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Consumer attitudes towards domestic solar power systems.

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Abstract

The success of the UK policy to reduce carbon emissions is partly dependent on the ability to persuade householders to become more energy efficient, and to encourage installation of domestic solar systems. Solar power is an innovation in the UK but the current policy of stimulating the market with grants is not resulting in widespread adoption. This case study, using householders in central England, investigates householder attitudes towards characteristics of solar systems and identifies some of the barriers to adoption. The study utilises Diffusion of Innovations theory to identify attitudes towards system attributes, and isolates the characteristics that are preventing a pragmatic 'early majority' from adopting the technology. A group of 'early adopters', and a group of assumed 'early majority' adopters of solar power were surveyed and the results show that overall, although the 'early majority' demonstrate a positive perception of the environmental characteristics of solar power, its financial, economic and aesthetic characteristics are limiting adoption. Differences exist between the two groups showing support for the concept of a 'chasm' between adopter categories after Moore (1999). However, if consumers cannot identify the relative advantage of solar power over their current sources of power, which is supplied readily and cheaply through a mains system, it is unlikely that adoption will follow. Recommendations concerning the marketing and development of solar products are identified.

Keywords

Solar power, innovation adoption, consumer perceptions

1. Introduction

In the UK, the use of solar power as a widely recognised energy efficiency measure in domestic situations is innovative, compared with conventional methods, for example loft and cavity wall insulation, or high efficiency boilers (Schonherr 2003). To date it is only being used to generate 13.4 GWh of power, equivalent to the average annual energy use of 3,350 households (DTI 2003). The UK Government has proposed a series of policies to help combat greenhouse gas emissions from domestic use (Boniface 2003), including setting national targets for increasing the use of solar power (Oxera & Arup 2002; Land Use Consultants and IT Power 2001). These targets represent a significant increase from the existing installed capacity and success in the domestic sector will be dependent on private householders adopting the technology. In 2002, the Northamptonshire Home Energy Efficiency Partnership developed a marketing and grant scheme for domestic solar systems, covering both Solar Thermal (ST) and Photovoltaic (PV) technologies. ST systems use the available heat energy to warm

a liquid that passes through a pipe system facing the sun, which is in turn passed through a heat exchange and the heat stored in a thermal store, whereas PV systems convert light energy into electrical current using a charged array. Interest in the technology was high, but despite the provision of grants that reduce the capital cost by up to 50%, very few households actually purchased a system. This research was commissioned to examine consumer attitudes towards domestic solar energy systems in order to identify the barriers to the adoption of solar systems and inform future marketing activity.

2. Solar power systems

Past research shows that both types of domestic solar systems are well-suited to an urban environment, are a proven and effective technology, and offer the opportunity for individuals to make a statement about their environmental beliefs (BRECSU 2001). The systems are also defined as economic (Book 1999), affordable (Berger 2001), compatible with other technologies (Knudsen 2001), able to reduce pollution (Luque 2001), and technically reliable (Cabraal 1998). Timilsina et al. (2000) suggest solar power is attractive at a national policy level because it can reduce national carbon emissions and contribute to the GDP through jobs and income in the manufacturing and engineering sectors and provide an export product.

Solar systems can raise a householder's awareness of energy consumption by means of a monitoring facility provided with the installation. This enhanced awareness of energy use could encourage further energy efficiency. Truffer et al (2001) define this type of efficiency as using 'negawatts'; units of energy never used, perhaps due to intervention by an energy efficient product or more efficient behaviour arising from changing attitudes towards energy use. This type of behavioural change is advantageous to the adoption of solar as it increases the compatibility of the systems with current energy consumption trends. An example can be seen in hot water consumption trends in Denmark, where the average daily hot water demand has dropped from 250 litres per day to 100 litres per day, which matches the daily hot water production of a ST system (Knudsen 2002).

However, despite their positive characteristics, solar systems remain unattractive to individual householders as a home improvement (Timilsina 2000) and incompatible with personal priorities (Berger 2001). Issues such as long simple payback periods, high capital costs and a lack of confidence in the long-term performance of the systems are limiting widespread adoption (ETSU 2001; Timilsina 2000). Knudsen (2001) reports that oversized

systems are often installed which adds expense. Cabraal (1998) proposes that quality service, products and support should help overcome the high initial costs. Oliver and Jackson (1999) state that installed costs are being reduced, however, in later research Luque (2001) concludes that there is very little potential for reducing costs in the future. However, to provide an attractive payback period of less than or equal to ten years, the systems would need to cost approximately £1000 at 2003 UK prices (BRECSU 2001), which would mean a reduction of at least £1500 - £2000. In the case of PV, it is suggested that unless electricity prices rise, or cheaper and more efficient panels are developed, it will not be competitive with conventionally produced electricity (Luque 2001).

3. The Adoption and Diffusion process

The diffusion of an innovation is the process by which it is communicated through certain channels, over time and among members of a social system. The diffusion process has been modelled and theorised over time, and despite some weaknesses regarding the forecasting of adoption and an inherent pro-innovation bias, it has been favourably reviewed. Examples include the Bass model and the Roberts and Urban model (cited in Mahajan et al 1990; Lynn and Gelb 1996; Sultan and Winer 1993). Diffusion of Innovations Theory (Rogers 1995) sets out a practical innovation adoption process. The speed at which an adopter passes along this process is influenced by the attributes of particular innovations, and the propensity of the adopter to accept innovation. The theory has been utilised to model the diffusion of a range of products, for example agricultural products and techniques (Rogers 1995), medical treatment protocols and emergency contraception (Heimburger et al. 2002), and the use of solar power systems (Kaplan 1999; Labay and Kinnear 1981; Velayudhan 2002).

The innovation-decision process (see Figure 1) systematically follows five phases that adopters will follow when deciding whether or not to procure an innovation. Firstly, adopters need to be knowledgeable of a product, and then be motivated to raise their awareness about it. At the ‘awareness’ stage, the adopter is concerned with the attributes of the innovation, particularly any advantages it has over another product. The innovation must possess attributes that are perceived as attractive to adopters, although this level of attraction will vary between individuals as they all vary in their disposition to adopt the products. The awareness stage in the process is the optimal point at which to gain a full understanding of the product attributes and thus overcome any risk of post-purchase dissonance. At the ‘decision’ stage, an adopter can choose to either adopt or reject the innovation, although if adopted, use of the innovation can be later discontinued. The actual implementation of the

innovation follows the decision to adopt, after which an adopter will confirm that the product meets all expectations. (Rogers 1995).

Not all individuals follow the innovation-decision process or adopt an innovation at the same time. To reflect this, diffusion theory identifies five adopter categories as the diffusion sequence unfolds (Rogers 1995). The categorisation is based on consumer personality and behaviour, values and attitudes. Figure 1 shows that adopters are categorised into (a) 'innovators' (2.5% of adopters), (b) early adopters (12.5%), (c) early majority (35%), (d) late majority (35%) and (e) laggards (15%). The theory suggests that the distribution of these categories follows a normal distribution curve, with the first 50% of eventual consumers being in the first three adopter categories. Rogers (1995) proposes general profiles for each adopter category, based on socio-economic, personality and communication behaviour characteristics. The 'innovators' and 'Early Adopters', display characteristics such as more years of education, and a greater knowledge about the technology. Sultan and Winer (1993) challenge the profile of adopters as proposed by Rogers (1995) arguing that there is inconsistency in behaviour across products; that is to say, an 'innovator' for one product may be a 'laggard' for another, suggesting that innovativeness is a relative phenomenon.

Moore (1999) develops the utility of adopter categories by adding the concept of a 'chasm' between the early adopters and the early majority (see Figure 1). The concept of the chasm arises because personality traits between adopter categories differ. 'Innovators' and 'early adopters', who are committed to the concept of the innovation, will put up with inconvenience factors to do with product complexity or lack of performance because they are focused on the long-term benefits the innovation may have. The width of the chasm becomes smaller if the innovation attributes are sufficiently developed to appear attractive to the more pragmatic audience of the 'majority' categories; therefore it is important for manufacturers to develop the products with the earlier adopter categories to make them more reliable and productive. Pragmatic 'early majority' adopters will find innovations attractive when they originate from an established manufacturer, have a recognisable quality, and fit within a supporting infrastructure of products and systems. Pragmatists care about the quality and reliability of service they receive from suppliers. While it appears that the 'early majority' are a more challenging group to satisfy, they are vital for the sustained success of the innovation as they number three times more than the innovative categories.

Garling and Thorgesen (2001) suggest that earlier adopters have developed internal reference prices based on knowledge and competence. In other words, the actual cost of the innovation is not important; what matters is what it is worth to them as individuals. These values can transcend demographic or socio-economic categorisation For example, an electric vehicle will be more readily adopted by an individual who is more interested in improving air quality and reducing demand for natural resources, than by an individual who desires speed and performance. Solar power systems in particular are an innovation designed for reducing pressure on environmental resources and it seems logical that 'green' consumers should be attracted to buy them. However, previous research findings relating to 'green consumers' are often inconclusive and incompatible with the profile of Rogers' adopter categories (Laroche et. al. 2001). Pedersen (2000) also points out that inconsistencies exist within 'green' consumption areas, stating that individuals' purchasing behaviour is not predictable between 'eco-products'. For example, 'green' consumers won't necessarily favour 'green' energy products just because they recycle materials, use 'green' transport or purchase organic food and verbally state that they favour environmental issues.

Several authors agree that the features of the innovation or other environmental features have greater influence on the adoption decision than the adopters' demographic profile (Pedersen 2000; Garling and Thorgesen 2001; Martinez et. al 1998; Lynn and Gelb 1996). However, it has been shown that demographics are useful for understanding perceptions, environmental knowledge and attitudes of 'green' consumers (Diamantopoulos et al. 2003), particularly as these consumers display varying shades of 'green' behaviour (Peattie 2001). In turn, analysis of perceptions can be used to assess the rate of adoption, and time preferences for products (Sultan and Winer 1993). The study of perceptions has been used in marketing research to form the basis for studying motivations and attitudes (Lusk 1973; Auty and Elliott 1998; Hsu et al 2000). Perceptions and attitudes can affect consumer behaviour and innovation adoption. Perception is the process by which individuals make sense of sensations utilising their sensory receptors, whereas attitude is the way that an individual views, or behaves towards an object, often in an evaluative way (Kotler 2003).

Diffusion theory proposes that innovations have five predominant attributes. These are relative advantage, compatibility, observability, trialability, and complexity (see Figure 1). The 'relative advantage' describes the marginal advantage an innovation has over existing products, which can be expressed through a variety of factors. 'Compatibility' describes how the innovation fits with an adopter's values, attitudes and behaviour.

Attributes are also related to how visible the innovation is (‘observability’), or how accessible it is for individuals to use on a trial basis (‘trialability’). ‘Complexity’ is considered as a restrictive factor in adoption, and describes how difficult it is to understand either the innovation, or its principles (Kai-ming Au and Enderwick 2000; Rogers 1995). Consumers develop expectations of products and services prior to adoption based on product attributes, particularly those surrounding ‘relative advantage’, ‘compatibility’, and ‘complexity’ (Dunphy and Herbig 1995; Martinez et al 1998).

Understanding consumers' attitudes towards an innovative product provides two key benefits. First, strengths and weaknesses in the innovation attributes can be identified and managed effectively (Hsu et al. 2000). Second, more control can be imposed on the marketing strategy in order that the innovation is made attractive to the most receptive audience (Auty and Elliott 1998). The marketing strategy can then take into account the step-wise process that individuals take when deciding whether or not to adopt an innovation. However, product manufacturers and marketers must overcome the challenge that consumers' stated behaviour does not always manifest itself in actual consumption behaviour.

Using the knowledge gained from the literature, this project investigated three research questions: Firstly, Do the pragmatic ‘early majority’ have a sufficiently positive attitude towards the characteristics of ST and PV systems which relate to ‘relative advantage, compatibility, complexity, and observability’ that indicates adoption will follow in the near future? Secondly, Is there a significant difference in attitude towards the characteristics of solar systems between the innovative categories (referred to as the ‘early adopters’) and the later, more pragmatic householders (referred to as the ‘early majority’) or within the socio-economic or demographic sub-groups of the ‘early majority that would influence marketing activity? Thirdly, is it possible to identify characteristics of solar power that may be creating the adoption ‘chasm’ as defined by Moore (1999)?

It should be noted that despite there being a difference in the two solar technologies, which will affect the economics of the systems, due to grants in the UK that have become available, the costs of the two technologies are comparable. Therefore, the term ‘solar power’ was throughout the survey process, so as not to confuse individuals who may not appreciate differences in the technology. This is accepted as a limitation in this study.

4. Methodology

Several techniques and methodologies exist that can be used to research consumer views of innovations, or products in the development stage. Of these, either Conjoint Analysis or Kelly's Repertory grid could have been applied to this study. These techniques, which focus the attention of the respondent on the product as opposed to their own needs, can be used to elicit constructs about a product. The critical factor in the choice of technique was that the grid that formed the basis of the survey questionnaire was going to be sent to people who were not familiar with solar power products. Therefore, it was decided that because Kelly's repertory grid derives constructs in an unstructured format, the words and phrases used would originate from non-technical sources i.e. consumers, that the resultant survey would be more accessible because the terminology would be more readily understandable than if the constructs had originated from technical sources. Further, Conjoint Analysis results in constructs being ranked against each other or a pre-determined concept, and the aim of this study was to consider each aspect on its own merit. (For a fuller review of these two techniques see van Kleef et al. 2004). Further research could therefore be carried out using Conjoint Analysis between differing solar products, or investigating the impact of the differing perspective of the products between consumers and technical experts, who so often sell the products.

Kelly's Repertory grid method involves personal interviews, during which interviewees choose three words that they believe describes the product; in this case, solar power. These are noted, and the interviewer asks them to take a pair of the words and describe how they are similar, but different to the third. This is repeated until the interviewee has exhausted all their options, and then another pair is chosen. The process results in a series of descriptor pairs, in which the pairs consist of words or phrases that oppose each other. The added value of this triadic sorting technique (Lusk 1973) is that the respondents own terminology describes the product, as opposed to a technocrat. A semantic differential table is then developed from these responses. This consists of each pair being placed at either end of a line, without guide marks, in order to allow respondents to mark their response freely, the concept being that the stronger a respondent feels about the descriptor, the closer to the end of the line the mark is placed (Dillon et al 1994).

For the purposes of this study, 10 previous adopters of solar power were interviewed to identify the characteristics of solar power. These 10 were chosen randomly from known adopters of systems, from the Solarplan scheme. The survey was tested on 10 other randomly chosen adopters to determine its ease of use.

Following this, 8 descriptor pairs were deleted from the test as they either confused the respondent or their meaning was unclear.

The survey was then used to survey 100 adopters of solar power (the 'early adopters') and 1000 previous adopters of other types of energy efficiency measures, who, for the purposes of this survey were classified as 'early majority'; i.e. pragmatic enough to purchase energy efficiency measures, but not so innovative as to purchase solar power. It should be noted that the 100 adopters of solar power are different to those who were used to develop the survey form. The disparity in sample size is due to the small number of people who have adopted solar power, and the large number who have adopted loft or cavity wall insulation.

On the survey form, the descriptor pairs that describe the characteristics were each placed at either end of a line, and down the form, negative and positive attitudes were randomly placed at either end and realigned for the analysis. As previously mentioned, this line was unbroken so as not to prejudice their strength of feeling. To interpret the point at which respondents marked the line, a clear template was placed over the line, which separated it into 13 unnumbered segments. This number of segments was chosen so it was possible to differentiate scores as clearly as possible. The scores were then given a numeric value from 0-13. The scores from 0-5.99 were viewed as positive, from 6-7.99 as 'don't know', and from 8-13 as negative. The reason for describing the middle scores as 'don't know' is that the survey could not ascertain whether the respondents had no opinion on the characteristic, or whether they did not feel sufficiently informed to answer the question.

Respondents were also asked to provide information about certain demographic and socio-economic factors, namely gender, age, occupation, number of home occupants, household income, location, house type and size, and main fuel type.

The results are drawn from the data generated by the surveys, comparison of the means between the subgroups within the 'early majority' group, and a comparison of the means between the 'early adopters' and the 'early majority' for the characteristics.

5. Results

The results of the interviews and the surveys are presented in this section, which details the descriptor pairs used to describe the systems, the resulting attitudes to each of these, and the difference in attitude between the survey groups and sub-groups identified within the larger survey group.

5.1 Bi-polar descriptor pairs of the technology

The interviews with the adopters of the technology provided 23 bi-polar descriptor pairs of the characteristics of solar power systems. These have been listed in Table 1, and categorised against Rogers' innovation attributes using the generalisations described in that text (Rogers 1995). It should be noted that characteristics are not mutually exclusive within each attribute category. The descriptor pairs mainly related to the attribute of 'relative advantage' (18 pairs), with eleven pairs relating to 'compatibility' and a nominal four pairs relating to each complexity and observability. None of the pairs relate to trialability, which is to be expected, as domestic solar power is not generally considered to be 'trialable' due to its nature. This would be an area worthy of future work, as solar power is well-used in small-scale applications such as calculators and radios, and more recently in street lighting and ticket dispensers and the fact that people do not associate small scale applications to larger applications may be limiting its acceptance as an energy source.

Anecdotally, the profile of the interviewed adopters was similar in that they were either retired or approaching retirement. Their primary motivations for adoption focused on financial or environmental aspects, or a desire to live sustainably. All the interviewees indicated that they had a surplus of disposable income and were considering the long-term benefits of energy efficiency on their future financial position; solar was a method for reducing future expense in the context of the interviewees having a potentially reduced income later in their retired lives. One adopter also indicated the belief that the value of his property would increase by installing a system.

5.2 Attitudes to the characteristics of solar power by the 'early adopters'

The 'early adopters', identified from householders who had adopted solar panels through the Northamptonshire Solarplan scheme, provided 43 complete questionnaires, which provided sufficient data to produce a robust analysis of the results using standard statistical techniques. Table 2 shows the values of the responses of the innovator group (shown in brackets).

As a reminder, the scores from 0-5.99 were viewed as positive, from 6-7.99 as ‘don’t know’, and from 8-13 as negative. Considering the mean value of the responses, the ‘early adopters’ viewed only 4 of the 23 characteristics in a less than positively. Of these four, the issue of ‘payback’ was viewed as a negative issue, whereas the other three characteristics, relating to affordability, visual attractiveness, and available grants to support purchase, were returned as ‘don’t know’. However, given the fact that the respondents had purchased systems, the characteristics were clearly over-ridden in the overall decision process.

In table 1, the characteristics were assessed against the ‘innovation attributes’ as defined by Rogers (1995). The results of the ‘early adopters’ suggest that the attributes of solar meet the expectations of the adopters, sufficiently in terms of compatibility, complexity, and observability, and where the single issue of ‘payback’ occurs in terms of relative advantage, their purchase of the systems demonstrates their overall adoption of the technology.

5.3 Attitudes to the characteristics of solar power by the ‘early majority’.

The survey of the ‘early majority’ resulted in 350 complete surveys (35%), which provided sufficient data for statistical analysis. Table 2 provides the value of mean responses, together with the 95% confidence intervals. In practical terms this indicates that there is a 95% chance that the respondent would answer within this range of scores.

The results show that respondents were positive about 13 of the 23 characteristics to a lesser or greater extent, but returned negative responses to 3 characteristics and ‘don’ know’ to 7. The 13 positive responses focussed predominately on the environmental aspects of solar power, such as its ability to reduce carbon emissions, reduce pollution and generate power cleanly. However, similarly to the ‘early adopters’, they were negative about the payback period, and whereas the ‘early adopters’ returned ‘don’t know’ to the levels of grant available, the attractiveness, and affordability of the systems, the ‘early majority’ were clearly negative. The characteristics that were viewed as ‘don’t know’ related mainly to operational elements of the systems, such as their intrusiveness, their installation and maintenance. This is probably to be expected, as most people unfamiliar with the technology will not know how the systems operate on a day-to-day basis.

The results indicate that 'early majority' consumers do not have a sufficiently positive perspective of the solar systems against the 'innovation attributes' in order for them to pass along the innovation decision process. They have a positive perspective of only 10 of the 18 characteristics relating to 'relative advantage', 8 of the 11 relating to 'compatibility', 2 of the 4 relating to complexity and only 1 of the 4 relating to 'observability'. The implications of this are discussed below.

5.5 Differences between the 'early adopters' and the 'early majority' and differences between sub-groups within the 'early majority' group.

Between the groups' responses to their perceptions of solar power, 14 instances of statistically significant difference arose. However, none of these provided contrasting perceptions, i.e. negative vs. positive. Remembering that mean values under 6 represent a positive attitude, the results show that:

- 7 characteristics showed different levels of positive response, where the 'early adopters' were more positive each time e.g. 'Solar being a home improvement' (3.12 vs. 4.46)
- 5 characteristics showed that while the 'early adopters' were positive, the 'early majority' were 'don't know' e.g. 'maintenance free' (4.98 vs. 6.43)
- 2 characteristics showed that while the 'early adopters' were 'don't know', the 'early majority' were negative e.g. 'Grant levels' (7.31 vs. 8.50)
- Contrary to expectation, the only characteristic that both groups had a negative perspective of, the 'payback, the 'early majority' were actually less negative than the 'early adopters' (9.90 vs. 10.86).

The value of this comparison was to define the characteristics that may contribute to the 'chasm'. This is further defined in section 6.

The second research question sought to investigate whether or not there were differences between responses of the sub-groups of the 'early majority'. Statistically, differences were found using standard tests to compare means of response. However, the comparison of the mean values showed that whilst a statistical difference in response value existed, the actual response did not change, for example all respondents thought that the payback time was too long, but the people aged over 50, thought it was longer than those aged under 50. Other instances of this were that:

- Female respondents were less likely to think that solar would negatively affect the visual landscape,

- People aged over 50 were more likely to think that the payback is longer compared with people aged under 50
- People with a total household income under £50,000 p.a. were more likely to think that solar power appreciated in value more than the higher earners did

This type of information will be useful when considering 'target' groups for marketing, and the type of communication messages used. For example, from the instances found, females are more likely to be responsive to marketing as they have a marginally better perspective than males, so the communication used should target that group,

In conclusion, it would appear to be critical that if solar power is to be adopted, the ''early majority'' must have a positive attitude to it. The results of the survey have shown that while the 'early majority' have a positive attitude to some characteristics, the characteristics of 'relative advantage' particularly the payback, the level of grant support, and the visual attractiveness of the systems are perceived negatively and are thus limiting adoption. In addition, ambiguity towards other operational and aesthetic characteristics as described above may be limiting adoption. In conclusion to the first research question, there appears to be sufficient evidence to suggest that the pragmatic majority, while they may feel positively towards some aspects of solar power, do not have a sufficiently positive attitude towards solar power to be motivated to adopt it.

6. Marketing implications

The conditions explored above lead to some key implications for those who are marketing the systems about the target consumers and the system attributes.

6.1 Identifying the 'chasm' and developing the product

The difference in perception between the householders that have adopted the technology and those that have not is suggested to constitute the adoption 'chasm' (Moore 1999). The results of the survey have shown that between the householders identified as 'early adopters', and those identified as the 'early majority', the 'early majority' perceive to a greater extent than the 'early adopters' that the following statements about solar systems apply:

- That they are unattractive
- That they are unaffordable
- That grant levels to aid the purchase are not high enough

Further to this, the 'early majority' need convincing that:

- That the systems are not too visually intrusive
- That they are maintenance free
- That they may add value to a property
- That the installation of a system may not affect the visual landscape
- That the installation process is simple and with minimal disruption

These perceived characteristics highlight that consumers are unlikely to adopt solar if they perceive it to affect the visual landscape, and to be intrusive. Furthermore, if solar does not bring additional value for the property, then adoption will not be considered by householders who may move home before the 'payback' period ends. Hence, the value of solar to a property is intrinsically linked to the productivity or capital cost of systems, and if these are improved, adoption should follow as more reasons for people to adopt become apparent.

The results of the perception study identified that the 'early majority' have a negative opinion of the simple 'payback' period, which is the single most important limiting factor overall. The current policy of reducing capital costs through grant aid is an easy method of reducing cost, but as the Repertory Grid exercise showed, householders consider capital cost as only one element of the purchase decision. Simple payback is determined by the time taken to recover the capital costs from the revenue gains that the product brings, so reducing prices is one side of the equation, however householders would also like to see improved productivity of the systems and decreasing capital prices, as the technology improves. This, coupled with generous electricity buy-backs for PV systems would enhance the relative advantage and provide the adopter with an income, which would in turn improve the payback period (Bolinger et al.2001). Alternatively, marketing could follow a service-based approach, whereby suppliers install a system for a nominal charge, and energy is paid for as it is supplied. This concept is compatible with previous marketing schemes that have recommended that a 'whole product' view be taken; in this way complementary products are marketed together, for example, highly efficient electrical appliances with PV systems and effective insulation products with ST systems.

6.2 Limitations within the study

As mentioned above, a limitation of this study is that the term 'solar power' is used and solar power is not defined between Solar Thermal and Photovoltaics. In time, when consumers are more aware of the types of technology, this will be an area of work that should be pursued to define whether or not the two are perceived differently. This study focused specifically on attitudes to retrofitted domestic solar power systems. Other solar products are available, such roof-integrated replacement tiles, or laminate systems, which can be used for

domestic situations. These will potentially elicit different perceptions as they both look and perform differently from the retrofit systems. However, the study was based on retrofit systems, as they are the solar power product that householders in the UK are probably most familiar with.

A further point of consideration is centred on the 'don't know' classification, which may have been more clearly defined for respondents if an 'opt-out' box was available in the questionnaire. Several areas for further research have been identified; a conjoint analysis method could be used to determine how adopters perceive different solar products, and secondly, the perspective that manufacturers and suppliers have of the systems may be influencing the marketing methods and terminology used. This in turn could be limiting adoption, as the public cannot relate to it. Future work could also investigate the perceptions that consumers have of small-scale applications of solar power systems, in particular PV, and how it might relate to large-scale application

6.3 General conclusions and recommendations

The study investigated three questions:

- Do the pragmatic 'early majority' have a sufficiently positive attitude towards the characteristics of ST and PV systems which relate to 'relative advantage, compatibility, complexity, and observability' that indicates adoption will follow in the near future?

The answer to this question is that whilst the attitudes of 'early majority' consumers, in the case study area, towards domestic solar power systems are largely positive, they do not hold sufficiently positive views to characteristics of the systems that cover all the innovation attributes, that suggests they will adopt the systems in their present form. If the innovation decision process is followed, the 'relative advantage' of the systems will need to be enhanced, which will require a review of the current policies to grant aid the technology, and improve the financial advantage further.

- Is there a significant difference in attitude towards the characteristics of solar systems between the innovative categories (referred to as the 'early adopters') and the later, more pragmatic householders (referred to as the 'early majority') or within the socio-economic or demographic sub-groups of the 'early majority that would influence marketing activity?

The research highlighted that the 'early adopters' are currently adopting the systems, whereas, unless the attributes of solar power change, or external factors increase their 'relative advantage', the 'early majority' are unlikely to adopt. However, some marginal differences do exist between sub-groups within the 'early majority,

which may influence how marketing messages should be directed and delivered, at a time when solar power becomes attractive to the ‘early majority’.

- Is it possible to identify characteristics of solar power that may be creating the adoption ‘chasm’ as defined by Moore (1999)?

The study found that the ‘chasm’, previously considered by Moore (1999) to exist primarily in the hi-tech sector, is also applicable to other technologies and innovations. The barriers to the adoption of domestic solar systems lie primarily with the financial aspects of the systems. However, with product development, the economic, operational and aesthetic aspects could be improved and by utilising sensible marketing strategies that spread awareness of the innovation and improve its observability, the potential for solar power is greatly enhanced.

Particular recommendations to arise from this study are that:

- Suppliers and manufacturers should work closely with the ‘early adopters’ to develop the operational, economic and aesthetic aspects of the products;
- Suppliers should seek to achieve greater understanding of what customers' perceptions actually are, in order for them to develop products that meet their needs;
- Financial assessments of solar power products should be undertaken, as well as determination of the optimal level at which domestic solar products become attractive to current householders;
- As more solar systems are fitted, further work could determine the differences between the two solar technologies, and types of product within them, such as roof integrated, replacement tiles, or laminate systems:
- Further work should be carried out to develop a sound theoretical base for the concept of the ‘chasm’.

References.

Aggarwal P., Cha T., Wilemon D. (1998) Barriers to the adoption of really-new products and the role of surrogate buyers. *Journal of Consumer Marketing*. Vol 15. 4. pp 358-371

Auty S., Elliott R. (1998) Fashion involvement, self-monitoring and the meaning of brands. *The Journal of Product and Brand Management* Vol 7. 2. pp109-123

Berger W. (2001) Catalysts for the Diffusion of Photovoltaics – a review of selected programmes. *Progress in PVs: research and applications* 9 pp145-160

Bolinger M., Wiser R., Milford L., Stoddard M., Porter K. (2001) States emerge as Clean Energy investors: A review of state support for renewable energy. *The Electricity Journal.* November pp82-95

Book T. (1999) Marketing and selling solar energy equipment. *Renewable Energy* 16 pp. 800-804.

BRECSU (2001) Solar hot water systems in new housing – a monitoring report. Energy Efficiency Best Practice Programme General Information Report 88. BRECSU Watford UK.

Diamantopoulos A., Schlegelmilch B.B., Sinkovics R.R., Bohlen G.M. (2003) Can socio-demographics still play a role in profiling green consumers? A review of the evidence and an empirical investigation. *Journal of Business Research* 56 pp465-480

Dillon W.R., Madden T.J., Firtle N.H. (1994) Marketing research in a Marketing environment. Third Edition. Times Mirror/Mosby College publishing. USA.

DTI (2003) Digest of UK Energy Statistics 2002. Available on the DTI Internet site: http://www.dti.gov.uk/energy/inform/energy_stats/renewables/index.shtml. Accessed 17 April 2003

Dunphy S., Herbig P.A. (1995) Acceptance of Innovations: The Customer is the Key! *The Journal of High Technology Management Research* 6 2 pp193-209

ETSU (2001) Solar Results Purchasing. Contractor Dulas Ltd Prepared by J. Sanders. ETSU S/P3/00273/REP DTI/Pub URN 01/1141

Garling A., and Thorgorsen J. (2001) Marketing of Electric Vehicles. *Business Strategy and the Environment* 10 pp 53-65

Heimburger A., Acevedo-Garcia D., Schiavon R., Langer A., Mejia G., Corona G., del Castillo E., Ellertson C. (2002) Emergency contraception in Mexico City: knowledge, attitudes, and practices among providers and potential clients after a 3 year introduction effort. *Contraception* 66 pp 321-329

Hsu S.U., Chuang M.C., Chang C.C. (2000) A semantic differential study of designers and users product form perception. *International Journal of Industrial Ergonomics* 25 pp375-391

Kai-ming Au A., Enderwick P. (1999) A cognitive model on attitude towards technology adoption. *Journal of Managerial Psychology* 15 4 pp 266-282

Kaplan A.W. (1999) From passive to active about solar electricity: innovation decision process and PV interest generation. *Technovation* 19 pp 467-481

Karagiorgas M., Tsoutsos T., Berkmann R. (2003) The PHILOSOL project: a strategic market development of the ST sector in Southern Europe. *Energy Conversion and Management* 44 pp1885-1901

Knudsen S. (2002) Consumers influence on the thermal performance of small SDHW systems – theoretical investigations. *Solar Energy* 73 1 pp33-42

Kotler P. (2003) Marketing Management. International Edition. Eleventh Edition

Labay D.G., Kinnear T.C. (1981) Exploring the Consumer Decision Process in the Adoption of Solar Energy Systems. Journal of Consumer Research 8 pp271-278

Lusk E.J. (1973) A bipolar adjective screening methodology. Journal of Marketing Research Vol 10. pp202-203

Land Use Consultants and IT Power (2001) Viewpoints on Sustainable Energy in the East Midlands. A study of Current Energy Projects and Future Prospects. Final Report. Land Use Consultants and IT Power. London

Laroche M., Bergeron J., Barbaro-Ferleo G. (2001) Targeting customers who are willing to pay more for environmentally friendly products. *Journal of Consumer Marketing* 18 No.6 pp 503-520

Luque A. (2001) PV market and costs forecast based on a demand elasticity model. *Progress in PVs; Research and Applications* 9 pp303-312

Lynn M., Gelb B. (1996) Identifying innovative national markets for technical consumer goods. *International Marketing Review* Vol. 13 No. 6 pp43-57

Mahajan V., Muller E., Bass F.M. (1990) New product diffusion models in marketing; A review and directions for research. *Journal of Marketing* 54 pp1-26

Martinez E., Polo Y., Flavian C. (1998) The acceptance and diffusion of new consumer durables: differences between first and last adopters. *Journal of Consumer Marketing* 15 4 pp323-342

Moore G.A (1999) Crossing the Chasm: Marketing and Selling High-tech products to mainstream customers. HarperPerennial New York.

Oxera & Arup. (2002) Regional Renewable Energy Assessments. A report to the DTI and DTLR. Oxera Consulting Ltd. Oxford

Peattie K. (1992) Green Marketing. M&E Business Handbooks. Longman Publishing London UK

Peattie K. (2001) Golden Goose or Wild Goose? The hunt for the green consumer. *Business strategy and the environment* 10 pp.187-199

Pedersen L.H., (2000) The Dynamics of Green Consumption: A matter of Visibility? *Journal of Environmental Policy and Planning* 2 pp193-210

Prakash A. (2002) Green marketing, public policy and managerial strategies. *Business Strategy and the Environment* Vol 11 pp 285-297

Rogers E.M. (1995) Diffusion of innovations. 4th Edition. Free Press. New York

Rowlands I.H., Parker P., Scott D., (2002) Consumer perceptions of 'green power'. *Journal of Consumer Marketing* Vol 19 No 2 pp112-129

Schonherr M. (2003) ST in the EU; A renewable energy mosaic. REFOCUS March/April Edition. Elsevier Science. Oxford

Straughan R.D., Roberts J.A. (1999) Environmental Segmentation alternatives: a look at green consumer behaviour in the new millennium. *Journal of Consumer Marketing* 16 6 pp558-575

Sultan F., Winer R. (1993) Time preferences for products and attributes and the adoption of technology-driven consumer durable innovations. Journal of Economic Psychology 14 pp587-613

Timilsina .R., Lefevre T., Shrestha S. (2000) Financing Solar Thermal technologies under DSM programs; an innovative approach to promote renewable energy. *International Journal of Energy Research* 24 pp 503-510

Truffer B., Markard J., Wustenhagen R. (2001) Eco-labelling of electricity – strategies and trade-offs in the definition of environmental standards. *Energy Policy* 29 pp 885-897

van Kleef E., van Trijp H.C.M., Luning P. (2004) Consumer research in the early stages of new product development: a critical review of methods and techniques. *Food Quality and Preference*. Article in Press

Velayudhan S.K. (2002) Dissemination of Solar PVs: a study on the government programme to promote solar lantern in India. *Energy Policy* Article in press.

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The Innovation – Decision process					
1. Knowledge	2. Persuasion	3. Decision		4. Implementation	5. Confirmation
Adopter Categories					
1. 'early adopters' (2.5%)	2. Early Adopters (12.5%)	THE CHASM	3. Early Majority (35%)	4. Late Majority (35%)	5. Laggards (15%)
Attributes of Innovations					
Relative advantage	Compatibility	Observability		Trialability	Complexity

Figure 1. The 3 key components of Diffusion Theory(Rogers 1995), including the point of the Chasm suggested by Moore (1999)

Table 1. Bi-polar descriptor pairs used in the survey, and their categories of innovation attributes (after Rogers 1995)

Positive statement	Negative statement	Innovation attribute				
		R	C1	C2	O	T
Clean	Dirty	*	*			
Reduces carbon emissions	Increases carbon emissions	*	*			
Reduces pollution	Increases pollution	*	*			
Safe form of power generation	Not a safe form of power generation	*	*			
Could develop in the future	Probably won't develop in the future			*		
Solar power is compatible with modern living	Solar power is not compatible with modern living		*			
Will be more widespread in the future	Unlikely to become more popular		*	*		
Generates savings	Does not generate savings	*				
Home Improvement	Waste of money	*				
Provides a visual statement of beliefs	Not a highly visible technology	*			*	
Acts all of the time	Seasonal	*	*			
Solar systems provide a comprehensive solution for hot water and electricity	Normal heating and mains power provides an adequate solution	*	*			
Solar systems are an appreciating asset	Solar is a depreciating asset	*				
The positioning of solar panels does not affect the visual landscape	The positioning of solar panels does affect the visual landscape				*	
Maintenance free	Solar systems needs more maintenance than existing heating systems	*	*	*		
Might help sell a house any faster	Does not help sell a house any faster	*				
Adds value to a property	Does not add value to a property	*				
The systems are hidden away	The systems are intrusive	*	*		*	
Affordable technology	unaffordable technology	*				
Simple to install in a property	Difficult to install in a property			*		
Attractive	Unattractive	*	*		*	
There is a high level of grant available	There is a low level of grant available	*				
Solar has a short payback	Solar has a long payback	*				

Key R: Relative Advantage C1: Compatibility C2: Complexity..O: Observability T: Trialability

Table 2. Values of returns and 95% CI levels for descriptor pairs from the pragmatic survey group (innovator responses are shown in brackets)

Positive statement	Negative statement	Low	Mean	High
Clean	Dirty	1.84 (1.24)	2.07 (1.91)	2.3 (2.57)
Reduces carbon emissions	Increases carbon emissions	1.91 (1.63)	2.12 (2.49)	2.33 (3.35)
Reduces pollution	Increases pollution	1.94 (1.25)	2.23 (1.72)	2.52 (2.19)
safe form of power generation	Not a safe form of power generation	2.08 (1.24)	2.27 (1.60)	2.46 (1.97)
Could develop in the future	Probably won't develop in the future	2.66 (1.59)	2.88 (1.98)	3.1 (2.37)
Solar power is compatible with modern living	Solar power is not compatible with modern living	3.24 (1.59)	3.49 (2.05)	3.73 (2.49)
Will be more widespread in the future	Unlikely to become more popular	3.4 (1.59)	3.66 (1.98)	3.92 (2.37)
Generates savings	Does not generate savings	3.57 (3.42)	3.88 (4.69)	4.19 (5.96)
Home Improvement	Waste of money	4.16 (2.32)	4.46 (3.12)	4.77 (3.92)
Provides a visual statement of beliefs	Not a highly visible technology	4.78 (3.62)	5.1 (4.63)	5.42 (5.64)
Acts all of the time	Seasonal	4.77 (3.60)	5.17 (4.70)	5.57 (5.80)
Solar systems provide a comprehensive solution for hot water and electricity	Normal heating and mains power provides an adequate solution	5.25 (3.56)	5.59 (4.38)	5.94 (5.20)
Solar systems are an appreciating asset	Solar is a depreciating asset	5.29 (4.17)	5.65 (5.00)	6.00 (5.83)
The positioning of solar panels does not affect the visual landscape	The positioning of solar panels does affect the visual landscape	5.99 (3.80)	6.4 (4.95)	6.81 (6.11)
Maintenance free	Solar systems needs more maintenance than existing heating systems	6.09 (3.96)	6.43 (4.98)	6.78 (5.99)
Might help sell a house any faster	Does not help sell a house any faster	6.07 (4.80)	6.43 (5.70)	6.78 (6.60)
Adds value to a property	Does not add value to a property	6.39 (4.47)	6.73 (5.37)	7.08 (6.27)
The systems are hidden away	The systems are intrusive	6.59 (4.37)	6.97 (5.24)	7.35 (6.11)
Affordable technology	Unaffordable technology	6.9 (4.98)	7.23 (6.15)	7.56 (7.31)
Simple to install in a property	Difficult to install in a property	6.91 (4.24)	7.23 (5.32)	7.55 (6.40)
Attractive	Unattractive	7.91 (5.61)	8.24 (6.49)	8.57 (7.37)
There is a high level of grant	There is a low level of grant available	8.15 (6.23)	8.5 (7.31)	8.85 (8.39)
Solar has a short payback	Solar has a long payback	9.6 (10.09)	9.9 (10.86)	10.2 (11.63)