

Optimisation of solar thermal panel use

J.P.R. Williams ¹, Christopher Jones ², and Stephen Beck ³

¹ Student (*Departments of Psychology and Mechanical Engineering*), *The University of Sheffield UK*, *J.R.P.Williams@sheffield.ac.uk*

² Supervisor (*Department of Psychology*), *The University of Sheffield, UK*,
C.R.Jones@sheffield.ac.uk

³ Supervisor (*Department of Mechanical Engineering*), *The University of Sheffield, UK*,
S.Beck@sheffield.ac.uk

Abstract Technologies that are more energy efficient are being sought due to the pressures emanating from: (i) Global Climate Change; (ii) diminishing stocks of fossil fuels; (iii) a massively expanding global population; and (iv) high energy consumption closely linked to modern life. Ensuring that new technologies are adopted by a large proportion of the population is dependent on having a clear understanding of consumer behaviour. One energy efficient technology is solar thermal panels (STPs) which have the potential to supply a large proportion of domestic hot water demand. Focus groups were conducted with three groups of consumers to better understand the public perception of the technology and any socio-economic barriers that might hinder the adoption of this technology. The consumers that were involved in the focus groups were: those that have STPs; those that are interested in investing in STPs; and those that have never thought of investing. There is generally little understanding about how STPs work across all three groups, although this is less of a concern for those that own STPs. There were concerns about the effectiveness and the maintenance of the panels but most participants felt that receiving good information from either the local or national government would dispel any fears. The participants were wary of information originating from companies as it was felt this would be biased to try and sell a product. People were less concerned about their appearance or the fact that water would be heated by the sun. The information gathered in these focus groups can be used to inform a wider study in Sheffield and Thessaloniki to better understand consumer opinions of this technology. From these studies a clearer understanding of local and nation policy, to take full advantage of this technology, can be made.

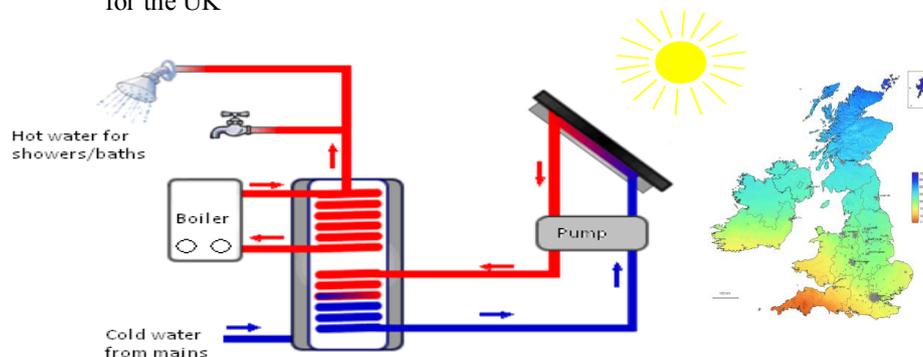
Keywords: *Solar Thermal Panels, Technology Acceptance Model, Focus Groups*

1 Introduction

1.1 Solar Thermal Panels

Solar Thermal Panels (STPs) are collectors that are attached to the roofs of homes with water running through them which is heated by the sun's rays which can then be used in the home for baths and showers (Figure 1). In the UK heating water in homes accounts for approximately 25% of energy used in the home (Allen, Hammond, Harajli, McManus, & Winnett, 2010) and so any significant improvements in the technology used to heat domestic water will have a similarly significant energy improvement. STPs provide this improvement in energy efficiency in the heating of water for domestic use.

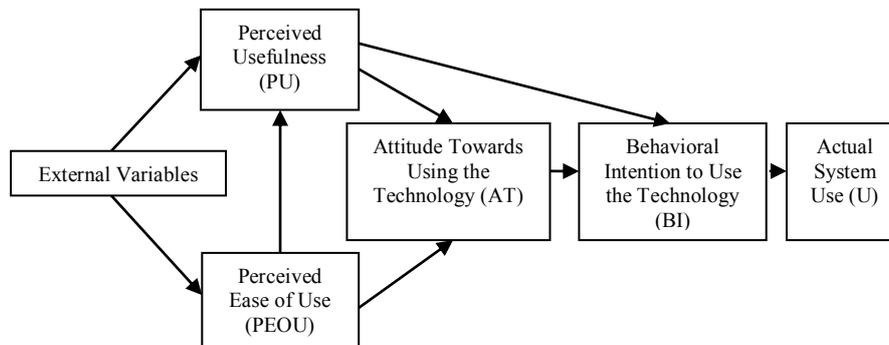
Figure 1: A solar thermal panel arrangement and a map of the solar radiation for the UK



At the start of 2011 there were approximately 100,000 STP systems installed on homes in the UK making it the most used form of micro-generating technology although this only accounted for 1TWh (DECC, 2011). With approximately 27 million homes in the UK this represents only 0.37% of homes in the UK and so there is clearly a large potential for the technology. To help ensure that STP technology is adopted widely a better understanding of the market in the UK is needed.

There are a number of existing models that describe consumer behaviour with respect to innovative technology (Technology Adoption Life Cycle, Diffusion of Ideas, Model of Adoption of Technology in Households) but the model that is discussed here is the Technology Acceptance Model (TAM) (Davis, 1989). The TAM has been applied to a number of technologies since it was devised by Davis in 1989 and is considered a robust model at describing actual behaviour of a technology but has yet to be applied to STPs. The TAM model is shown in Figure 2.

Figure 2: The Technology Acceptance Model (Davis, 1989)



Previous work concerning the TAM has been applied to a large number of technologies in the home (Porter & Donthu, 2006) and outside it (Legris, Ingham, & Collette, 2003). The TAM has been studied in a large number of journals as detailed in (King & He, 2006). It has also been applied to different countries exploring any differences between the nations (Straub, Keil, & Brenner, 1997). However despite its widespread applications the TAM has never been applied to solar thermal panel technology. Previous work concerning domestic attitudes towards solar energy technology has tended to focus on solar photovoltaic technology (Faiers & Neame, 2006) although there has been scant research into consumer attitudes towards solar thermal technology (Woersdorfer & Kaus, 2011).

1.2 Aims of this study

This research was carried out with a few objectives in mind:

- Develop a better understanding of the drivers and barriers to consumer behaviour in the solar thermal panel market;
- Use the improved understanding to better inform a widespread study in the English city of Sheffield and the Greek city of Thessaloniki; and
- Incorporate the findings in to a novel solar thermal panel system.

The work presented here was performed to assess the main themes and opinions consumers had concerning energy used in a domestic setting. By assessing consumer Perceived Usefulness and Perceived Ease of Use a better understanding of consumer Attitudes Towards Using the Technology and their Behavioural intention to Use the Technology can be discerned.

1.3 Qualitative Data

The use of focus groups to illicit public opinions is well established and has been used extensively in the energy sector (Itaoka, Saito, & Akai, 2011; West, Bailey, & Winter, 2010). A main benefit to this approach is that it allows a better understanding behind the 'why' people make the choices they do and how much emphasis is placed on those choices. Focus groups:

'...determine the perceptions, feelings, and thing of people about issues, products, services, or opportunities.' (Krueger & Casey, 2009)

Focus groups are however limited in providing concrete analysis of generally held opinions if results are considered alone although focus groups can significantly direct further research.

1.4 Method

For this study, data came from focus groups conducted at the University of Sheffield after the participants had completed an online survey to distinguish which of the three categories they fell into:

1. Those who have solar thermal panels;
2. Those that do not have but are considering to buy solar thermal panels; and
3. Those that have never considered buying solar thermal panels.

The focus groups were held in groups of four or six with the discussion topics divided into five sections:

1. Introduction to energy;
2. Energy use discussion;
3. Displaying energy use;
4. National/global issues;
5. Solar thermal panels.

The focus groups each had a mix of genders, ages, ethnicities and backgrounds as well as residents with varying housing situations. The audio of the resulting conversations were audio recorded and transcribed for ease of analysis. The computer software NVivo 9 was used to analyse the transcripts of the conversations. The focus groups were led by a moderator who briefed the participants of the received ethics approval for the study and the reason for the focus group. The participants were also briefed about the nature of the present research although no specifics were given.

2 Results

2.1 Introduction to energy

The discussion started with the participants talking about times when they have used a lot of energy in the home, which rooms in the home use a lot of energy, if they had noticed a change in the energy habits recently and if there were any concerns. The participants talked about specific occasions when they had used a lot of energy in the home and all indicated the living room and kitchen as being rooms in the home that predominantly use a lot of energy in the home, mainly due to cooking and the concentration of electrical equipment (such as TV's, stereos etc). This was also thought to be universal across all the groups with the general feeling that people in other countries use most of their energy in the home either in the kitchen or the living room. A few participants were foreign nationals and agreed that people from other countries would use energy in those two rooms as they would be using the energy for cooking or entertainment.

2.2. Energy usage discussion

Many participants talked of knowing they were energy inefficient with electrical items often left on standby rather than being turned off. Electrical items consuming electricity whilst being on standby was a common annoyance ('..especially when the reason for not turning off is because we know it will lose memory'. For the groups that heated their water using gas, leaving electrical equipment on was less of a concern for them, particularly energy efficient light bulbs. It was a common annoyance that the bulbs take a while to fully turn on and that was a reason why they were left on, however there were some dissenters to this viewpoint ('I know it's irritating at the beginning, but that I got used to').

The participants in all the groups were aware that they had recently reduced their energy usage due to a change in energy prices although this was less so in the group of people who had STPs installed on their home as they have a large proportion of their water heated from the sun and therefore haven't been affected as much by changes in energy prices. Energy prices were highlighted as the main reason that people have changed their energy consumption in the past ('I'm not sure that most people are conserving energy for the environment. I think it's more to do with money'. The groups also highlighted that there has been a change in energy consumption linked to both a change in technology and a change in attitudes. An improvement in technology has reduced energy consumption but so has a change in attitude to energy usage, particularly with children ('Sarah comes home and does tell me off for doing things, and then she forgets and does it herself!').

2.3. Displaying energy usage

Smart meters and displays that informed the participants of their energy usage had reduced some of their energy usage. This was felt especially when the cost of the energy usage was displayed. Smart meters were not known across all the groups

however and there was some misinformation about them. However there were positive comments about their usage particularly as energy companies would be more accurate in their charges ('...it's going to put an end to estimated bills as well. They'll know exactly what you're using'). There were even some suggestions of an online website where a constant monitoring ('If there was an automatic system for logging all the meter readings on a regular basis directly onto my computer, that would save a lot of messing around').

People from all groups expressed a desire to have real-time feedback showing an instantaneous reading of how much energy is being consumed and a few thought it would change their energy behaviour ('Knowing how much you are using gives you an idea of how much you are spending, and curbs your energy usage' 'The washing machine and dryer use quite a lot. You knew this intellectually, but actually seeing a number attached is quite illuminating').

People on the whole do not pay much attention to the few places in the home that display their energy usage (electricity meters or gas meters). There was a strong agreement that they would be interested in knowing how much energy the individual devices in their homes consumed. People on the whole only noticed their energy consumption clearly when they paid their bills and although generally positive about smart meters there was a good deal of suspicion of energy companies and intentions of the energy companies installing these meters in their homes.

This suspicion was not reflected in the bills however, as the participants trusted the bills as being accurate of their energy used ('I would like to be able to actually check how much individual devices have taken. I think the bill is just the sum total, and it's very hard to figure out from the bill or the meter, really, where does that come from?'). In the group of participants who had STPs installed on their home they were aware of how much energy they consumed in the home (particularly their electricity usage) with some people sharing their energy usage with others outside their home ('I'm a member of a so-called Carbon Reduction Action... We keep data and compare each with another to see what the effects of particular houses, cars, and ways of doing things might be' 'I actually joined the iMeasure' 'I am a member of the Solar Farm Collective').

2.4. National/global issues

Participants in this section talked about their lack of knowledge of the government's policy towards global issues such as climate change and energy policy ('What the current government is actually doing I don't really understand'). There was agreement across all three groups that Climate Change was being exacerbated by anthropogenic activity. The participants talked about the responsibility of doing something about Climate Change resided with the individual and governments alike. Some participants raised the issue that governments have a problem with short-termism and not seeing beyond the next election so having a coherent policy and an education policy would be crucial to overcome this problem. A 'fear' of the electorate was said to be the reason why governments either did nothing to combat Climate Change or play down its concerns ('I've no confidence that they're doing anything serious').

With regard to other nations it was a general agreement that the UK government should be leading the way of smaller nations as well as larger nations ('If you're trying to persuade the Americans to use less energy the first thing to do is to show that you can do it yourself').

The government, it was felt should play a role in providing good advice to those wanting to invest in STPs and regulating STP companies ('It's like any kind of building work, it should be regulated').

2.5. Solar thermal panels

In the final discussion the first topic was to do with any concerns the participants might have with STPs. The main concerns were: their effectiveness; how much hot water could be produced; and if it would be hot enough to be used for baths and/or showers. These concerns were across all three groups and were shared even by the group of participants who currently own them. Some members of this group were still unsure as to how much hot water was generated by the panels or how they worked but the sentiment was treated light-heartedly by the group ('I think we need a 'solar power for dummies' book, actually!'). Other concerns were about the installation and maintenance of the panels ('In terms of it getting put up there. That'd have to be fairly quick and painless') although the group that has STPs installed reported a positive experience of STP companies ('Very good in our case. A personal relationship almost'). None of the groups were worried about water that was heated by the sun and most liked the idea ('Personally, I think it's a lovely idea).

The appearance was also mostly viewed favourably by Those That Have and Those That Are Thinking of categories with only a few concerns raised ('I like the idea. I don't like the visual impact.' The concerns centred on their appearance on older homes or in areas of particular beauty. There were more people in the Those That Are Thinking Category who found their appearance less favourable ('They are ugly looking' 'Bloody ugly') although this was a universal opinion for the group ('...solar panels, flat on the roof, not much uglier than anything else'). There were a few participants who felt that the appearance of the STPs would not affect their decision as to whether they would invest in the technology.

3. Discussion

The results garnered from the focus groups in this study appear to suggest that there is a link between a consumers perceived usefulness and perceived ease of use and their attitude towards the technology. As a minor study the work presented here can only be viewed in context but it does add weight to the argument that a questionnaire study would provide definitive answers to some of the issues raised. The focus groups also highlighted a good deal of misinformation and distrust of the government indicating that the improved education and availability of sound information to consumers would be advised. To that end further research is advised.

4. Conclusions

This paper analysed and commented on a number of focus groups of actors concerned with the solar thermal panel (STP) market in the UK. The focus groups involved three consumer groups; those that have STPs; those that are thinking of investing in STPs; and those that have never thought of investing in STPs. The focus groups showed that there is a lack of understanding of the technology with regard: its operation; its suitability; the required maintenance; and places where sound information can be received. Those that had never considered investing in STPs were less interested in the technology as a whole and would only install it if they could be guaranteed of its performance. Those that have STPs already installed on their homes were very positive about their experience and were keen to share this experience with others. They had a good experience of the STP companies this was probably due in part to their interest in the technology and their willingness to research the topic and inform themselves. They were less interested in features of the technology such as the appearance and the payback period. Money was a defining issue which would determine whether people would invest in the technology. There was little agreement as to whether STPs would increase or decrease the value of homes and for some that rented they simply did not know whether they could have the STPs installed.

5. Future Work

The work presented here has only started to fully understand the state of the solar thermal panel market in the UK. The qualitative data that has been analysed here can be expanded to encompass other important actors in the STP sector such as companies, politicians and community leaders. Once interviews are conducted with these actors a better understanding can be made of the drivers and potential stumbling blocks to ensuring that this technology is adopted widely. An extensive questionnaire could then be designed to include the work here and be distributed to a high number of households. It is intended that this study will be conducted in Sheffield, UK (population approximately 325,000) and Thessaloniki, Greece (population approximately 550,000). Repetition of the survey in the two cities will provide a clearer understanding of the solar thermal panel market in two cities that are comparable in size but are at different stages of development with the Greek market at least ten years more advanced than the UK market. Any lessons from the Greek market can then be learnt to inform and focus development of the UK market.

6. References

- Allen, S. R., Hammond, G. P., Harajli, H. A., McManus, M. C., & Winnett, A. B. (2010). Integrated appraisal of a Solar Hot Water system. [doi: 10.1016/j.energy.2009.11.018]. *Energy*, 35(3), 1351-1362.
- Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319-340.

- DECC. (2011). *UK Renewable Energy Roadmap*. London.
- Faiers, A., & Neame, C. (2006). Consumer attitudes towards domestic solar power systems. [doi: 10.1016/j.enpol.2005.01.001]. *Energy Policy*, 34(14), 1797-1806.
- Itaoka, K., Saito, A., & Akai, M. (2011). A study on roles of public survey and focus groups to assess public opinions for CCS implementation. [doi: 10.1016/j.egypro.2011.02.649]. *Energy Procedia*, 4(0), 6330-6337.
- King, W. R., & He, J. (2006). A meta-analysis of the technology acceptance model. [doi: 10.1016/j.im.2006.05.003]. *Information & Management*, 43(6), 740-755.
- Krueger, R. A., & Casey, M. A. (2009). *Focus Groups: A Practical Guide for Applied Research*: Sage.
- Legris, P., Ingham, J., & Collette, P. (2003). Why do people use information technology? A critical review of the technology acceptance model. [doi: 10.1016/S0378-7206(01)00143-4]. *Information & Management*, 40(3), 191-204.
- Porter, C. E., & Donthu, N. (2006). Using the technology acceptance model to explain how attitudes determine Internet usage: The role of perceived access barriers and demographics. [doi: 10.1016/j.jbusres.2006.06.003]. *Journal of Business Research*, 59(9), 999-1007.
- Straub, D., Keil, M., & Brenner, W. (1997). Testing the technology acceptance model across cultures: A three country study. [doi: 10.1016/S0378-7206(97)00026-8]. *Information & Management*, 33(1), 1-11.
- West, J., Bailey, I., & Winter, M. (2010). Renewable energy policy and public perceptions of renewable energy: A cultural theory approach. [doi: 10.1016/j.enpol.2010.05.024]. *Energy Policy*, 38(10), 5739-5748.
- Woersdorfer, J. S., & Kaus, W. (2011). Will nonowners follow pioneer consumers in the adoption of solar thermal systems? Empirical evidence for northwestern Germany. [doi: 10.1016/j.ecolecon.2011.04.005]. *Ecological Economics*, 70(12), 2282-2291.