Energy service demand in Japan’s household sector

The 21th AIM international workshop @ NIES
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Characteristics of Japan’s household sector energy consumption

Various factors are associated with energy consumption in household sector.

– Household type, income level, number of household members, climate and building type etc.

※Family income and expenditure survey
Outline of estimation

• Aim of the research
  – Develop model to estimate energy service and consumption in household sector considering household characteristics.

• Target area: Japan
• Target year: 2035 (Base year: 2010)
• Energy: Electricity, gas, heat
• Energy service: 6 type (Heating, cooling, hot water supply, cooking, lighting, others)
Estimation method (1)

- Relationship between energy consumption and energy service

\[ E_r^l = \sum_k E_r^{k,l} = \sum_s \left( D_r^s \cdot \sum_{k \in SK(s)} cnv_{r,k}^s \cdot ef_{r,k}^{l} \right) \]

Energy service demand

Device share \[ \sum_{k \in SK(s)} cnv_{r,k}^s = 1 \]

Energy consumption

Device efficiency \[ ef_{r,k}^{l} = E_r^{k,l} / D_r^{k,l} \]
Estimation method (2)

• Energy service demand

Energy service demand = Energy service size × Energy service time × Energy service intensity

<table>
<thead>
<tr>
<th>Energy service</th>
<th>Size</th>
<th>Time</th>
<th>Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating</td>
<td>Floor area</td>
<td>Active time at home</td>
<td>Heating degree day</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Heating temperature</td>
</tr>
<tr>
<td>Cooling</td>
<td>Floor area</td>
<td>Active time at home</td>
<td>Cooling degree day</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cooling temperature</td>
</tr>
<tr>
<td>Hot water supply</td>
<td>Hot water supply per capita</td>
<td>Number of hot water use</td>
<td>Hot water temperature</td>
</tr>
<tr>
<td>Cooking</td>
<td>Size of meal</td>
<td>Rate of in-home dining</td>
<td>Power of stove</td>
</tr>
<tr>
<td>Lighting</td>
<td>Floor area</td>
<td>Active time at home</td>
<td>Illumination intensity</td>
</tr>
<tr>
<td>Others</td>
<td>GDP per capita</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Gray factors are not considered in this research.
Social economic scenario (1)

- Population and number of household (1)
- Floor area(2)
- Active time at home(1)
- Rate of eating at home(1)
- Hot water supply per capita (2)

(*) : * shows number of case
• Population, number of household

※National institute of population and social security research
**Socio economic scenario (2)**

- **Floor area by building type and prefecture**
  - There are big differences about average floor area among prefecture.
  - Average floor area of detached house in Tokyo is about 110 m²

- **Share of building type:**
  - BaU: Keep change rate of the share in 2008-2013 by prefecture, household type and building type
  - LCS: Keep share of detached house at 2008 level
  - A certain number of aged person will move from detached house to collective house
### Socio economic scenario (3)

#### Rate of home-meal replacement and eating outside

<table>
<thead>
<tr>
<th></th>
<th>Home-meal replacement</th>
<th>Eating outside</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single male household</td>
<td>16.1</td>
<td>23.7</td>
</tr>
<tr>
<td>over 65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single female household</td>
<td>12.4</td>
<td>13.2</td>
</tr>
<tr>
<td>over 65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>12.3</td>
<td>19.1</td>
</tr>
</tbody>
</table>

※Family income and expenditure survey, Japan statistics bureau

#### Active time at home (Unit: min/week) ※1 week=10080 min

<table>
<thead>
<tr>
<th></th>
<th>10-19</th>
<th>20-29</th>
<th>30-39</th>
<th>40-49</th>
<th>50-59</th>
<th>Over 70</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>2685</td>
<td>2437</td>
<td>2356</td>
<td>2321</td>
<td>2660</td>
<td>3631</td>
</tr>
<tr>
<td>Female</td>
<td>2726</td>
<td>3002</td>
<td>3791</td>
<td>4090</td>
<td>4311</td>
<td>4768</td>
</tr>
</tbody>
</table>

※National time use survey (NHK Broadcasting Culture Research Institute)

#### Per capita hot water supply

- Water use of shower per capita will decrease. (Water-saving shower will become popular and people will try to decrease 10% of water use.)
Technology scenario

• Energy efficiency of device... (1) Efficiency in 2035 was set and (2) linear interpolation using 2010 and 2035 data
  – **AC**: Unit energy consumption of device will be $\frac{2}{3}$ compared with 2010 level
  – **Gas and oil devices**: Unit energy consumption of device will be 90% compared with 2010 level.
  – **Lighting and other devices**: Unit energy consumption of device will keep 2010 level

• Share of device...Electrification and shift to energy efficient device.
  – Heating: Share of air conditioner will increase by about 30%
  – Hot water supply: Share of heat pump water heater will increase by about 20%
  – Cooking: Share of electric cooking stove will increase by about 15%
Estimation scenario

- Based on technology scenario and socio economic scenario, 4 estimation scenario are set.

<table>
<thead>
<tr>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
<th>Case 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy efficiency</td>
<td>×</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>Device share</td>
<td>×</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>Lifestyle change</td>
<td>×</td>
<td>×</td>
<td>×</td>
</tr>
</tbody>
</table>

Only population and household composition change are considered.
Result: Energy consumption by service

Energy consumption change (2010=1)

- Others: 100%
- Lighting: 32%
- Cooking: 6%
- Hot water supply: 30%
- Cooling: 8%
- Heating: 76%

Demographic change: 19%
+Energy efficiency: 20%
+Device share: 17%
+Activity change: 1%

2010: 2035_1, 2035_2, 2035_3, 2035_4
Future tasks

• (1) How to estimate “Others energy service” appropriately?
  – “Others” includes various kind of devices such as refrigerator, TV ...
  – All kind of devices have different penetration level, energy efficiency improvement speed.

• (2) How to estimate aged people’s energy consuming activity?
  – Lower device replacement demand
  – Time allocation / Share of consumption expenditure
Thank you for your attention!

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