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EXPERIENCE AND FAMILIARITY'S ROLE IN THE DIFFUSIONOF PHOTOVOLTAIC TECHNOLOGIES

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Abstract

Due to large shortfalls of electric-power generation, solar photovoltaic energy is one of the special-purpose decentralized forms of power-generating units that the government is trying to promote in an attempt to alleviate the power problem in India. Rogers' innovation decision model comprises of a sequence of stages progressing from knowledge acquisition to persuasion or interest followed by the adoption/rejection decision. Rogers emphasizes knowledge as the means to persuading decision makers to adopt or reject an innovation. Another major variable in Rogers' model is persuasion, the formation of a favourable or unfavourable attitudes toward the innovation being considered for adoption. Kaplan proposed an improved way of explaining how potential adopters mature to a level of innovation interest. In an attempt to fill the gap between Knowledge and Interest, Kaplan identified Motivation, Context, Experience and Familiarity, variables that were hither to ignored. The present study explores the importance of decision makers' Experience and Familiarity with solar based technologies in the diffusion of these technologies. The data was collected from managers in hotels, using a structured questionnaire. The results of descriptive analysis shows that these managers had a moderate level of Experience and Familiarity with applications such as solar water heating, solar lighting etc. Therefore, concerted efforts must be directed toward providing potential adopters with more direct Experience with different PV based applications. Familiarity with the existing efforts to demonstrate and use different PV based applications in India can be increased through appropriate measures taken by the government.

Keywords: Diffusion, Experience, Familiarity, Photovoltaic Technologies.

1. Introduction

Energy is one of the most important inputs for the economic development of a country because its availability improves the standard of living. India has large shortfalls of electric-power generation, so the Government of India has introduced reforms in the power sector and is encouraging large-scale generation by private sector and joint sector participation. There is a shift towards decentralized power generation and private entrepreneurship in power generation. Solar photovoltaic (PV) energy is one of the special-purpose decentralized forms of power-generating units that the Ministry for New Energy Sources is trying to promote in an attempt to alleviate the power problem in the country. This paper explores the importance of decision makers' Experience and Familiarity with solar based technologies in the diffusion of these technologies.

2. Literature Review

Rogers' innovation decision model comprises of a sequence of stages progressing from knowledge acquisition to persuasion or interest followed by the adoption/rejection decision (Rogers, 1995). At every step of this process, communication channels, which include formal and informal social networks, cues, mass media etc, can influence cognitive, affective or even behavioural states (Goes and Park, 1997).

2.1. Knowledge

The critical issue in the innovation decision process is the way information is acquired, processed and used. Rogers (1995) emphasizes knowledge as the means to persuading decision makers to adopt or reject an innovation. A series of 'prior conditions' such as previous practice, felt needs/problems, innovativeness and norms of the social system serve as antecedents to the knowledge state. Rogers also identifies socioeconomic characteristics, personality variables and measures of communication behaviour as basic characteristics of the decision-making unit. All these contribute to knowledge acquisition and relate directly to two primary elements in the model, knowledge and persuasion.

2.2. Persuasion/Interest

The second major variable in Rogers' model is persuasion, the formation of a favourable or unfavourable attitude toward the innovation being considered for adoption (Rogers, 1995). Kaplan (1999a) proposed an improved way of explaining how potential adopters mature to a level of innovation interest. He examined the factors that influenced the interest of utility managers in adopting solar-based technology in the USA. Increased interest is the product of heightened knowledge of the technology. Knowledge is the product of motivation and experience. Exogenous variables such as socioeconomic characteristics, personality variables and norms of the social system remain. In an attempt to fill the gap between knowledge and interest, Kaplan (1999a) included Motivation, Context, Experience and Familiarity and identified relationships that have hitherto been ignored. These variables are discussed in the following section.

2.3. Motivation

Kaplan's (1999a) concept of motivation explains not only knowledge, but other stages of the early decision process. Motivation can be economic factors or incentives that encourage firms to get interested in technologies (Livesay and Lux, 1996; Kaplan, 1999a; Vasseur and Kemp 2015); Griesser (1993); Peter and Nayar (2002) have proposed autonomy as another motivational factor that influences choice of technology. Salience, the degree of local merit in an innovation can be an important factor too. Managers may consider PVs an economically viable alternative with positive environmental qualities, but they are also driven by specific utility needs and political receptivity. It gauges the impacts a potential adopter perceives of expected consequences from adopting or rejecting a technology (Kaplan, 1999a; Vasseur and Kemp, 2015). Motivation is a precursor to interest or persuasion, but is an insufficient predictor of interest. Motivation alone may not guarantee the development of interest in a particular solution, which the innovation may offer.

2.4. Context

Context essentially consists of factors such as environmental, organizational and personal characteristics. This is equivalent to the organizing concepts identified in Rogers' original model (Kaplan, 1999a; Vasseur and Kemp 2015).Environmental variables also include stage of economic development, political stability, cultural forces, trade regulations and exchange rate. Organizational characteristics relate to 1) individual characteristics, 2) internal organizational structural characteristics, and 3) external characteristics of the organization. Individual characteristics is measured by the individual leaders' attitude towards change. External

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characteristics is reflected by system openness, which is the degree to which members of a system are linked to other individuals who are external to the system.

2.5. Experience

The phenomenon Rogers calls 'previous practice' is the root of experience and is expected to be a key contributor not just to knowledge, but also to behavioural intentions and actual adoption. This variable accounts for three critical aspects of experience: exposure, direct and indirect – or vicarious experience, and innovativeness, which refer to the inherent capacity to innovate (Kaplan, 1999a; Vasseur and Kemp 2015). Studies on experience demonstrate the importance of measuring sources of learning and information other than technical knowledge (Carroll and Teo, 1996; Kaplan 1999a). Likewise, extramural knowledge used by early adopters who cannot base their decisions on existing technical information is acquired from sources such as peers at the forefront of the diffusion cycle (Pennings and Harianto, 1992; Peter and Nayar ,2002).

Direct and indirect experience can be measured in different ways and they have a number of dimensions. It helps to explain perceived risks of product failure in diffusion research. Clearly experiential factors can play a critical role in decision-making, but are ignored because they fail to fit conventional models of knowledge (Schmidt, 1993; Kaplan 1999a; Peter and Nayar, 2002). According to Kaplan (1999a), decision makers can be persuaded by experience and they develop a sense of familiarity about their options even when many technical facts may be missing.

2.6. Familiarity

The cognitive state resulting from experience is familiarity. It speaks of a degree of close acquaintance and suggests a level of comfort that would not arise from objective technical knowledge alone. It needs exposure to and experience with the object and a tangible tie to an innovation can contribute to evoking a positive adoption decision. Kaplan (1999a) cites our experience with computers as an example of the combinations that knowledge, experience and familiarity foster. Most people are comfortable using computers, but are ignorant about how it works. The basis for utilizing the technology is experiential rather than verifiable. The user has greater familiarity than knowledge. Familiarity also demonstrates a degree of confidence inherent in neither experience nor technical knowledge (Lim and Kim, 1992; Kaplan 1999a; Peter and Nayar, 2002).

3. Method

3.1. Questionnaire Design

A combination of extensive literature review, interaction with other researchers and results of the pre-tests led to the development of the final questionnaire, which was used as the survey instrument in this study. The use of structured questions helped to reduce any biases that could occur due to the influence of the interviewer and the respondent (Malhotra,2009). Fixed alternative questions were used rather than open-ended questions. Higher order scales such as interval scales are more powerful than nominal scales. They are more useful since they allow stronger comparison and stronger conclusions to be made. Hence interval scales (a seven-point interval rating scale from 1 = Not Important to 7 = Very Important, 1 = Very Ineffective to 7 = Very Effective; or 1 = No Experience to 7 = Lots of Experience; 1 = Not Familiar to 7 = Very Familiar; 1 = Not Comfortable to 7 = Very Comfortable) were used.

Single-item measures are generally deficient both with respect to validity and reliability (Pedhazur and Schmelkin, 1991; Hair, et al., 2006). Hence, multi-item scales were resorted to and the development of multi-item scales starts with an understanding of the construct being measured. Theory is helpful not only for constructing the scale, but also for interpreting the results. The item pool was generated from a list of items that relate to the constructs Experience and Familiarity and is drawn from literature.

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3.2. Scales of Measurement for Experience

Experiential factors refer to personal experience with either PV based power supply systems or related solar-based technologies. There are seven items E1 to E7 which measure experience A seven point scale from 1 = No experience to 7 = Lots of Experience (Mishra, Umesh and Stem, 1993) is used to measure experience with the following applications. The items are:

- Solar Lighting (Sastry 1997, Devraj and Haribabu 2015)
- Water heating (Peter and Nayar 2002)
- Telecommunications (Adurodija, Asia and Chendo 1998; Chaurey and Kandpal2010)
- Power generation during peak loads (Koner & Dutta 1998; Deng and Liu 2012)
- Captive power generation (Sastry 1997, Devraj and Haribabu 2015)
- Remote area applications (Bugaje 1999; Chaurey and Kandpal 2010)
- Water Pumping (Sastry 1997; Devraj and Haribabu 2015)

3.3. Scales of Measurement for Familiarity

Familiarity refers to the degree of comfort that the respondent has with PV systems following exposure/experience with PV technologies. A twelve item, seven-point Likert type scale (Srinivasan & Ratchford 1991; Murray 1990; Park & Lessig 1981) is used to measure this construct. Seven of the scale items use from 1 = Not Familiar to 7 = Very Familiar as the anchor points. These seven items FAM1 to FAM7, assess the respondent's familiarity with existing efforts to demonstrate and use PVs in different applications in India. The applications are:

- Solar Lighting (Sastry 1997; Devraj and Haribabu 2015)
- Water heating (Peter and Nayar 2002)
- Telecommunications (Adurodija et al. 1998; Chaurey and Kandpal 2010)
- Power generation during peak loads (Koner & Dutta 1998; Deng and Liu 2012)
- Captive power generation (Sastry 1997; Devraj and Haribabu 2015)
- Remote area applications (Bugaje 1999; Chaurey and Kandpal 2010)
- Water Pumping (Sastry 1997; Adurodija et al. 1998; Devraj and Haribabu 2015)

Five more items FAM8 to FAM12 use a Likert type scale from 1 = Not Comfortable to 7 = Very Comfortable as the end points. These variables assess the degree of comfort expressed by the respondents toward each of the following statements:

- Describing PV systems to your next door neighbour (Smith & Park 1992; Peter and Nayar 2002)
- Describing PV systems to your colleague (Smith & Park 1992; Peter and Nayar 2002)
- Explaining the technical aspects of PV systems (Lim & Kim 1992; Peter and Nayar 2002)
- Explaining the cost effectiveness of PV systems (Koner & Dutta 1998; Deng and Liu 2012)
- Recommending PV systems as an alternate power generation option to your management (Boulding, Kalra, Staelin, and Zeithaml. 1992; Peter and Nayar 2002)

3.4. Data Collection

The Directory of Hotels and Resorts in India was used as the sampling frame as it provided a comprehensive listing of the target population. The hotels were categorized according to their star ratings and adequate care was taken to ensure a representative sample. The sample size of 205 was spread across six Indian cities covering the different regions of the country. The data was collected from the hotels, using a structured questionnaire. The results of descriptive analysis are presented in this paper.

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This paper includes an examination of the frequency responses of the respondents to various statements. Those who circled a 1, 2 or 3 as their response were grouped together to denote the lower end of the scale. Those who circled a 5, 6 or a 7 were grouped together to denote the higher end of the scale. In a seven point scale, 4 represents a neutral response and therefore those who had indicated 4 as their response to a particular statement were not included in the frequency analysis. Hence, the percentages shown in the tables in this paper will not add to 100 percent.

4. Discussion of Results

4.1. Experience

Figure 1 highlights the mean values of the respondents' experience with either PV systems or solar-based technologies. A seven point scale from 1 = No experience to 7 = Lots of Experience was used to measure experience. It is clear from the mean ratings that the respondents have had more experience with solar water heating (E2: $\bar{x}$ = 3.89), some experience with solar lighting (E1: $\bar{x}$ = 3.20) and little or no experience with Water Pumping (E7: $\bar{x}$ = 2.64),Telecommunications (E3: $\bar{x}$ = 2.42), Remote area applications (E6: $\bar{x}$ = 2.32), Power generation during peak loads (E4: $\bar{x}$ = 2.28) and Captive power generation (E5: $\bar{x}$ = 2.16).

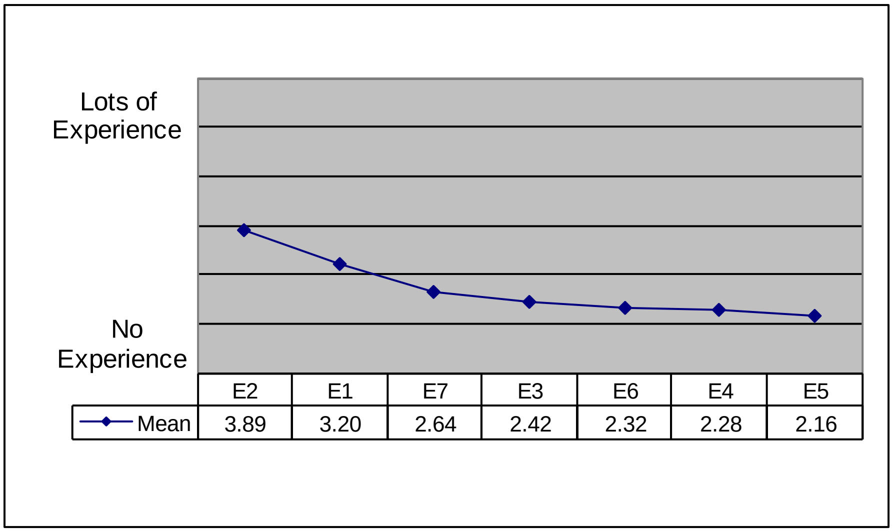

Figure 1: Experience

As is the case, the mean value for experience with solar water heating (E2) is higher than that of experience with solar lighting (E1). This is reflected in the frequency responses in Table 1 which shows that 44.4% of the respondents indicated that they had experience with solar water heating (E2) as against 33.2% who stated that they had experience with solar lighting (E1). 14.6% reported that they had experience with solar water pumping (E7), 16.6% specified that they had experience with PV based telecommunication systems (E3), 14.6% noted that they had experience with PV based remote area applications (E6), 16.1% said that they had experience with PV based power generation during peak loads (E4), and lastly 12.2% declared that they had experience with PV based captive power generation (E5).

Table 1: Experience – Frequencies and Percentages (N = 205)

	No Experience		Lots of Experience	
	N*	%**	N*	%**
Water Heating (E2)	91	44.4	91	44.4
Solar Lighting (E1)	133	57.6	68	33.2

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Water Pumping (E7)	139	67.8	30	14.6
Telecommunications (E3)	145	70.7	34	16.6
Remote Area Applications (E6)	153	74.6	30	14.6
Power generation during peak loads (E4)	152	74.1	33	16.1
Captive power generation (E5)	155	75.6	25	12.2

*Number (N) of responses

**Percentage of responses

4.2. Familiarity

Familiarity refers to the degree of comfort that the respondent has with PV systems following exposure/experience with PV technologies. A twelve item, seven-point Likert type scale is used to measure this construct. Seven of the scale items use from 1 = Not Familiar to 7 = Very Familiar as the anchor points. These seven items are the variables FAM1 to FAM7. Figure 2 illustrates the extent to which respondents' are familiar with existing efforts to demonstrate and use PVs in different applications in India.

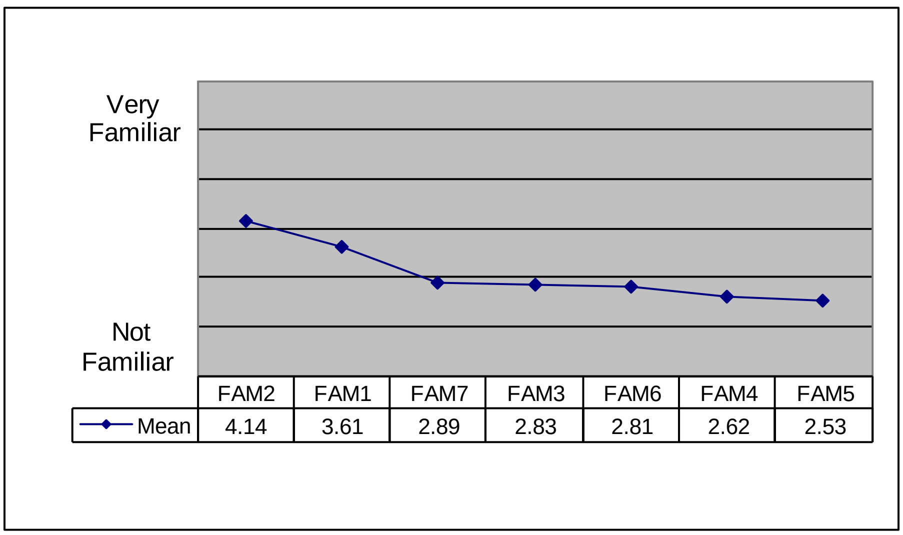

Figure 2

It is clear from Figure 2 that to some extent, the respondents are familiar with efforts to use solar water heating (FAM2: $\bar{x}$ = 4.14) and solar lighting (FAM1: $\bar{x}$ = 3.61). They do not appear to be familiar with the efforts to demonstrate and use — solar water pumping (FAM7: $\bar{x}$ = 2.89), PV based telecommunication systems (FAM3: $\bar{x}$ = 2.83), PV based remote area applications (FAM6: $\bar{x}$ = 2.81), PV based power generation during peak loads (FAM4: $\bar{x}$ = 2.62), and PV based captive power generation (FAM5: $\bar{x}$ = 2.53).

An examination of the frequency responses as shown in Table 2 reveals that 49.3% of the respondents were familiar with efforts to use solar water heating (FAM2) while 41% were familiar with solar lighting (FAM3). Approximately 23% were familiar with efforts to

Table 2: Familiarity with Existing Efforts – Frequencies and Percentages

	Not Familiar		Very Familiar	
	N*	%**	N*	%**
Water Heating (FAM2)	80	39.0	101	49.3
Solar Lighting (FAM1)	101	49.3	84	41.0

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Water Pumping (FAM7)	131	63.9	47	22.9
Telecommunications (FAM3)	129	62.9	48	23.4
Remote Area Applications (FAM6)	130	63.4	46	22.4
Power generation during peak loads (FAM4)	137	66.8	37	18.0
Captive power generation (FAM5)	144	70.2	32	15.6

*Number (N) of responses; N = 205
**Percentage of responses

use — solar water pumping, PV based telecommunication systems and PV based remote area applications. Less than 20% were familiar with PV based power generation during peak loads and PV based captive power generation. Five more items (FAM8 to FAM12) were used to assess the degree of comfort expressed by the respondents toward five different statements. A Likert type scale where 1 = Not Comfortable to 7 = Very Comfortable were used to assess these variables. The mean values are shown in Figure 3.

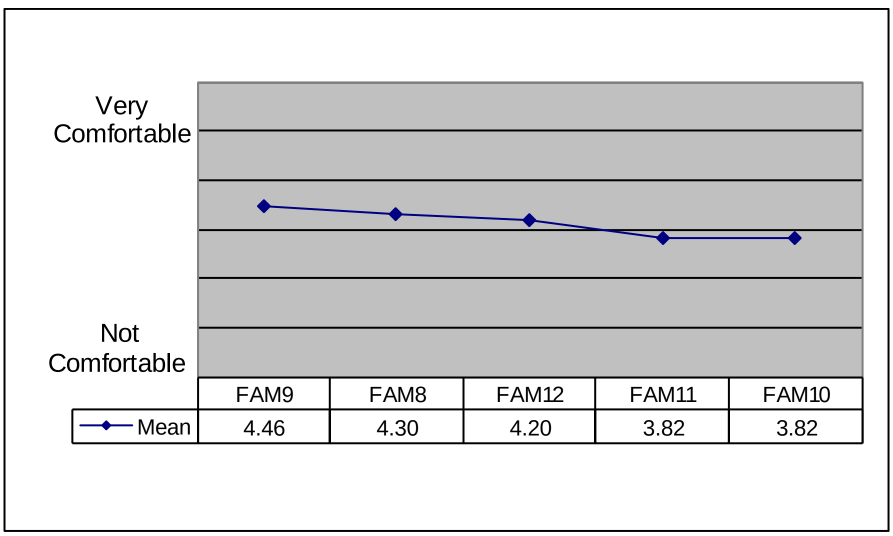

Figure 3

It is interesting to note that although these mean values are not very high, they are adequate to suggest that respondents are comfortable enough to — describe PV systems to their colleagues (FAM9: $\bar{x}$ = 4.46); describe PV systems to their next door neighbour (FAM8: $\bar{x}$ = 4.30); recommend PV systems as an alternate power generation option to their management (FAM12: $\bar{x}$ = 4.20); explain the cost effectiveness of PV systems (FAM11: $\bar{x}$ = 3.82); and to explain the technical aspects of PV systems (FAM10: $\bar{x}$ = 3.82);

It can be seen from Table 3 that 52.2% of the respondents are very comfortable in describing PV systems to their colleagues (FAM9); 50.2% are very comfortable in describing PV systems to their next door neighbour; 44.4% are very comfortable in recommending PV systems as an alternate power generation option to your management; 37.1% are very comfortable in explaining the technical aspects of PV systems and 35.6% are very comfortable in explaining the cost effectiveness of PV systems.

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Table 3: Familiarity with PV Systems– Frequencies and Percentages (N = 205)

	Not Comfortable		Very Comfortable	
	N*	%**	N*	%**
Describing PV systems to your colleague (FAM9)	60	29.3	107	52.2
Describing PV systems to your next door neighbour (Fam8)	65	31.7	103	50.2
Recommend PV systems as an alternate power generation option to your management (FAM12)	66	32.2	91	44.4
Explaining the cost effectiveness of PV systems (FAM11)	87	42.4	73	35.6
Explaining the technical aspects of PV systems (FAM10)	82	40.0	76	37.1

*Number (N) of responses
**Percentage of responses

Conclusion

Results of the study showed that more than a third of the respondents had some level of experience with solar water heating and solar lighting. Between 12 and 17% of the respondents had little experience with PV technologies associated with captive power generation, remote area applications, water pumping, telecommunications and power generation during peak loads. Therefore, efforts must be directed toward providing potential adopters more direct Experience with different PV based applications. Another step is to explore ways of enhancing the vicarious Experience that decision makers have with PV systems.

50% or more of the respondents were comfortable with describing PV systems to their colleagues and neighbours; about 44% of the respondents were comfortable to recommends PV systems as an alternate power generation option to their management; and more than a third of the respondents were comfortable to explain the cost effectiveness of PV systems and to explain the technical aspects of PV systems.

Between 40 and 50 percent of the respondents were familiar with the efforts to demonstrate and use solar lighting and solar water heating. About a fifth of the respondents were familiar with the efforts to demonstrate and use solar water pumping, PV technologies involved in telecommunications and remote area applications. Less than 20% were familiar with the efforts to demonstrate and use PV based power generation during peak loads and PV based captive power generation systems in India. The respondents' Familiarity with the existing efforts to demonstrate and use different PV based applications in India can be increased through appropriate measures taken by the government. Increasing the potential adopters' Experience with different PV systems can enhance their Familiarity levels.

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