CHAPTER 5

RESULTS AND DISCUSSION

The summary of the results of the brainstorming session, focus group discussion, and conjoint analysis simulation, is presented before discussing the two important parameters obtained as the output of the conjoint simulation analysis, which in turn, could be applied for the development of DSWH.

5.1 BRAINSTORMING SESSION AND FOCUS GROUP MEETING

The brainstorming session identified eighteen attributes as shown in Table 4.7. The focus group discussed the various aspects of these 18 attributes, and selected five important attributes, with two levels for each of the attribute. These five attributes along with the two levels for each of the attributes, are shown in Table 4.10. Data from Tables 4.7 and 4.10 are used for further analysis.

5.2 CONJOINT ANALYSIS SIMULATION

The various combinations of the two levels for each of the five attributes yields $2^5 = 32$ possible product profiles. Considering the difficulties for the respondents to analyse and rank all the 32 possible product profile combinations, the following eight product profiles selected by the conjoint analysis simulator of the SPSS package, were given as a CBC questionnaire
to the respondents for rating and further analysis. These eight product profiles are shown in Table 4.12. Based on customer ranking for the selected eight product profiles and further analysis, the conjoint simulator generates the following output, shown in Figure 5.1.

**Figure 5.1 Screenshot of the output of conjoint analysis**

The following two important parameters obtained as the output of the conjoint analysis are very useful to arrive at the final decision.
i). Relative importance values for each of the five attributes.

ii). Total utility values for each of the eight product profiles.

### 5.2.1 Relative Importance Values

Most of the researchers now calculate an importance value for each attribute. A relative importance score or value reflects the effect of each attribute on the choice of the product. These importance values of each attribute are shown in Figure 5.2.

![Relative Importance Chart](image)

**Figure 5.2 Relative importance chart for the attributes**

Based on the relative importance values of each attribute obtained from the output of the conjoint analysis, the following observations are made.

The relative importance chart indicates that price is the most important attribute, which dictates the decision-making process of a customer. This is quite natural, if the hidden advantages or imperatives of environmental
concerns are not considered. This also lays emphasis on the need to educate and create awareness of such merits in the customers.

However, in the absence of a conviction on the life-cycle cost issues, all earlier studies on the barriers to diffusion also corroborate the high initial cost as the most significant barrier. In order to encourage widespread acceptance, pricing the SWH appropriately is absolutely necessary, when introducing it into the market. The initial cost of acquiring and installing a solar water heater is enhanced by other factors, like the cost of plumbing and insulation, which substantially impact the same. For apartment complexes with multi-storeyed tenements, this is a crucial factor when terrace mounted systems are considered. This indirectly brings in location considerations. It is also seen that all the consumers and potential consumers do not consider the impact of the indirect environmental benefits involved (though at a higher cost). This, in a way, signifies customer indifference.

Of course, for any product, pricing plays a very important role; however in the case of DSWH in India, this study reveals that customers are very much interested in getting the subsidies and soft loans immediately, while buying the product.

Payback period is another important attribute, in which the customers are keen to invest if the interest part (for the loan obtained from the bank to purchase the product) involved is extended further. Reliability coupled with extended use will justify the initial higher cost, and needs to be addressed in the design. Any value addition to the product in this aspect would aid in developing the DSWH into a successful product in India.

The temperature of the hot water comes next in the relative importance chart, followed by the capacity and duration of use. It gives an idea of how the consumers prioritise the benefits for the price paid by them.
5.2.2 Total Utility Values

Apart from the utility levels for the individual attributes, to evaluate which are the best product profiles with different levels of attributes, all the utility values of the levels are added up, and the product with the highest total utility value is considered as the most preferred by the customer. Figure 5.3 shows the total utility values for the selected product profiles in the questionnaire, and these values have been obtained through the conjoint analysis.

![Bar chart showing total utility values for selected product profiles](image)

**Figure 5.3 Total utility values for the selected product profiles**

Table 5.1 shows all the combinations of the selected product profiles, along with a column showing the total utility values. These values can help us to compare the product combinations, and to decide the best combination of the individual attributes, which makes the best product as desired by the customers.
Table 5.1 Total utility value of the products for ranking

<table>
<thead>
<tr>
<th>Product</th>
<th>Capacity (LPD)</th>
<th>Price range (Rs.)</th>
<th>Payback Period (Yrs)</th>
<th>Hotness (°C)</th>
<th>Duration (Hour)</th>
<th>Total Utility Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (1)</td>
<td>100</td>
<td>17000</td>
<td>2</td>
<td>Hot(40 to 60)</td>
<td>½ to 1</td>
<td>4.906</td>
</tr>
<tr>
<td>B (2)</td>
<td>150</td>
<td>17000</td>
<td>2</td>
<td>Warm(30 to 40)</td>
<td>½ to 1</td>
<td>5.359</td>
</tr>
<tr>
<td>C (3)</td>
<td>150</td>
<td>20000</td>
<td>2</td>
<td>Warm(30 to 40)</td>
<td>½ to 1</td>
<td>4.516</td>
</tr>
<tr>
<td>D (4)</td>
<td>100</td>
<td>17000</td>
<td>2</td>
<td>Warm(30 to 40)</td>
<td>½ to 1</td>
<td>4.348</td>
</tr>
<tr>
<td>E (5)</td>
<td>150</td>
<td>20000</td>
<td>4</td>
<td>Hot(40 to 60)</td>
<td>1 to 1 ½</td>
<td>4.17</td>
</tr>
<tr>
<td>F (6)</td>
<td>100</td>
<td>17000</td>
<td>4</td>
<td>Hot(40 to 60)</td>
<td>½ to 1</td>
<td>3.998</td>
</tr>
<tr>
<td>G (7)</td>
<td>150</td>
<td>17000</td>
<td>4</td>
<td>Warm(30 to 40)</td>
<td>1 to 1 ½</td>
<td>4.635</td>
</tr>
<tr>
<td>H (8)</td>
<td>100</td>
<td>20000</td>
<td>2</td>
<td>Hot(40 to 60)</td>
<td>1 to 1 ½</td>
<td>3.887</td>
</tr>
</tbody>
</table>

Based on the Total Utility Values for the eight different products, it is concluded that Product B is the most feasible one, followed by Product A that comes close to fulfilling the customer requirements, as shown in Table 5.2. The combination of the attributes of the product B (2) are 150 LPD capacity, price Rs.17,000/-, payback period 2 years, hotness required ranging from 30 to 40°C, and duration expected from 30 minutes to one hour.

Table 5.2 Selected product profiles based on the total utility values

<table>
<thead>
<tr>
<th>Product</th>
<th>Capacity (LPD)</th>
<th>Price (Rs.)</th>
<th>Payback Period (Years)</th>
<th>Hotness (°C)</th>
<th>Duration (Hour)</th>
<th>Utility Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>150</td>
<td>17000</td>
<td>2</td>
<td>Warm(30 to 40)</td>
<td>½ to 1</td>
<td>5.359</td>
</tr>
<tr>
<td>A</td>
<td>100</td>
<td>17000</td>
<td>2</td>
<td>Hot(40 to 60)</td>
<td>½ to 1</td>
<td>4.906</td>
</tr>
</tbody>
</table>

The results of the above analysis help in finding the customer expectations, which have not been explicitly obtained, in the commonly followed design and development methodologies of these products by the manufacturers.
5.3 DERIVED OUTCOME OF THE ANALYSIS

Among the five attributes selected in the present analysis, the following two attributes are related to financial aspects:

i). Price

ii). Payback period

The following three attributes are related to human comfort:

i). Capacity

ii). Hotness

iii). Duration

The relative importance values are higher for the attributes related to cost aspects, than the attributes related to human comfort. This indicates that the respondents considered in the survey have given more importance to the cost aspect than to comfort. However, these results may not be the same in economically developed nations.

Further, it is observed that the other important attributes related to environmental concerns and technical aspects considered in the analysis were not selected by the respondents. This could be due to the lack of knowledge in the technical aspects and awareness about the environmental concerns among the respondents. This shows that all the efforts taken by the Government in promoting solar appliances have not reached the public in the right sense.

Energy poverty implying the inadequate availability of energy for an improved quality of life for all people leads to under-development in the most backward countries and the global organizations and the governments concerned need determination in breaking this vicious circle to accelerate the
use of renewable energy sources. Availability of commercial energy at affordable cost, particularly in the rural areas is to be ensured. The onus lies on the rich industrialized countries to help the developing countries in this task, which would in turn ensure their own long term economic security and a sustainable growth. The developing nations can make use of this opportunity to generate the required power through renewable sources.

Though the technical and the environmental attributes were not given much importance by the respondents, the price, payback period, and the comfort attributes of the DSWH could be brought to the level of customer satisfaction, only by paying attention to the development of the technical attributes.

The following various options could be considered with respect to the technical attributes:

i). Terrace mounted systems with large collector areas as commonly used, tend to increase the price and installation cost on account of piping and insulation. Wall mounted and sun-shade mounted systems with lower capacity could bring down the cost.

ii). Optimization pertaining to packaging and assembly of DWSH would be an area worth investigating.

iii). The efficiency of these heaters could be enhanced through the adoption of the SCAMPER (substitute, combine, adapt, modify, put to other use, eliminate, rearrange) techniques, by combining different concepts, like combination of flat plate and concentrated collectors, over a period of time, this deserves a careful study.
iv). A comprehensive decomposition, both physical and functional, together with the proper use of morphological charts, and recourse to tools like TRIZ, could also help in design changes involving a drastic reduction of the initial cost.

v). The structural integrity and efficiency of these heaters over a period of time deserves a careful study.

vi). Packaging and handling considerations are important.

vii). System optimization in a multidisciplinary fashion assumes importance.

viii). Insulations could be made out of indigenous materials.

ix). Recyclability of components cannot be overlooked.

x). Heat transfer mechanisms could be enhanced by considering the special needs of a DSWH, like the use of cheaper nanofluids.

xi). Introducing the concept of efficient thermal storage to bridge the time mismatch between the availability of the solar energy and the hot water demand.

xii). Introducing recent advancements in the field of nanotechnology.

a) To improve the thermal transport properties of the heat transfer fluid used in the collector.

b) To improve the absorption capacity of the solar collector with the use of nanocoatings in the solar collector.