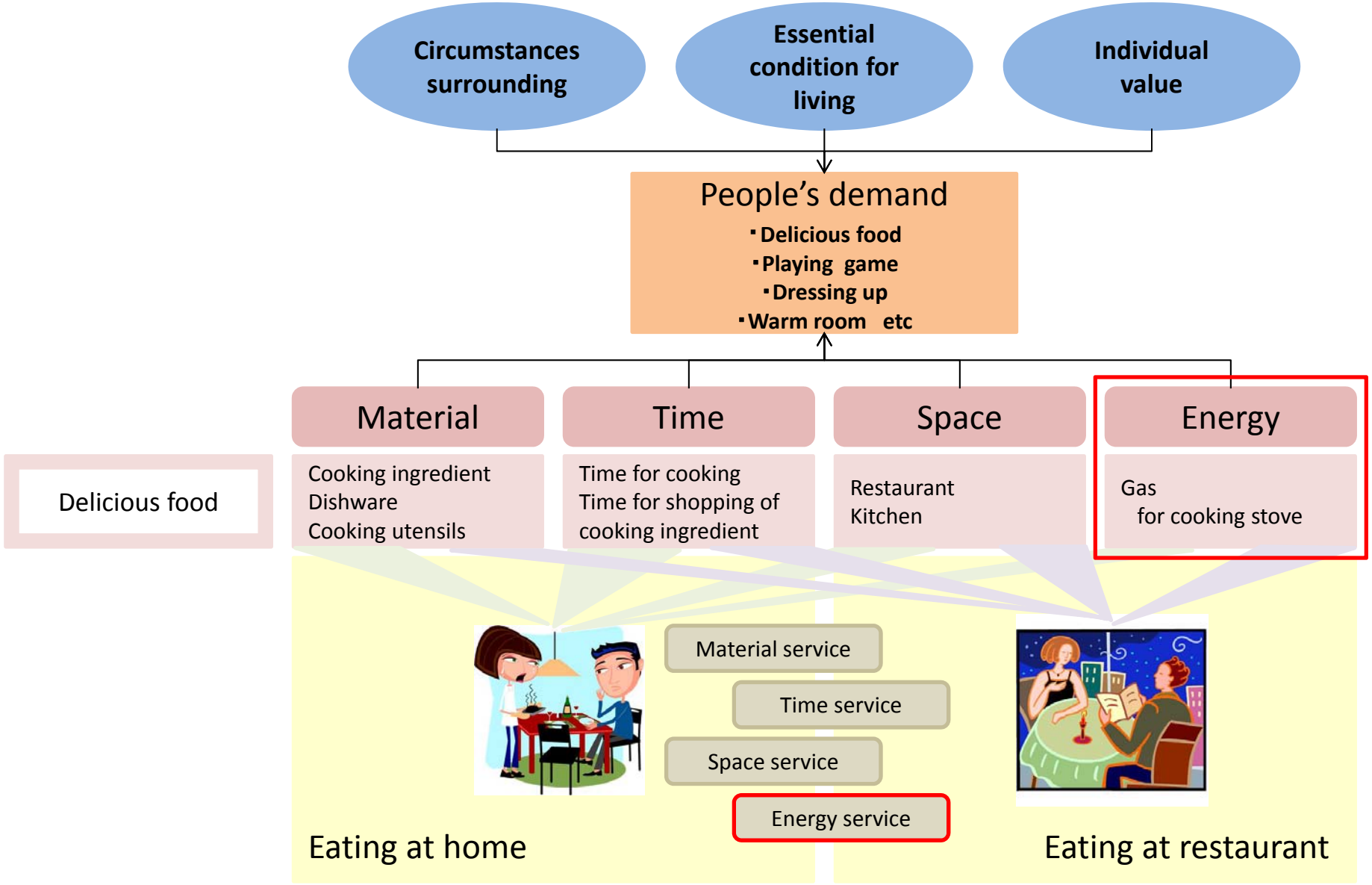



| | Material | Time | Space | Energy |
|---|---|---|---|---|
| Delicious food | Cooking ingredient<br>Dishware<br>Cooking utensils | Time for cooking<br>Time for shopping of cooking ingredient | Restaurant<br>Kitchen | Gas<br>for cooking stove |
| Warm room | Air conditioner Heater<br>Central heating<br>Clothes | Time for spending at home | Room<br>House | Electricity and kerosene<br>for room heating |
| Dressing up | Clothes<br>Shoes | Time for cleaning<br>Time for Shopping clothes | | Electricity<br>for washing machine |

# People's demand (1)



# People's demand (1)



# Definition of energy service (1)

- Goldemberg and Johanssonm(2004)
  - The objective of an energy system is to deliver to consumers the benefits that energy use offers. The term **energy service** is used to describe these benefits, which for households include illumination, cooked food, comfortable indoor temperatures, refrigeration, telecommunications, education, and transportation.
- Lovins et al (2011)
  - End-use covert delivered energy into **energy services** like light, heat, torque, or motion. These in turn give end users the functions and experiences they want, like visibility, comfort, hot showers, or cold beer. Note that these functions and sensations are what the end user really wants – not lumps of coal, cubic feet of gas, or raw kilowatt-hours.
- Haas et al (2008)
  - The basic premise of this analysis is that people do not demand energy per se but **energy services** like mobility, washing, heating cooking, cooling and lighting. These services are in general provided by combining different inputs of energy, technology, human and physical capital, and environment (including natural resources).

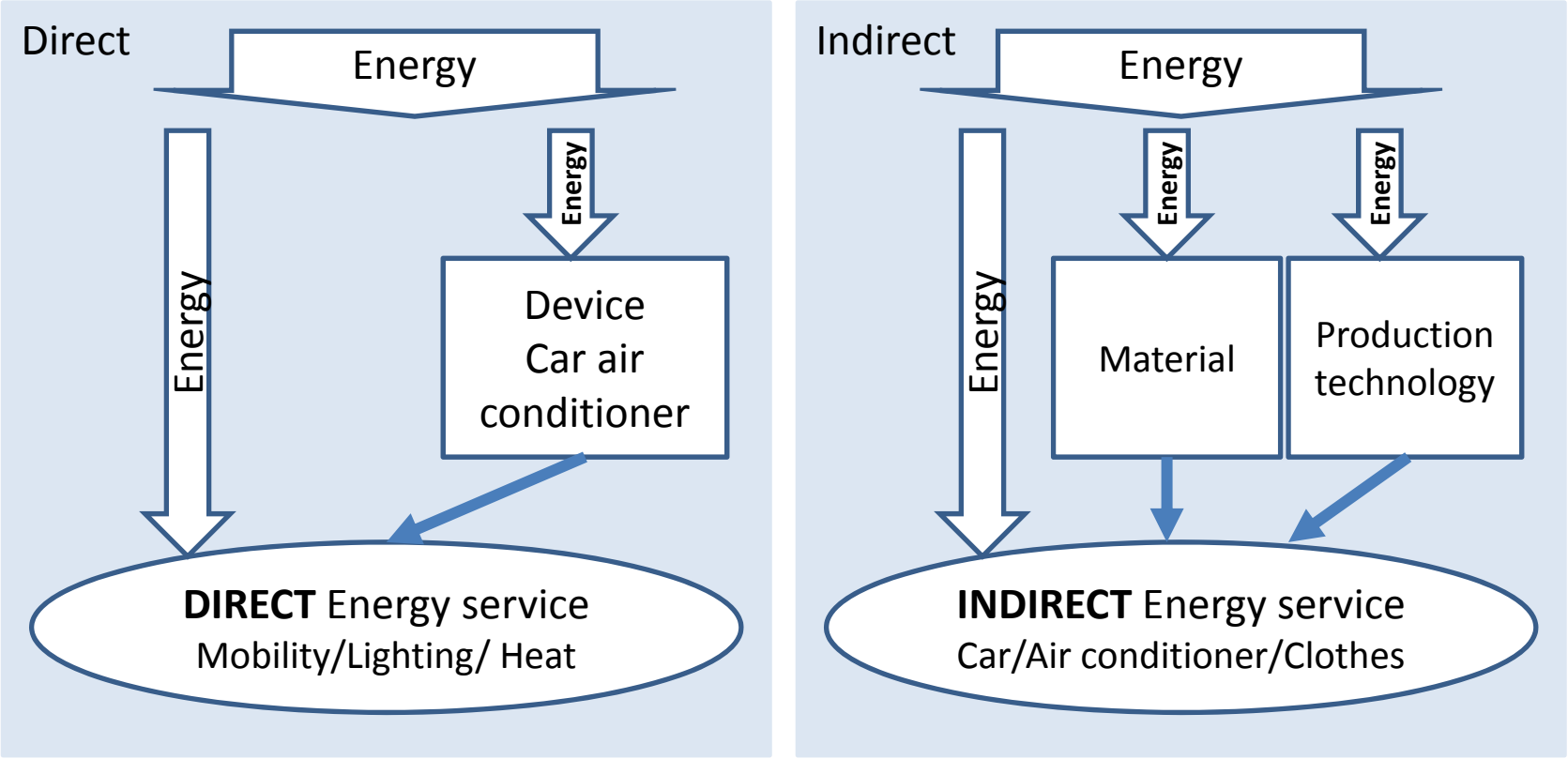
# Definition of energy service (2)

- In this study,

  "**Energy service** is defined as service which is mainly provided using energy device to satisfy people's demand related with comfortable and convenient life, such as lighting, heat, torque and motion."

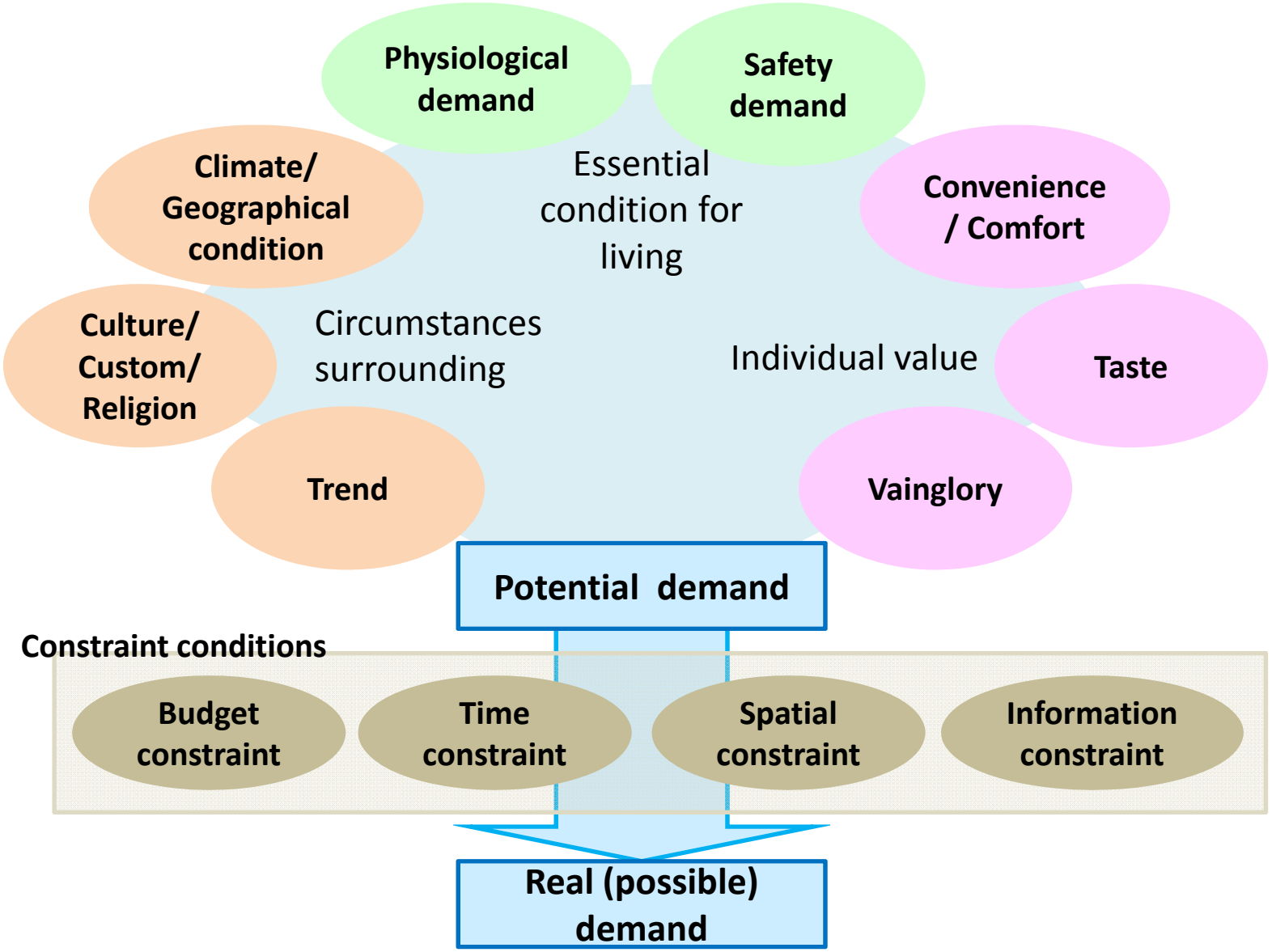
# Definition of energy service demand (1)

- Direct/Indirect Based on Haans et al (2008)




- Potential/Real

# Definition of energy service demand (2)



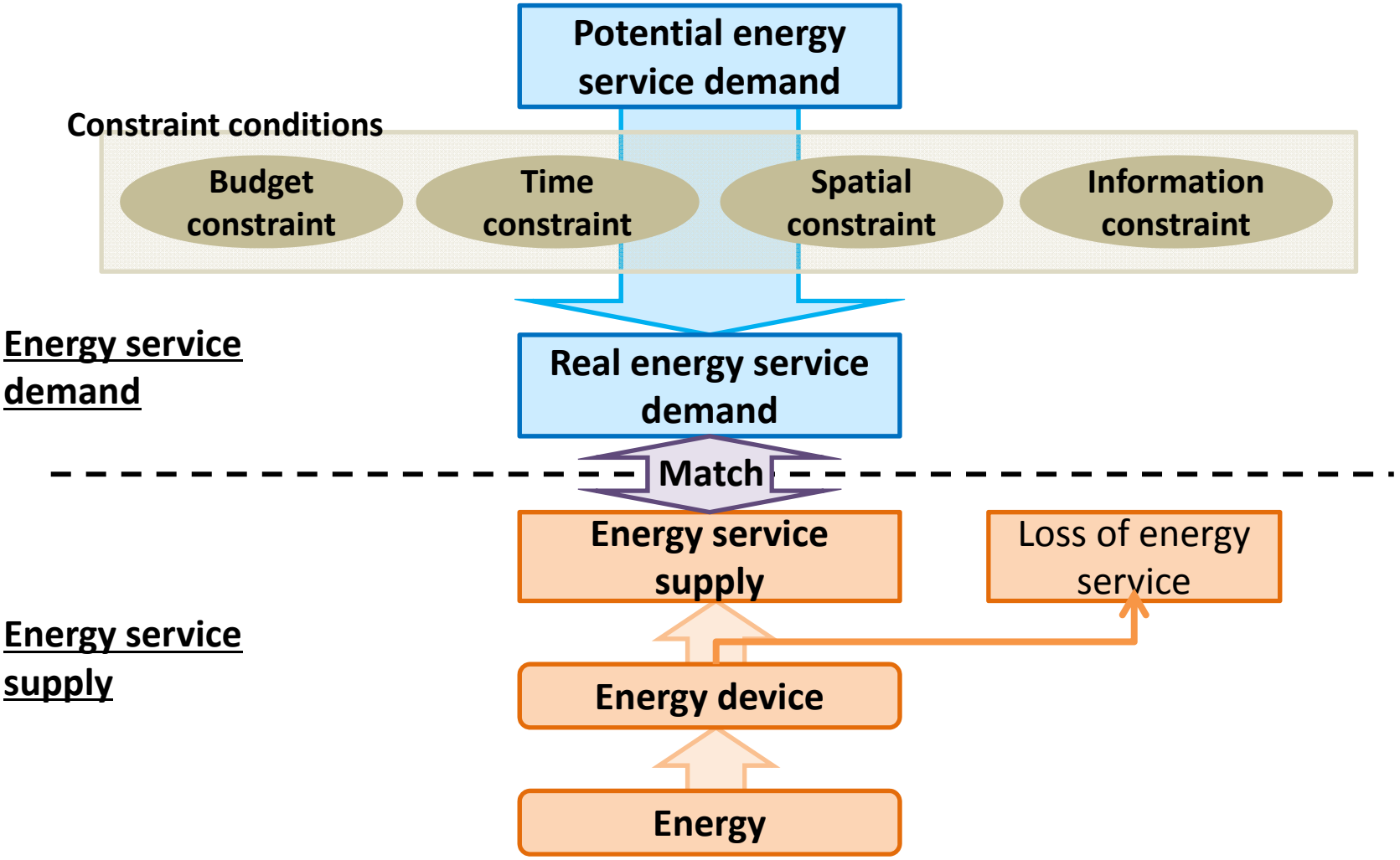
# Classification of energy service (1)

- Energy service is classified by “place (sector)”
  - **Residential (Household) sector**
  - Commercial sector
  - Transport sector
  - Industrial sector
  - Others

# Classification of energy service (2)

- Energy service in residential sector is classified **by type**.
  - Heating
  - Cooling
  - Hot water supply
  - Cooking
  - Lighting
  - Others

# Energy service supply-demand structure



# Energy service demand (1)

- Potential energy service demand

$$ESD_{r,es} = \sum_{p_r} pESD_{es,p_r,T} = \sum_{p_r} \left( pST_{es,p_r,T} \cdot \overline{pAR}_{es,p_r} \cdot \overline{INT}_{es,p_r} \right)$$

**Energy service demand** in region r

Individual p's energy service demand

**Time** which Individual p needs for energy service es

**Space** which Individual p needs for energy service es

**Intensity** which Individual p needs for energy service es

$$= pop_r \cdot \overline{pST}_{r,es} \cdot \overline{pAR}_{r,es} \cdot \overline{INT}_{r,es}$$

**Population** in region r

**Average Time** in region r of energy service es

**Average Space** in region r of energy service es

**Average Intensity** in region r of energy service es

# Energy service demand (2)

- Energy service real demand

$$rESD_{r,es} = ESD_{r,es} \cdot rC_{r,es}$$

**Real energy service demand** in region r

**Potential energy service demand** in region r

Expression factor

Expression factor: The ratio of real demand to potential demand .

■IF every constraints will be removed, expression factor is 1.

# Energy service supply

- Energy service supply

$$dESS_{r,j,es} = dUEN_{j,e} \cdot dEFF_{j,e,es} \cdot dTM_{j,es} \cdot dINT_{j}$$

**Energy service supply** in region r

**Unit energy consumption** of device j

**Energy Efficiency** of device j (= energy service / energy consumption)

**Operating time** of device j

**Operating Intensity** of device j

$$dESS_{r,j,es} = ESS_{r,j,es} + LOSS_{r,j,es}$$

**Energy service supply** in region r

**Real energy service supply** in region r

**Energy service loss**

# Scenario (Japan)

## ■ Technology scenario (1 scenario)

- Electric device efficiency will be improved.
  IH cooking heater/Heat pomp water heater: 1 (2010) → 1.1 (2050)
  Other electric device : 1 (2010) → 1.4 (2050)

- Share of electric device will be large.

## ■ Demand scenario (2 scenarios)

- [**FIX**] Fix at 2010 level: Energy service demand per capita keep the same level at 2010.

- [**BaU**] : Trends of 5 factors (floor area, time at home (exclude sleeping time), rate of eating at home, shower/bath ratio, penetration of "other" device) related with energy service demand are considered.

# Scenario (China)

## ■ Technology scenario (1 scenario)

- All device efficiency will be improved.
  Chinese all device efficiency in 2050 will reach to same level of Japanese device in2050.

- Share of electric device will be large.

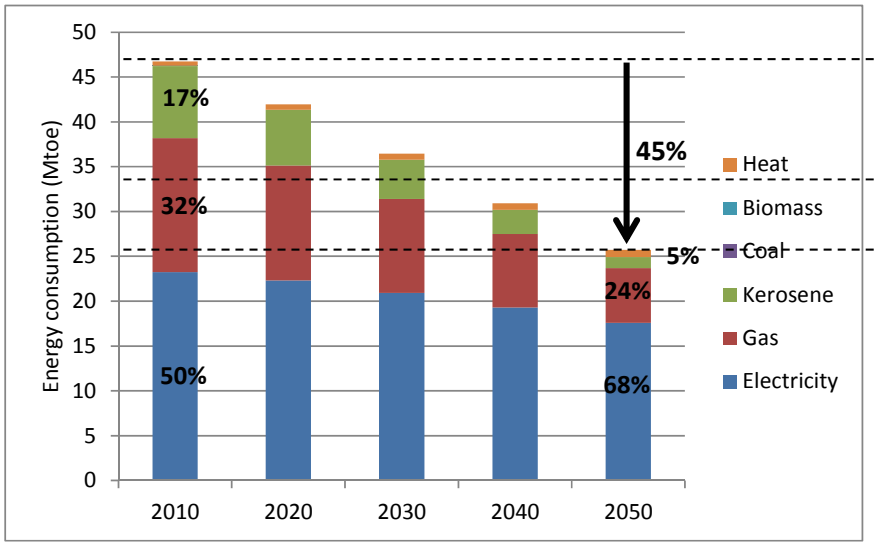
## ■ Demand scenario (3 scenarios)

- [FIX] Fix at 2010 level: Energy service demand per capita keep the same level at 2010.
- [MAX]: Chinese energy service demand per capita will reach to Japan's level in 2050 ( If Chinese demand is smaller than Japanese one.)
- [CHN]: **Heating**, **Cooling**, **Lighting**, and **Other** demand → Japan's level
  **Cooking** → rate of eating at restaurant will be large
  **Hot water supply**→ keep 2005 level

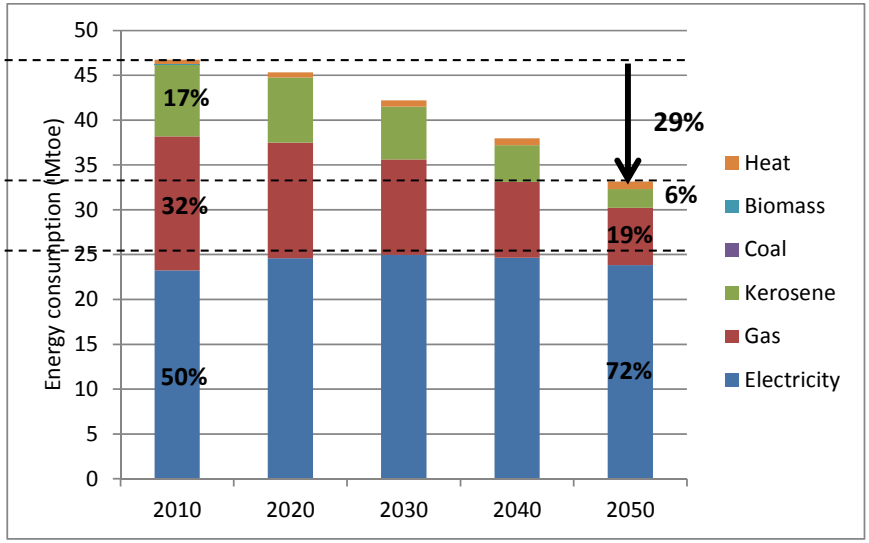
# Energy consumption (Japan)

*Tentative result

**FIX**




**BaU**



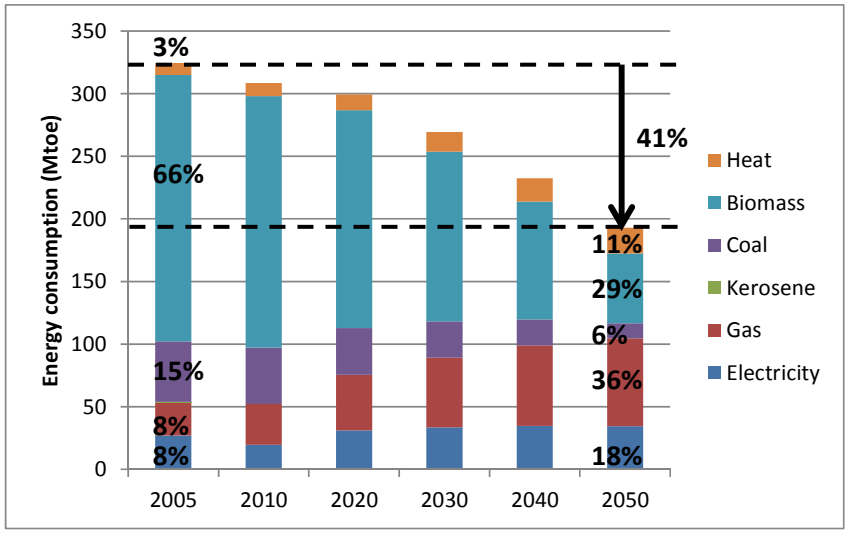

**FIX** case: Energy consumption in 2050 will be reduced by technology change and population decrease.

**BaU** case: Because of expansion of energy service demand per capita, energy consumption in 2050 will be about 33 Mtoe.

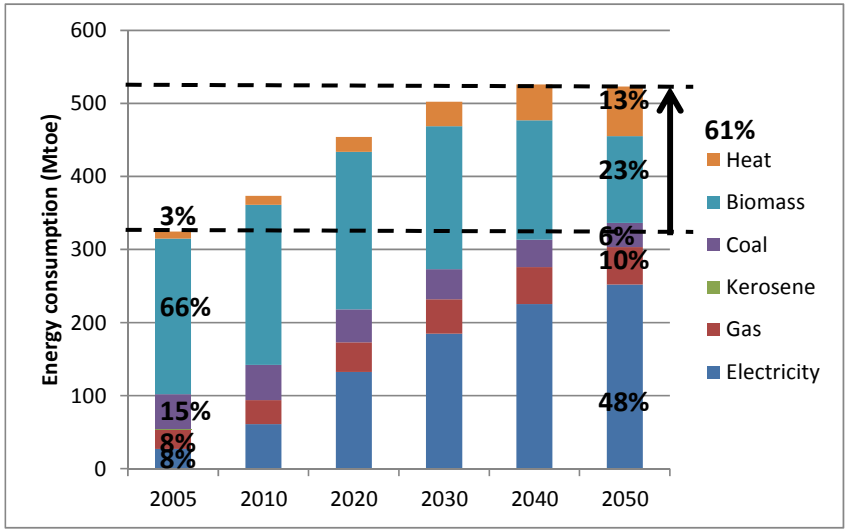
# Energy consumption (China)

*Tentative result

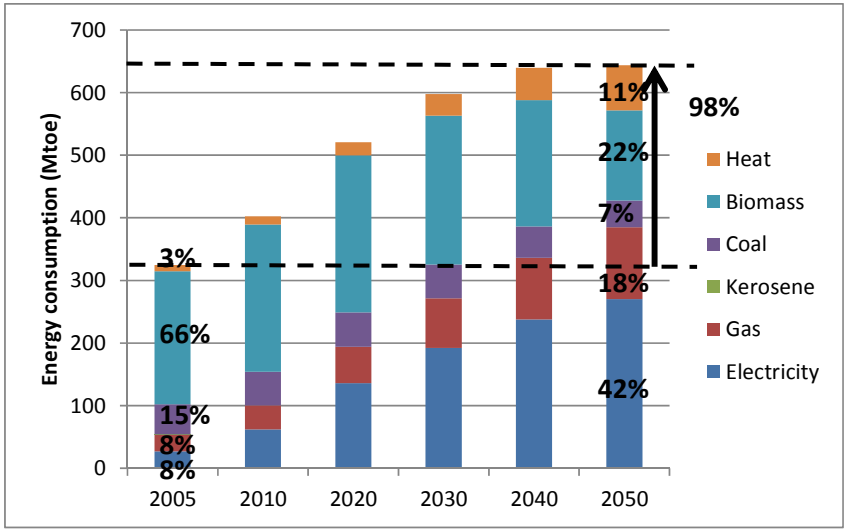
**FIX**




**CHN**




**MAX**



# Future works

- To make residential energy service scenarios by region and estimate energy consumption by 2050
- Commercial sector and other sectors…
- To estimate household garbage generation based on people's demand structure

**Thank you for your attention!**

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