Socio-Economic Study on Advanced Energy Technology by a Statistical Method; The Conjoint Analysis

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Aim of this assessment

We have tried to determine general function-curves for figure of merits on various characteristics of energy systems, i.e. effect-functions, without showing the name of individual energy technology or resource, for example, solar, thermal power by petroleum, fission, fusion etc..

Once we get the effect-functions for the figure of merits, we will able to show clearly the advantage and disadvantage of each energy system, without any factitious adjustments.

This method will be developed into a study of the externality on, such as, security of energy plants or feasibility of energy resource where it is difficult to show the quantitative figure of merit.

Concept of the conjoint analysis

- The conjoint analysis is one of techniques to survey on public opinions.
- Profile Cards, where various attributes of the target product or concept are listed, are used.
- The respondents choose the most preferable Profile Card from the set of Cards (two or more) which are shown in each questionnaire.
- The effect-function for the figure of merit on the individual attribute can be determined through a kind of statistical treatment.

Example: a choice of your personal computer

Attributes

*CPU speed
*RAM size
*Hard-disk capacity
*Price
*Brand image, design etc.

Profile example

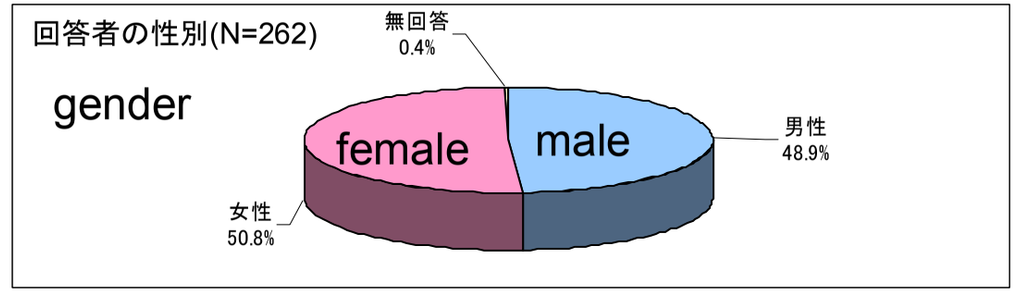
- Pentium4 3.0GHz
- 512MB
- 10GB
- 98000 Yen
- NEC, Slim type, etc

Attributes and levels in our research

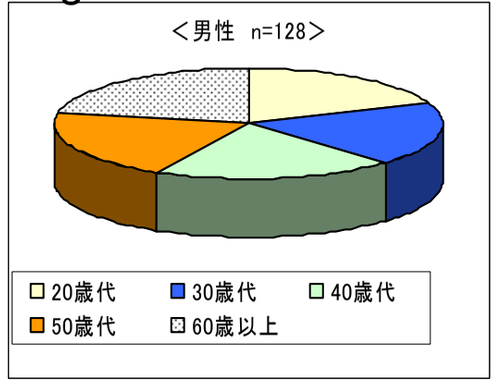
The questions must be comprehensive to general public, but, possible to convert into the quantitative values, which will be able to use in the assessment.

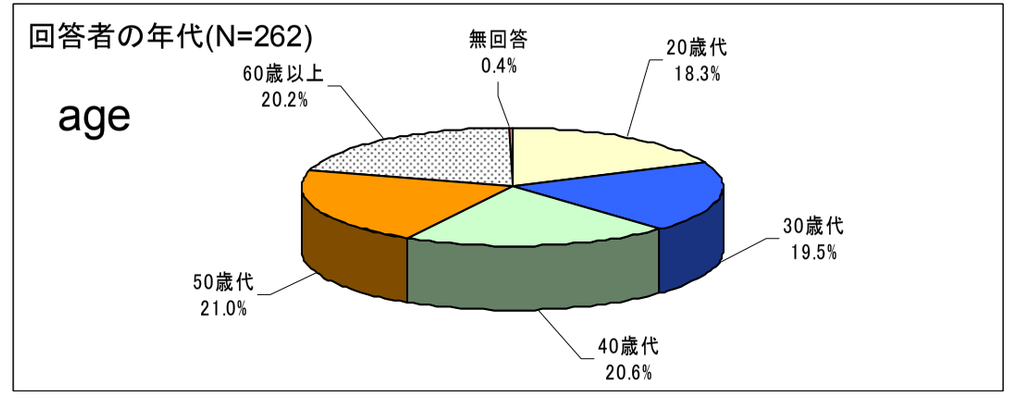
Attribute	Level
1. Resource	① nearly infinite ② 100 times as large as petroleum ③ 10 times as large as petroleum ④ equal to petroleum
2. Resource Distribution	① every country ②most of countries ③localized like petroleum ④localized more than petroleum
3. CO2 emission	① 1/100 as low as petroleum ② 1/10 as low as petroleum ③ 1/2 as low as petroleum ④ equal to petroleum ⑤ twice as large as petroleum
4. Electricity expense in Japan	①-2400 billion $/year (-200$ /year per person) ②-1200 billion $/year (-100$ /year per person) ③ equal to present (total 14 trillion $ in Japan) ④ +2400 billion $/year (+200$ /year per person) ⑤ +10 trillion $/year (-800$ /year per person)
5. Interruption due to natural phenomena	① no effect ② interrupted but regularly ③ interrupted irregularly and suddenly
6. Interruption due to social phenomena	① highly tolerant ② vulnerable to domestic socio-event only ③ vulnerable to international socio-event only ④ vulnerable to both societies
7. Impact in the worst accident case	① no impact to periphery ② no impact to health of public with evacuation ③ injury and health damage can be possible ④ some fatalities
8. Abuse by terrorism	① less useful ② useful

Distribution of respondents

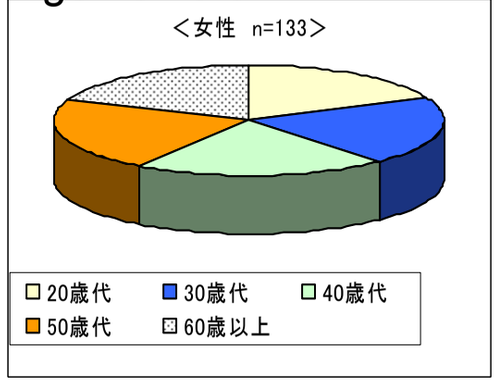


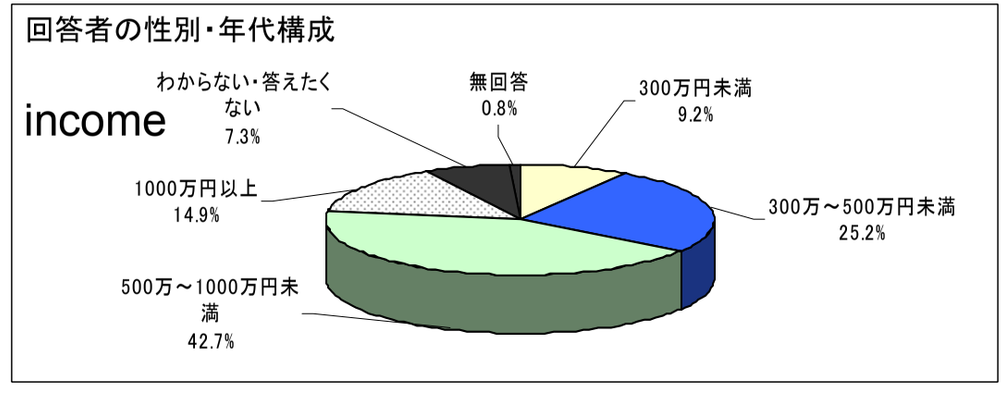
Age/male





Age/ female





Pair-wise rating method of 3 attributes, which are chosen from all 8 attributes at random for each question, has been used.
30 questions per person. The number of respondents is 1300. Then we got 39,000 answers.

< Question 1 >

Do you prefer which of electricity generation technology A or B?

Please mark one of the ( ).

Please assume that the characteristics not listed here are the same between the technologies.

Technology A

Attributes	Characteristics
CO2 emission	Less than 1 tenth of oil-burning generator
Electricity expense in Japan	Annual 1.2 trillion yen decrease (10 thousand yen decrease per capita)
Impact at accident	No impact to health

( )

Technology B

Attributes	Characteristics
CO2 emission	Half of oil-burning generator
Electricity expense in Japan	Equivalent to current amount
Impact at accident	Some fatalities

( )

Figure 1 Typical choice question

Effective value and effective functions

Effect value $U = a_{1i}X_{1i} + a_{2i}X_{2i} + a_{3i}X_{3i} + a_{4i}X_{4i} + \text{-----} + \varepsilon$

X_{ki} is the i-th level value for the attribute k.

a_{ki} is the coefficients for the effect-function

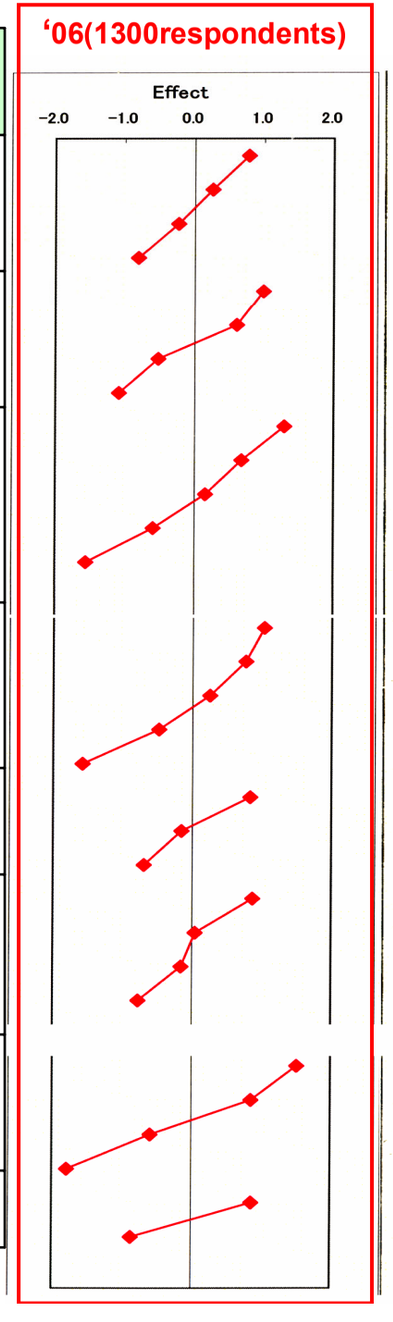
the effect-function for the attribute k is shown as a line graph by $\{a_{ki}X_{ki}\}$.

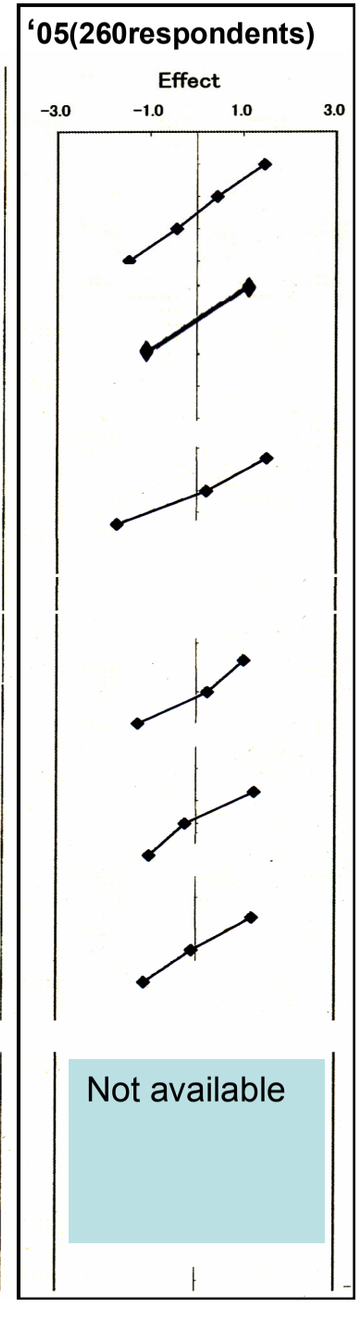
We get a lot of data-set for $(X_{1i}, X_{2i}, X_{3i}, X_{4i}, \text{----})$

Using a kind of statistical method, a set of a_{ki}'s which give the largest likelihood, can be determined

Effect-functions constructed by the answers

Attribute	Level
1. Resource	① nearly infinite ② 100 times as large as petroleum ③ 10 times as large as petroleum ④ equal to petroleum
2. Distribution	① every country ②most of countries ③localized like petroleum ④localized more than petroleum
3. CO2 emission	① 1/100 as low as petroleum ② 1/10 as low as petroleum ③ 1/2 as low as petroleum ④ equal to petroleum ⑤ twice as large as petroleum
4. Energy cost	①-2400 billion $/year (-200$ /year per person) ②-1200 billion $/year (-100$ /year per person) ③ equal to present (total 14,000 billion $ in Japan) ④ +2400 billion $/year (+200$ /year per person) ⑤-10,000 billion $/year (-800$ /year per person)
5. Interruption due to natural phenomena	① no effect ② interrupted but regularly ③ interrupted irregularly and suddenly
6. Interruption due to social phenomena	① highly tolerant ② vulnerable to domestic society only ③ vulnerable to international society only ④ vulnerable to both societies
7. Impact in the worst accident	① no impact to periphery ② no impact to health with evacuation ③ injury and health damage can be possible ④ some fatalities
8. Abuse by terrorism	① less useful ② useful





In this method, the differential of effects for every attributes can be compared each other.

Resource 100 times as large as petroleum has a same effect to resource distributed in most of country. The increment of effect by “every country” is small.

An effect reduction due to 200$ increment in cost can be canceled by an increment of effect due to a reduction of CO2 emission by half.

The effect of “no interruption by natural phenomena” = The effect change between “No impact to health” and “injury and health damage”

Level
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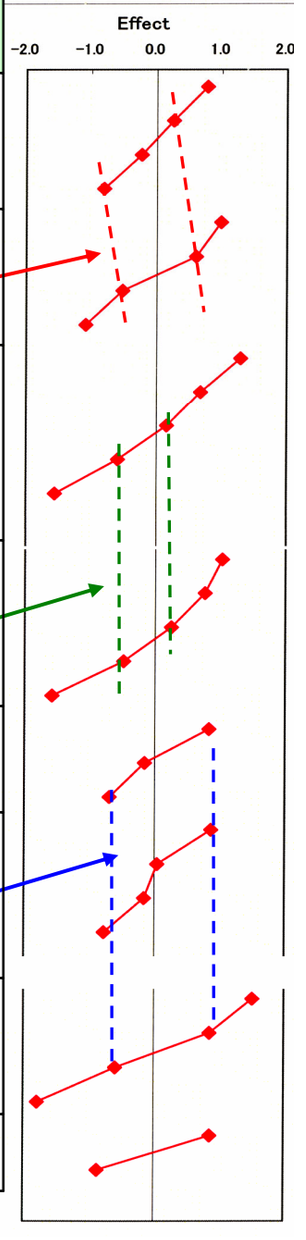
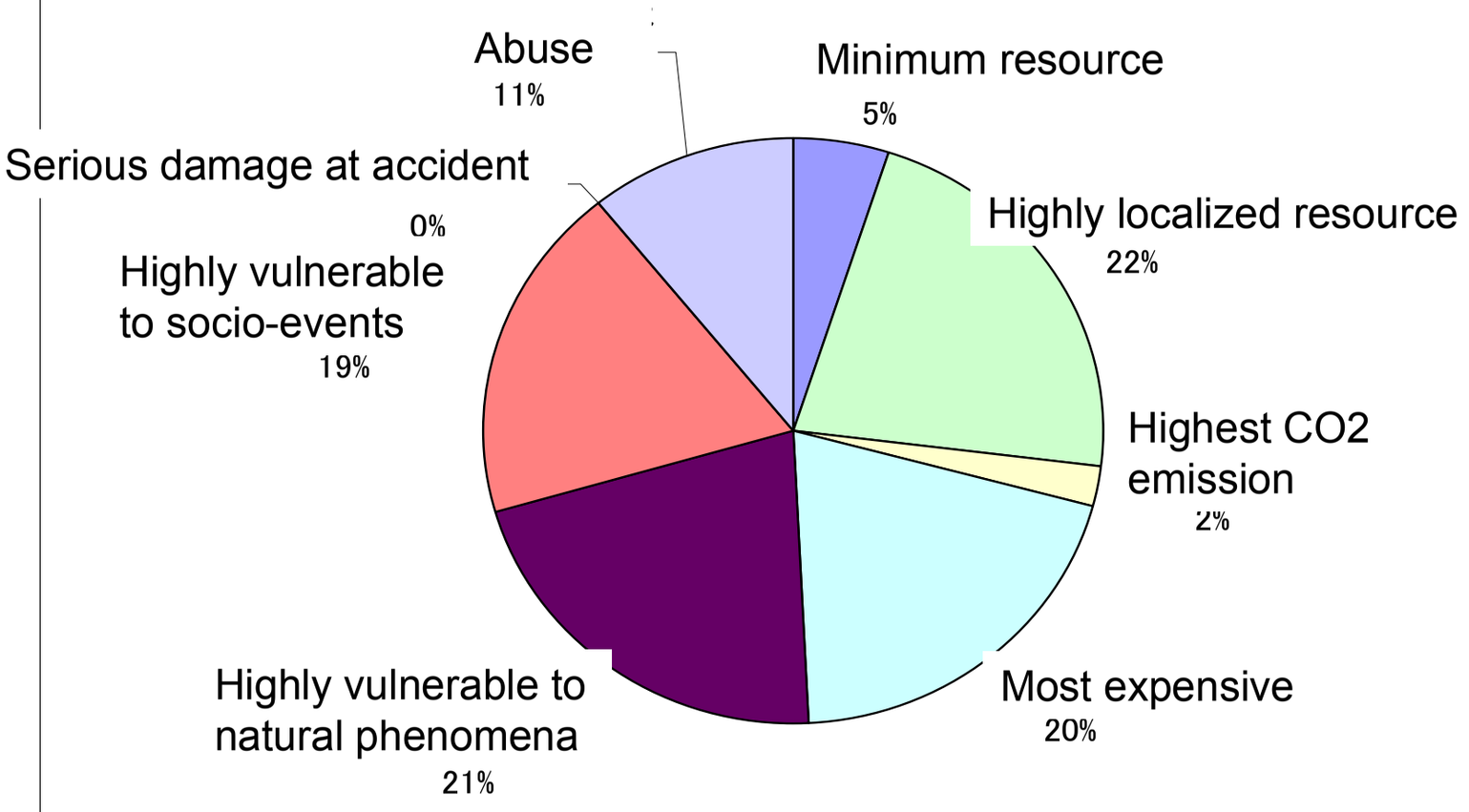
① no useful ② useful



Another example: Preference in market

Eight extreme examples of plants in which one of the attributes is the worst level while the other attributes are the best levels.



Future Work

1) The results shown here are still tentative. Further analysis is on-going.
2) Evaluation of various types of plants will be done in 2007.
3) Comparing the present effect-function of public to that of researchers of energy technology. (same one or large deviation?)
4) Some comment on a new “best-mix” concept where support and satisfaction of public will be maximized.