Photovoltaics in the Home:

Exploring the role of domestic PV in the future of UK Energy

Submitted by Daniel Goodchild to the University of Exeter as a dissertation towards the degree of Master of Science by advanced study in Sustainable Development

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I certify that all material in this dissertation which is not my own work has been identified with appropriate acknowledgement and referencing and I also certify that no material is included for which a degree has previously been conferred upon me

Acknowledgements

Abstract

By adopting a mixed methods approach, this dissertation aims to explore the role that photovoltaic installations can play in the future of UK energy. It explores three main themes that contribute to the overall value that PV users derive from their system. These are: the motivations and barriers that potential installers face prior to purchasing PV; the ability of PV and related energy displays to raise awareness of energy issues; and the potential for behavioural changes as a result of PV installation. This study allowed participants to provide feedback on the UK's Feed-In Tariff (FIT), introduced after studies such as those conducted by Keirstead (2006) were undertaken.

In line with other studies, it was demonstrated that having PV increases the tangibility of energy supply (Dobbyn and Thomas, 2005), and that awareness raising technology such as smart meters can play a significant role in reducing overall energy demand (Darby, 2008). The increase in PV adoption has allowed domestic PV to become more socially acceptable, yet further barriers, including doubts about the technology (Palm and Tengvard, 2011) are still noted.

By analysing questionnaire and semi-structured interview data, it is concluded that the economic incentives to installation, provided by the FIT, are playing a significant role in encouraging environmentally aware households to install PV. Despite some flaws in the FIT, the subsequent increases in energy literacy have produced some noticeable double dividend effects, further reducing the demand that adopting households make from the national grid. Nevertheless, participants felt that the high initial investment was still the primary barrier to uptake amongst the 'early majority' of the market. It is recommended that policy should encourage adoption across wider social groups and that every opportunity to increase energy awareness be taken by companies and users.

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Definitions

CHP – Combined Heat and Power

CO_2 – Carbon Dioxide

DECC – Department for Energy and Climate Change

FIT – Feed-In Tariff

GHG – Greenhouse Gas

IPCC – Intergovernmental Panel on Climate Change

NEP – New Environmental Paradigm

NGO – Non-Governmental Organisation

Ofgem – Office of Gas and Electricity Markets

OVESCo – Ouse Valley Energy Supply Company

PAYS – Pay As You Save

PV – Photovoltaic

WREN – Wadebridge Renewable Energy Network

WWF – World Wide Fund for Nature

1.0 Introduction

This chapter will contextualise the research by providing an outline of contemporary issues relevant to the subject area, introducing the aims and objectives of the research, and summarising the structure of the dissertation.

1.1 Why Care about Energy?

Energy is the driving force behind industrialisation and global development. It has been used to enable humanity to achieve seemingly endless technological progression for centuries and its demand seems to be ever increasing. Despite this, the realisation that there exists fundamental shortcomings of continuing to assume limitless energy has meant that governments, NGOs and academics are becoming increasingly concerned with energy discussions.

As Mackay (2009) notes, there are three primary attributes of energy that fuel discussions in the twenty-first century. These are:

- Climate change
- Finite fossil fuels
- Energy Security

All three of these have had significant time and resources invested in them, yet much still remains unclear about the direction in which society is presently heading. Similar confusion also surrounds the direction in which it should head.

The IPCC's Fourth Assessment Report (2007) showed that it is very likely that anthropogenic climate change is having an irreversible impact on global ecosystems through a gradual but significant warming of global temperatures. Much of humanity's contribution to climate change is derived from the combustion of fossil fuels to produce energy. This emits harmful greenhouse gases (GHGs) into the atmosphere, which persist for long periods of time and expose all life on Earth to greater dangers. Governments are committing to reducing GHG emissions through schemes such as the Kyoto Protocol. More recently, the Climate Change Act (2008) has committed the UK to reducing its emissions by 80% compared to 1990 levels by 2050.

Humanity's combustion of fossil fuels can be framed as the depletion of a non-renewable natural resource (Common, 1995). It is therefore evident that, as these supplies diminish, it will become increasingly uneconomical to continue their extraction. This has the potential to cause significant disruption to global commodity prices, therefore creating widespread ramifications across economies (WWF, 2011).

At a national level, securing reliable energy supplies is pivotal for the successful functioning of any economy. At present, fossil fuels are traded between nations on a global scale. If, however, future geopolitical relations become strained, or infrastructure fails, these supplies may be terminated. As such it is often recommended to replace insecure energy supplies with secure ones (Hughes, 2009). For the UK, energy security is particularly important as, due to its island nature, it cannot easily import electricity from other countries (Mackay, 2009).

As the Stern Review (2006) demonstrated, all three of these problems could have a serious impact on all aspects of society. It appears, however, that there is considerable disagreement between academics, governments, and publics over the extent of, and solution to, the challenges mentioned above (Mackay, 2009). The adoption of low carbon energy could contribute to reducing the magnitude of the problems outlined above.

1.2 Low Carbon Energy

Low carbon energy sources allow electricity generation to occur without releasing carbon dioxide or other GHGs into the atmosphere. Whilst nuclear power is a low carbon form of energy generation, uranium resources could still be depleted within half a century (Goodstein, 2004) and the potential for environmental degradation resulting from an accident is vast. Environmental NGOs therefore advocate low carbon electricity from 'renewable' sources such as wind, hydro, and solar power (Greenpeace and WWF, 2008; WWF, 2011). These renewable energy resources offer the potential to provide electricity generation capabilities perpetually, yet typically the technology is relatively expensive when compared to traditional methods, including nuclear power (Mackay, 2009). Nevertheless, the cost of renewable energy technologies will decrease as it becomes more widespread. This is aided by the UK government, which has a

target to provide 15% of their total energy from renewable sources by 2020 (Greenpeace and WWF, 2008).

The majority of this energy will be supplied by large-scale renewable energy power plants, such as the offshore wind farms under construction around the coast of Britain (The Ecologist, 2010). In order to supplement this supply, there is also significant potential for domestic microgeneration to become increasingly widespread in the UK. This is supported by government policy (DECC, 2011a). Technology exists for this to be achieved through the installation of micro-hydro, micro-wind and micro-CHP installations, but it is solar power that has the largest potential, primarily due to its size, ease of installation and favourable public opinion (Devine-Wright, 2007).

1.3 Residential Solar Power

It has been possible to install residential solar power, in the form of Solar Thermal panels, for decades. This is perhaps the simplest and most affordable microgeneration technology available today and, as a result, its use is comparatively widespread. Accordingly, there have been many academic studies surrounding its use (Caird and Roy, 2010; Welsch and Kühling, 2009).

More recently, solar photovoltaic panels have become available. When exposed to light, these panels produce an electrical current, which, once it is passed through an inverter, can then be used at the point of generation or exported to the national grid (Keirstead, 2006). As a result, they have the potential to:

- Reduce demand for electricity from the national grid
- Contribute towards a decentralised electricity network
- Reduce household bills for users

The cost of photovoltaic electricity production is estimated at around four times greater than using oil, gas and coal (Moharil and Kulkarni, 2009). Each individual system is therefore a significant investment for individual homeowners and, without subsidies, estimates of simple payback periods can approach thirty years (Bergman et al., 2009).

Further to the intuitive benefits listed above, the increased tangibility of a households' energy supply can produce additional reductions in overall electricity demand from a household (Dobbyn and Thomas, 2005). This is often a result of behavioural changes made by users which can subsequently affect their decisions in other areas of their lives (Bergman et al., 2009).

The UK government is attempting to increase the energy awareness of the population and the uptake of photovoltaic technologies through two particular initiatives. Firstly, the aim to install smart meters in all homes by 2020 (BBC, 2009) is a clear indication that the government believes that raising energy awareness is beneficial to society. These meters provide increased information to a user and allow greater interactivity between individuals and their consumption of energy. Secondly, the Feed-In-Tariff (FIT) scheme, launched in 2010, promises to pay an installer up to 43.3p for every unit of solar electricity generated by photovoltaic panels over the next twenty-five years. Users can consume the energy generated from their array within their own home, whilst also receiving a small contribution for exporting unused electricity into the national grid. The introduction of this financial incentive has seen payback periods reduce significantly, and many companies now promote the installation of PV for long-term financial gain (southernsolar.com; sungiftsolar.co.uk).

1.4 Research Outline

This piece of research aims to contribute to existing literature surrounding photovoltaic user behaviour within the UK. In order to achieve this, the project will take a mixed-methods approach to establish an understanding of the attitudes towards electricity usage and solar PV power, before and after the installation of solar panels. The following objectives have been identified:

1. To identify variables affecting an individual's choice to install PV panels on their property
2. To explore ways in which awareness of energy generation and consumption has increased as a result of a PV installation

3. To identify common changes in attitudes towards energy usage as a result of increased energy awareness, with a particular emphasis on potential 'double dividends' or rebound effects

By achieving these objectives, it is hoped that the research will highlight some areas where further study should be conducted, as well showing authorities and installing companies how best to achieve greater uptake of photovoltaic systems.

1.5 Structure

Chapters 2, 3 and 4 introduce the literature surrounding user engagement and behavioural change where microgeneration and energy-efficiency technologies are concerned. These focus on the motivations for and barriers to installation, energy awareness, and behavioural changes. Chapter 5 then details the methodology of the project, before chapter 6 presents the analysis. This analysis utilises direct quotes from interview participants in order to reinforce the conclusions that were drawn from the data. Chapter 7 then discusses these results and finally chapter 8 concludes the report.

2.0 Traits of Photovoltaic Installers

2.1 Introduction

In order to fully understand the distribution of renewable energy technologies in the UK, it is important to evaluate the theory surrounding the motivations and barriers to installation. This is especially pertinent to solar technologies as they have been cited as being the most acceptable renewable energy technology (Devine-Wright, 2007). This chapter aims to highlight the findings of research showing that certain individuals have a higher propensity to install renewable energy systems than others. This chapter will also present evidence showing why the technology has appealed to these individuals and will highlight acknowledged barriers to increasing adoption across society.

2.2 Typical Microgeneration Installers

In accordance with the diffusion of innovation theory, it is likely that the majority of current PV users are 'innovators' or 'early adopters'. This is because the technology is still developing, with new users having to contend with large amounts of uncertainty and capital investment. Faiers and Neame (2006) suggest that the majority of photovoltaic installations therefore belong to about 15% of the overall population, with the remainder of the market comprising of 'passive installations'. The authors argue that these active installers show higher levels of educational attainment and typically have greater knowledge about the technology generally. Furthermore, these individuals may adopt a longer-term view of their investment, which helps to negate the potential lack of performance that they may initially experience (Faiers and Neame, 2006).

Bergman et al. (2009) add to the demographical factors typical of photovoltaic installers by showing that they are often wealthier, more likely to be home owners, and older than the average population. It is perhaps unsurprising that studies have also found greater environmental awareness amongst solar energy system adopters (Bergman et al., 2009; Jager, 2006). However, many studies have also argued that social influences have a significant impact on adoption rates (Janssen and Jager, 2002;

Spaargaren, 2000; Welsch and Kühling, 2009). These, along with other motivational influences, are now discussed further.

2.3 Motivations for Installing Micro-Renewable Technologies

As highlighted above, Palm and Tengvard found that "environmental concerns are the main motive for adopting PVs" (2011: 6), a sentiment echoed by Jager (2006). This is to be expected surrounding a form of renewable energy generation, but Palm and Tengvard (2011) also highlighted many additional motivations for installing renewable energy technologies. For example, the authors' study showed that some homeowners used it to distance themselves from the oligopolistic energy industry, whilst others were interested in the technology itself.

Palm and Tengvard also argue that renewable energy technologies are used by their owners symbolically, acting as a "way to show neighbours and friends that it is possible to do something, even as an individual" (2011: 10). It can therefore be argued that these installers have made a conscious decision to espouse their ambition to lead an environmentally responsible lifestyle (Faiers and Neame, 2006) which may lead some households to be "recognised by their neighbours for their civic virtue" (Dastrop et al., 2010). This publicity can, however, deter investment, as some users may wish to avoid such a display.

The most significant concept to be presented by the literature is the influence of others. Devine-Wright notes that beliefs around renewable energy technologies "are 'social' as much as 'personal', dynamic rather than static" (2007: 11). Bergman et al. (2009) showed the importance of social effects by demonstrating that despite cavity wall insulation having a much shorter payback time than double glazing, it is the latter that is more commonly purchased in the UK. This also highlights the secondary benefits of technologies, however, as it can be argued that double glazing provides additional benefits in the form of reduced noise pollution.

Social networks are important because they allow individuals to bypass much of the cognitive effort that decision-making individuals on their own must undertake (Welsch and Kühling, 2009). This can significantly reduce the lead-time of an installation and is therefore likely to increase adoption rates. Similarly, imitation and social comparison

could help to encourage photovoltaic technology to progress along the diffusion curve, especially after the early-adopter phase (Jager, 2006).

For a study of UK photovoltaic capacity, the feed-in-tariff is another important consideration. Introduced in April 2010, the FIT means that potential users can derive financial benefits from the technology. These benefits can be significant if viewed as a long-term investment and media articles have demonstrated that returns on an investment can be over 10%, significantly higher than those offered by banks (*The Guardian*, 2010a; *The Telegraph*, 2010). The FIT makes no concessions for the high price of installation. This is one of many barriers to photovoltaic adoption that are now discussed.

2.4 Barriers to Uptake

The finding that the large financial investment for installing PV is a significant barrier to adoption is supported by a plethora of academic studies (Keirstead, 2006; Luque, 2001; Palm and Tengvard, 2011). This expense is to be expected as the photovoltaic industry is still relatively nascent and, as such, has a typically low price-performance ratio (Palm and Tengvard, 2011). The development of this niche market has been supported through grants and subsidies such as the FIT, aimed at reducing payback periods. Moreover, Dastrop et al. (2010) noted that PV can provide additional value to a house. However, subsidies are not always sufficient. In one study, the payback period was reduced to three years, yet still the adoption rates were significantly lower than expected (Jager, 2006). It can therefore be concluded that finance alone is not the only barrier to adoption.

Doubts about the efficiency of installed technologies, as noted by Palm and Tengvard (2011) can also affect adoption rates. In order to successfully calculate personal payback rates, individuals must trust that their systems are operating effectively (Knudsen, 2002). Reliability issues are also noted as a concern for some authors (Palm and Tengvard, 2011), whereas they are not for others (Cabraal et al., 1998).

Other obstacles are often exacerbated by individuals. For example, Jager (2006) showed that by providing information and support to residents, perceived technical and bureaucratic barriers decreased. This exaggeration of barriers is perhaps derived

from historical problems with companies installing photovoltaic systems and an overall lack of public education in renewable energy technologies (Mrohs, 1998). Finally, it should be noted that there are some barriers, such a lack of a suitable installation site (Palm and Tengvard, 2011), that are almost impossible to overcome.

2.5 Conclusion

This chapter has shown that the majority of photovoltaic users are of the middle-class milieu identified by Welsch and Kühling (2009). This social class is most likely to exhibit traits, such as concern for the environment and homeownership, that are most affected by the motivational factors influencing renewable energy technology adoption. They are also most likely to be able to overcome the barriers facing installation, in particular the high financial outlay.

For other users to install photovoltaics, Faiers and Neame (2006) argued that publics must be reassured that installations are not unattractive or unaffordable, and are easily installed, maintenance free, and add value to a property. Jager (2006) argues that one way of achieving this is through current users acting as 'nodes', helping to disseminate information surrounding photovoltaic technologies. This research will aim to ascertain whether current users have faced the difficulties outlined in this chapter and how they would recommend they be tackled, as well as their individual potential to become social actors.

3.0 The Potential for Awareness Raising

3.1 Introduction

Literature often argues that consumers do not have a thorough understanding of energy usage within the home (Darby, 2010). This is important, as increasing energy literacy is likely to reduce carbon emissions in a shorter timeframe than technological fixes (Darby, 2008). Whilst it is unrealistic to expect complete knowledge to be achieved, an increased understanding could lead to rational action in the form of reduced energy demand. This chapter will present an outline of the arguments concerning this rational behaviour model and ways in which increasing energy literacy can be achieved, for example through home energy displays.

3.2 Benefits of Increasing Awareness

Pyrko and Darby (2011) report that UK consumers have a poor understanding of their energy consumption and that, as a result, it is often difficult for energy conservation to be achieved on a macro-scale. Hondo and Baba (2010) found a correlation between environmental behaviour and awareness of installed PV systems, suggesting that energy conservation could be achieved through initiatives to raise awareness. Furthermore, cost savings for individuals should also ensure that policymakers consider awareness raising as one strategy for reducing the number of fuel-poor households, especially given the recent trends in electricity price rises. These benefits, along with a potential reduction in demand from the national grid, have meant that national government has been the primary driver behind raising energy awareness. These strategies have previously been in the form of antecedent information (Hinchliffe, 1996) but direct feedback mechanisms are becoming increasingly discussed.

3.3 Methods for Awareness Raising

One of the main engineering-based solutions to the problem of increasing awareness has been to encourage the installation of home energy displays in households. Smart meters, for example, allow variable tariffs to be applied to consumers in order to encourage load-shifting behaviour. This is likely to reduce the overall cost of electricity

consumption nationwide. They can also increase the "immediacy and interactivity" of energy usage (Darby, 2010). This enables cognitive learning processes to be undertaken through experimentation with an increasingly tangible household energy supply, something that is vital for habit formation (Darby, 2008). Nevertheless, these displays must remain user-friendly, as consumers cannot be alienated by the devices. UK government is committed to installing smart meters in all homes by 2020 as part of government strategy to reduce carbon emissions (Darby, 2010). This demonstrates the belief of policymakers that increased information provision will lead to rational, energy reducing behaviours.

Whilst energy displays have many benefits, they are still considered an 'energy efficiency measure' by government (Darby, 2008). It is important that they are framed in a multi-dimensional manner by stakeholders, as the potential for learning can have a more profound impact than 'energy efficiency' indicates.

Finally, Hondo and Baba (2010) showed that social interaction can increase the awareness and environmental behaviour of others. These observations further corroborate the socio-technical definition that is ascribed to energy use and photovoltaic installations.

3.4 The Role of Feedback

Abrahamse et al. defined feedback as the process of "giving households information about their energy consumption [or] energy savings" (2005: 278). Van Houwelingen and Van Raaij (1989) suggested that feedback has three main objectives. These are to facilitate learning, habit formation and internalising behaviour. If this chain is followed successfully, it is suggested that feedback will have altered an individual's behaviour permanently.

Despite this positive observation, Van Houwelingen and Van Raaij (1989) also found that in one study, energy usages *increased* compared to baseline levels one year after intervention mechanisms ceased. This effect will be examined further in chapter 4. It is therefore important that feedback mechanisms and incentives persist. In the case of the UK FIT, which guarantees payments for 25 years, it appears that policy has adhered to this recommendation.

As suggested above, electronic displays are the most common method of engagement and the availability of real-time information has enabled this to be defined as 'direct feedback'. Darby (2006) argued that whilst indirect feedback, through periodic billing, can reduce energy consumption by up to 10%, direct feedback mechanisms achieve between 5 and 15%. An additional policy strategy is to provide consumers with antecedent information, for example through information pamphlets, although this is typically less successful (Wood and Newborough, 2003). Whilst these results demonstrate that consequential information relating to an individual's actions is the optimal strategy to reduce energy consumption, Honda and Baba (2010) showed that greater awareness does not always increase environmental behaviour. This could corroborate Fischer's (2004) findings that behavioural characteristics should be treated as heterogeneous. It also suggests that energy displays could have a significant impact on some 'energy-disengaged' individuals, something which is also highlighted by Brandon and Lewis (1999). Further uncertainties surrounding the links between awareness raising and energy use reduction are now introduced.

3.5 Drawbacks

Abrahamse et al. noted that "information tends to result in higher knowledge levels, but not necessarily in behavioural changes or energy savings" (2005: 273). Whilst this observation is worrying for policymakers, Wood and Newborough perhaps present a fairer argument. They suggest that "it can be easier for one person or one household to save energy relative to another" (2003: 823). This allows for social contexts to be included in the understanding of energy consumption behaviours and again warns against creating homogenous strategies to tackle the problem nationwide, suggesting that this may decrease interest in energy saving.

Darby (2010) also noted that raising awareness can produce little improvement where homeowners are constrained by practical or financial limits. Furthermore, some consumers merely "use smart-meter-generated feedback to confirm that nothing out of the ordinary is happening" (Darby, 2010: 453, citing Ersson and Pyrko, 2009). In this instance, a seemingly conscious decision to not change behaviour has been taken even though awareness has risen.

3.6 Conclusion

This chapter has shown that raising consumer awareness is necessary in order to tackle the poor understanding that users have of energy issues. It is suggested that this will promote rational action and therefore reduce or manage energy demand. Whilst both indirect feedback and social influences, primarily through communication, have had some positive results, Darby (2006) showed that direct feedback was the most effective form of simultaneously raising awareness and reducing consumption. Brandon and Lewis (1999) suggest that feedback mechanisms can have the most enduring effect on publics presently unengaged with energy issues but possessing pro-environmental attitudes. This is important as it shows that this group is the one most likely to progress through the model outlined by Van Houewelingen and Van Raaij (1989). This therefore minimises the possibility of a relapse after the 'honeymoon period'. These findings are further supported by Brandon and Lewis, who showed that the greatest impact could be achieved on those "who had done least [to conserve energy] in the past" (1999: 83). Nevertheless, it should be acknowledged that awareness raising can only go so far, and that many environmentally aware households may not be able to improve their energy conservation efforts any further.

The installation of photovoltaic capacity is likely to increase awareness of energy issues for an individual and also provide the opportunity to upgrade existing monitoring technology within the home. This research will attempt to identify the extent to which microgeneration has accelerated this process. Similarly, potential improvements to present metering arrangements will be explored, in order to provoke some discussion on additional mechanisms for engaging users in energy conservation.

4.0 Rebound Effects and Double Dividends

4.1 Introduction

In addition to raising awareness, the installation of photovoltaic capacity is likely to cause changes in the patterns of energy use exhibited by consumers. Much literature focuses on the rebound effect and energy efficiency, but the theory is broadly applicable to renewable energy generation. This chapter will firstly introduce literature surrounding the rebound effect, before discussing the role that consumer preferences play in energy behaviour. Some suggestions to overcome these effects will then be presented. As shown in chapter 3, raising awareness can reduce energy consumption. Further examples of this 'double-dividend', whereby demand reduces as a result of PV installation, are then presented.

4.2 Defining the Rebound Effect

Put simply, the rebound effect can be defined as

> *"The extent of the energy saving produced by an energy efficiency investment that is taken back by consumers in the form of higher consumption" (Herring and Roy, 2007: 195)*

This is because lower prices for a commodity make its use more affordable, increasing the potential amount that consumers can purchase (Herring, 2006). Typically expressed as a "percentage of the expected energy savings from an energy efficiency improvement" (Sorrell, 2007: vi), rebound effects can be viewed as "an outward shift in the production possibilities frontier" (Madlener and Alcott, 2009). This undermines engineering and policy assumptions that energy consumption reductions fully match the efficiency improvements provided by a technology (Madlener and Alcott, 2009).

Herring and Roy (2007) argue that 'non-price induced' gains, such as those derived from photovoltaic panels, should be of the greatest concern for policy makers, as this is where rebound effects are most common. There have been many studies providing empirical evidence of the existence of the rebound effect, and it is these that this report will now focus on.

4.3 Evidence of the Rebound Effect

Existence of the rebound effect appears irrefutable amongst academics (Herring, 2006; Sorrell, 2007), although it is acknowledged that there are still large uncertainties surrounding it (Binswanger, 2001; Sorrell and Dimitropoulos, 2007). The fact that it is omitted from government energy efficiency schemes (Madlener and Alcott, 2009) therefore implies that policy makers have continually overestimated potential energy savings. As a result, Hinnells' (2008) observation that residential energy consumption has risen each year since 1970 is not unexpected. This is in spite of energy saving initiatives such as the *Helping the earth begins at home* campaign in the 1990s (Hinchliffe, 1996). Residential energy consumption could have increased due to a higher volume of housing stock supporting a greater population, but it is still significant insofar as no reductions have been seen.

Empirical evidence for rebound effects to be greater than 100%, otherwise known as 'backfire', has been available for over a century (Madlener and Alcott, 2009) and is still valid with regard to public lighting in Great Britain today (Herring, 2006). On an individual level, the rebound effect occurs in one of two ways. Either consumers reinvest more money into the same energy services, or alternative ones. These two aspects will now be explored.

4.4 Direct Rebound Effect

Perhaps the most intuitive form of the rebound effect is that where consumption of goods increases due a reduction in cost. In economic theory, this price elasticity effect is commonly acknowledged (Herring, 2006) as individuals can obtain greater utility through increasing their overall consumption, rather than maintaining present levels and reducing expenditure.

Whilst Sorrell (2007) presented evidence of some rebound effects, Caird and Roy's (2010) study found that direct rebound effects existed in as little as one quarter of cases. However, more than half of their participants reported that their fuel bills had not reduced by as much as they had expected. This could indicate the presence of subtle direct rebound effects, or, as the authors suggest, that the technology was performing at a lower standard than expected (Caird and Roy, 2010).

Direct rebound effects could have significant implications for government policy, especially in the current period of energy price rises. For example, households in fuel poverty often produce energy rebound effects of almost 100% (Hong et al., 2006). Any policy aiming to reduce emissions through energy efficiency in fuel poor households is therefore likely to have significant rebound effects, as additional energy will be consumed to increase the standard of living, therefore maintaining current emission levels. Ethically, however, it would not be fair to omit households in fuel poverty from energy efficiency schemes, and any system that did so would not be socially sustainable.

Another vital factor influencing policy was highlighted by Madlener and Alcott (2009). The authors noted that by providing grants to reduce the amount of capital needed to be raised by individuals, the rebound effect may increase. Whilst the UK currently operates a feed-in-tariff system, which reduces payback periods instead of upfront capital investment, similar arguments may be presented. By providing support to households that will best utilise the money, subsidies would help satisfy the following Friends of the Earth statement:

> *"The real question is not so much 'how can we be that much more efficient' but, 'how can we ensure the gains from our efficiency strategies are used to deliver real environmental improvements'" (cited from Herring, 2006: 12).*

This highlights the importance of reducing rebound effects in order to achieve overall targets of environmental improvement, but the statement should also include reference to social equity. However, achieving such a target requires an expansion of the rebound effect in order to include other goods.

4.5 Indirect Rebound Effect

Seldom do direct rebound effects consume all of an individual's monetary savings. The increased disposable income that individuals accrue through efficiency savings can therefore be spent on other energy-intensive goods and services (Bergman et al., 2009). The subsequent reduction of efficiency savings is termed the indirect rebound effect. Whilst the exact magnitude is very difficult to quantify (Madlener and Alcott, 2009), it can still be significant.

In theory, combining the direct and indirect rebound effects could allow for the total amount of emission reduction from efficiency savings to be calculated for an individual. It is beyond the scope of this study to attempt this, but it should be acknowledged that any savings will always produce wider 'general equilibrium effects' (Greene et al., 1999). These are strongly influenced by consumer preferences, and the role of consumers will now be explored.

4.6 Behavioural Consumers

The importance of the consumer in energy efficiency, rebound effects, and microgeneration strategies is highlighted by a number of studies (Bergman et al. 2009; Cohen, 2007; Madlener and Alcott, 2009). Additionally, the heterogeneity of individuals (Fischer, 2004) and societies (Throne-Holst et al., 2007) indicates that there cannot be one overarching strategy to suit microgeneration policy. Fischer's (2004) analysis showed that there are at least four categories of microgeneration user, similar to those recognised by Abu-Ghanem and Haggett (2011).

The factors that influence an individual's desire to install microgeneration capacity are also relevant to policymaking. Innovators and early adopters, for example, typically have greater personal motivations for installing microgeneration capacity (Bergman et al., 2009) and so are less likely to follow social conventions than the majority of consumers. Many of these motivations, such as a concern for the environment or a desire to save money, were highlighted in chapter 1.

There are also important implications of microgeneration capabilities on individual consumer behaviour. Dobbyn and Thomas (2005) and Caird and Roy (2010) both found that consumer awareness of energy and efficiency issues was significantly greater, even if only marginal microgeneration capacity was installed in the home. This is important, as many of the participants were from 'passive households' that had little influence in the decision to install microgeneration. Bergman et al. also found this to be true, but added that some participants in their study exhibited "a love of the newfound warmth and comfort of their home" (2009: 33). This is an excellent example of direct rebound and is reinforced by Cohen, who noted that:

"The emphasis [of policy] has been on 'consuming more efficiently' as opposed to 'consuming less' or 'consuming differently' (2007: 58).

It is important that policy should, therefore, aim to increase microgeneration whilst minimising the subsequent increases in demand for energy services, in particular heating and electricity (Hinnells, 2008). Strategies for overcoming rebound effects will now be discussed.

4.7 Minimising Rebound Effects

At first glance, it would appear that there is already a prescribed solution to the problem of the rebound effect and environmental degradation more widely:

"The implementation of a well-designed mix of (mostly) environmental policies can result in a win-win situation for the economy and the environment. Environmental Policy measures primarily geared towards decoupling economic activity from material and energy throughput can be conducive to economic growth" (Giljum et al. 2008: 213).

The main fiscal mechanism for achieving this utopian aim is through taxation to reduce disposable income. Evidently, taxation is unpopular with the public, and thus any taxation increase would need to be counterbalanced by policy elsewhere. These taxes could take the form of carbon or energy pricing strategies (Sorrell, 2007) and the funds should be reinvested in natural capital rehabilitation (Wackernagel and Rees, 1997). Herring frames this argument differently, stating that "the goal should not be taxing energy so we use less, but raising money to pay for the shift towards CO_2 reductions" (2006: 18). Unlike Sorrell (2007) however, Herring only suggests taxing carbon, potentially allowing rebound effects surrounding decarbonised electricity, including nuclear power, to persist.

The use of technology is likely to be central to achieving Giljum et al.'s (2008) objective, something which is likely to be favourable for governments (Herring, 2006). However, Kline (2003) argues that a 'socio-technical system' needs to be created in place of the current passive stance that society often has towards technical fixes. In line with the literature presented in chapter 3, this greater understanding of energy consumption

could result in lower overall demand for electricity (Keirstead, 2006). This is especially true of 'passive adopter' households, who could make significant changes to their lifestyles.

> *"In order for [behavioural] changes to be durable, intrinsic behaviour controls will be important as short-term extrinsic rewards typically only have an influence for the duration of the intervention" (Dwyer et al., 1993, cited in Keirstead, 2006)*

Rudin uses a more moral argument for environmental protection, suggesting that "we should use less energy because it is the right action, not just because someone pays us to do so" (1999). This could be viewed as aligning with the belief that we should aim for energy sufficiency, not efficiency (Madlener and Alcott, 2009). One concept related to energy sufficiency, increased awareness and moral action is that of the 'double dividend'.

4.8 Double Dividends

In addition to Caird and Roy's (2010) study introduced earlier, a number of other studies have found evidence of the installation of microgeneration capacity having a positive influence on energy usage. Keirstead (2006), for example, found that the electricity saving after photovoltaic installation was around 6%. This double-dividend was as a result from load-shifting, electricity conservation efforts and the conscious decision to purchase more efficient appliances. Similarly, Sauter and Watson (2007) showed increased engagement amongst new users. They also, however, identified a 'honeymoon effect', whereby energy behaviours typically reverted back after a period immediately post-installation. Other research also casts some doubt regarding the existence of double dividends. Keirstead, for example, noted that energy conservation behaviours "tended to orientate around the energy type they were producing" (2006; 54). The installation of PV may therefore have little or no impact on household gas usage. Erge et al. (2001) also found a negligible difference in electricity usage between households with or without PV.

Overall, it appears that the research base needs to be expanded before definitive conclusions can be drawn regarding rebound effects and double dividends.

4.9 Conclusion

This chapter has shown that the rebound effect causes absolute energy savings to fall short of engineering estimates (Sorrell, 2007) for two main reasons. Firstly, economic mechanisms, such as the expansion of the production possibility frontier and the substitution effect, cause individuals to optimise their personal consumption patterns. Secondly, human irrationality and behavioural responses further account for digressions between technical predictions and realised savings (Mizobuchi, 2008). As Sorrell notes, "rebound effects therefore need to be taken seriously in policy appraisal" (2007: 87)

Microgeneration could have a key role to play in helping to combat some of these effects as it "can help bring the invisible to life" (Dobbyn and Thomas, 2005: 10). This is vitally important, as it is unwise to assume that technocracy will continue to combat the dual challenges of climate change and energy security (Throne-Holst et al., 2007). By placing microgeneration strategies in a social *and* technical framework, individuals will become increasingly aware of the nature of society's electricity supply. This is necessary in order to preserve current lifestyles (Boardman, 2004) and tackle sustainable development issues on both macro- and micro-scales.

This research will attempt to identify the self-reported extent of behavioural changes, rebound effects and double dividends after individuals install photovoltaic capacity.

5.0 Methodology

This section will explain how the research was undertaken in order to obtain and analyse the data necessary to answer the objectives of the project. As identified in chapter one, these are:

1. To identify variables affecting an individual's choice to install PV panels on their property
2. To explore ways in which awareness of energy generation and consumption has increased as a result of a PV installation
3. To identify common changes in attitudes towards electricity usage as a result of increased energy awareness, with a particular emphasis on potential 'double dividend' or rebound effects.

5.1 Epistemology

In order to answer objectives 2 and 3 above, a longitudinal study would be ideal. However, due to time and resource limitations, this methodology proved infeasible and an alternative structure was taken.

Although this study did distribute a number of questionnaires, these were used to provide an insight into current issues affecting PV users and to present results that could be discussed in more detail during interviews. This study therefore primarily adopted a qualitative research philosophy.

The semi-structured interviews allowed conversational dialogue to be generated pertinent to the research objectives. As Valentine notes, "the aim of an interview is *not* to be representative [...] but to understand how individual people experience and make sense of their own lives" (1997: 110). Interviews therefore allowed the questionnaire responses to be explored and enabled participants to present their own perspectives on relevant issues. The semi-structured nature of the interviews allowed in-depth answers to be obtained, whilst ensuring that participants' responses can still be compared (May, 2001).

5.2 Data Collection

A questionnaire was distributed to ensure that the research sample was of an adequate size and that the study was completed within the time frame. This enabled discourses concerning PV to be identified and allowed good questions to be posed from the outset of the interviews. This also enabled a reduced number of interviews to be undertaken to provide sufficient data.

5.3 Questionnaire Design

The questionnaire (see Appendix 1) used a combination of multiple-choice, Likert-scale and open ended questions in order to collect information on a broad range of user experiences with PV systems (Fink, 1995). In order to achieve this, the questionnaire had seven distinct sections designed to provide an insight into specific study objectives. The questionnaire layout is detailed in table 5.1.

Section	Title	Research Objective
1	Personal and Home Details	1
2	Environmental Attitudes	1
3	PV Installation Information	2
4	Information and Motivation for Installation	1
5	Environmental Behaviour	2, 3
6	Attitudes towards Energy Usage	2, 3
7	Contact Details and Feedback	

Table 5.1. Questionnaire sections and corresponding research objectives

Section 7 was explicitly noted as optional and was used to enable respondents to show their willingness to participate in further interviews. Participants could also request further information about the research in this section. As an incentive, the questionnaire also provided participants with the opportunity to win an Energy Monitor. This draw was done at random and the prize distributed after the completion of the analysis.

5.4 Questionnaire sampling

Due to data protection laws, it was not possible to obtain a database of contact details for significant numbers of participants. Subsequently, organisations were contacted to endorse the study and act as ‘gatekeepers’ in order to distribute the questionnaire. A

recent study conducted by Hondo and Baba (2010) achieved a response rate of 68.5% using this methodology. It was therefore reasonable to assume that a similar response rate could be obtained. Unfortunately, after initially receiving a number of positive responses, only three organisations eventually distributed the questionnaire. Stroud District Council posted questionnaires to households, with the opportunity to return them free of charge whilst Lewes District Council and the Wadebridge Renewable Energy Network (WREN) sent an electronic link to an online version of the study.

Overall, this method of distribution reached approximately one hundred and thirty households. It is possible that these households are similar in nature to one another, as participants' details were on file for specific reasons. In Stroud, for example, participants were part of a 'Pay As You Save' loan trial[1], run in coordination with government (pers comms. 16th June 2011). In this scheme, users were supplied with information about other energy reduction measures they could achieve and thus were not free from external influences. Nevertheless, this scheme significantly lowered financial barriers to installation. This is important for policy, as financial reasons are still a significant barrier to uptake (Keirstead, 2006). Similarly, it is likely that participants contacted by WREN were environmentally aware prior to installing PV, with some already owning other forms of microgeneration technologies.

Lewes and Stroud both have high installation rates of PV, as demonstrated by the number of properties receiving feed-in tariffs for domestic photovoltaic installations[2] (Ofgem, 2011). It should therefore be noted that the populations in these areas are perhaps slightly more aware of photovoltaic technologies than the general population.

5.5 Interview Participants

Twelve interviews, involving thirteen participants, were conducted. This amount was chosen as Guest et al. (2006) showed that after this number, little additional information was gained. Furthermore, interviewing can be time consuming (Seale,

[1] For more information, see http://www.energysavingtrust.org.uk/Home-improvements-and-products/Pay-As-You-Save-Pilots

[2] As of August 8th, 2011, there were 237 properties receiving a FIT in Stroud and 211 in Lewes. This compares to an average of 133 installations per region across England (statistics from https://www.renewablesandchp.ofgem.gov.uk/Public/ReportViewer.aspx?ReportPath=%2fFit%2fFIT+Installations+Statistical+Report_ExtPriv&ReportVisibility=1&ReportCategory=9)

2004). It was therefore decided that, for convenience purposes, the qualitative research would be primarily focused in two locations: Exeter and Lewes. Whilst this is not necessarily representative of the overall population, supplementing these two study locations with additional questionnaires from elsewhere did broaden the scope of the study.

A range of techniques were used to obtain sufficient numbers of interview participants:

- Four respondents to the questionnaire were contacted
- Five households with PV arrays visible on their property were approached unannounced
- Three participants were obtained through a contact of the researcher

Each participant had the opportunity to complete a questionnaire prior to interview, but in order to ensure respondents remained engaged with the project, this was not necessary.

Many participants may be of a similar demographic or social standing, however the results demonstrated many different reasons for installation, so this was not considered a problem. Also, the cold-calling provided an opportunity for some non-self selection to be achieved in the sample.

5.6 Interview Structure

Each interview was conducted in a quiet location of the participant's choosing and was recorded using a voice recorder. Eleven interviews were conducted in participants' homes and one in a university classroom. Similarly, eleven interviews had only one interviewee, whilst one was a couple. If the participant had submitted a questionnaire beforehand, this was examined in order to save time during the interview.

The interviews lasted between twenty and eighty minutes, with the majority around half an hour. By applying theory to the research objectives, the areas of discussion were identified which could facilitate interviewees in providing the most useful data (Valentine, 1997). Subsequently, the interview focused on five key experiences users had with their array:

- Installation
- Lifestyle Changes
- Energy Awareness
- Financial Savings
- Other People

Questions surrounding each of these experiences were prepared prior to interview, although conversational flow was more important than direct answers to each question. In covering all of these topics, the feelings and experiences of participants pertaining to each research objective were obtained.

Each interview was transcribed as soon as possible in order to retain as much of the nuances of the conversation as possible (May, 2001). An example transcript is provided in Appendix 2.

5.7 Data Analysis

As mentioned previously, the data obtained from the questionnaire section of the report was not analysed in detail. Nevertheless, descriptive graphs and tables were created in order to give a broad indication of the sample. Its primary purpose remained to provide discussion themes for the interviews.

5.7.1 Interview Analysis

Initially, content analysis was applied to the interview data. This was firstly coded after a preliminary reading in order to ensure that the data was transcribed robustly.

By relating to literature corresponding to each research objective, topics and phrases were identified and extrapolated from the text. This was facilitated by the interview structure, as the conversation typically addressed each objective in turn. This axial coding allowed dominant discourses and common themes between participants to develop. The majority of these themes were constructed codes, often combining many related strands of discussion, in order to highlight the key ‘meta-narratives’ that became apparent in multiple interviews. In doing this, discourse analysis was also performed on the data. This was used in order to provide a more thorough

interpretation of participants' views and to highlight any contradictions within beliefs and understandings.

The analysis provided key quotes from participants in order to substantiate the conclusions of this research. These are important as they are constructed by the participants themselves, rather than being words deriving from the researcher.

6.0 Analysis

After outlining the research sample, this section will answer the research objectives by evaluating each one in turn.

6.1 Questionnaire Respondents

Questionnaires were collected over a period of six weeks. Three batches of paper questionnaires were received from Stroud District Council and further responses were submitted online from individuals contacted by Lewes District Council, WREN, the researcher, and others.

Forty-eight responses to the questionnaire were received. Of these, 23 were from Stroud District Council, representing a response rate of 59% from the paper-based surveys. Due to difficulties faced by other organisations in ascertaining the exact nature of householders' solar power installations, the number of respondents eligible for completing the survey differs from the number it was distributed to. Therefore, the overall questionnaire response rate of 36.9% is probably an underestimate.

Four online questionnaires were incomplete. The data obtained from these has been used where applicable, but some questions subsequently had fewer responses than others.

6.2 Sample Characteristics

6.2.1 Demographics and Environmental Ethics

The overall characteristics of questionnaire respondents is shown in table 6.1

		Frequency	Percentage of Total
Age	Under 30	0	0
	31-45	9	18.7%
	46-60	18	37.5%
	Over 60	21	43.8%
Gender	Male	31	64.6%
	Female	17	35.4%
Number of Regular Household Residents	1	7	14.6%
	2	26	54.2%
	3	3	6.3%
	4	11	22.9%
	5	1	2.1%
Household Location	Rural	31	64.9%
	Suburban	12	25.0%
	Urban	5	10.1%
Household on Mains Gas	Yes	28	58.3%
	No	20	41.7%

Table 6.1: Socio-demographics of questionnaire respondents

In addition, all households had mains electricity and 77% of respondents had degree-level education. Figure 6.1 (below) shows the household incomes of participants.

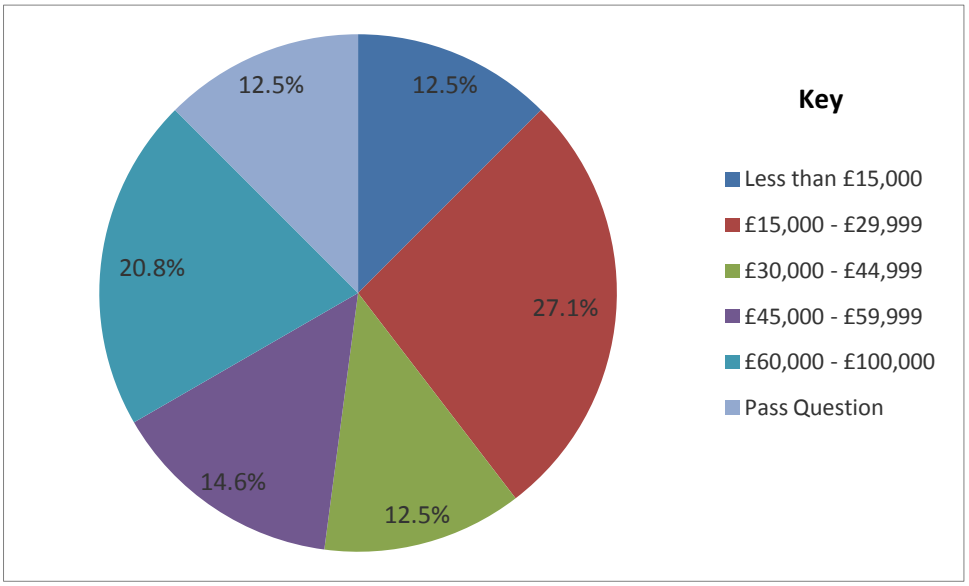

Figure 6.1: Household incomes of questionnaire respondents

As this demonstrates, respondents covered a wide variety of income brackets.

Many households used a variety of measures to heat both water and space in their homes (table 6.2)

Water Heating Methods	Frequency	Space Heating Methods	Frequency
Gas	28	Gas	28
Electricity	8	Electricity	6
Oil	6	Oil	8
Wood	4	Wood	29
Solar Thermal Panels	11	Other	6
Other	6		

Table 6.2: Water and space heating methods of questionnaire respondents

This table indicates that all those with gas used it for both water and space heating. Noticeably, 60.4% of respondents used wood to heat their home, although no distinction was made between using a traditional fire or a wood-burning stove.

Information was gathered on individuals' environmental attitudes. This was achieved using the New Environmental Paradigm (Dunlap and Van Liere, 1978). The results were then recoded so that for all answers a value of '5' represented a 'strongly pro-environmental' stance, whilst '1' represented a strongly anti-environmental belief. These attitudes are presented in figure 6.2.

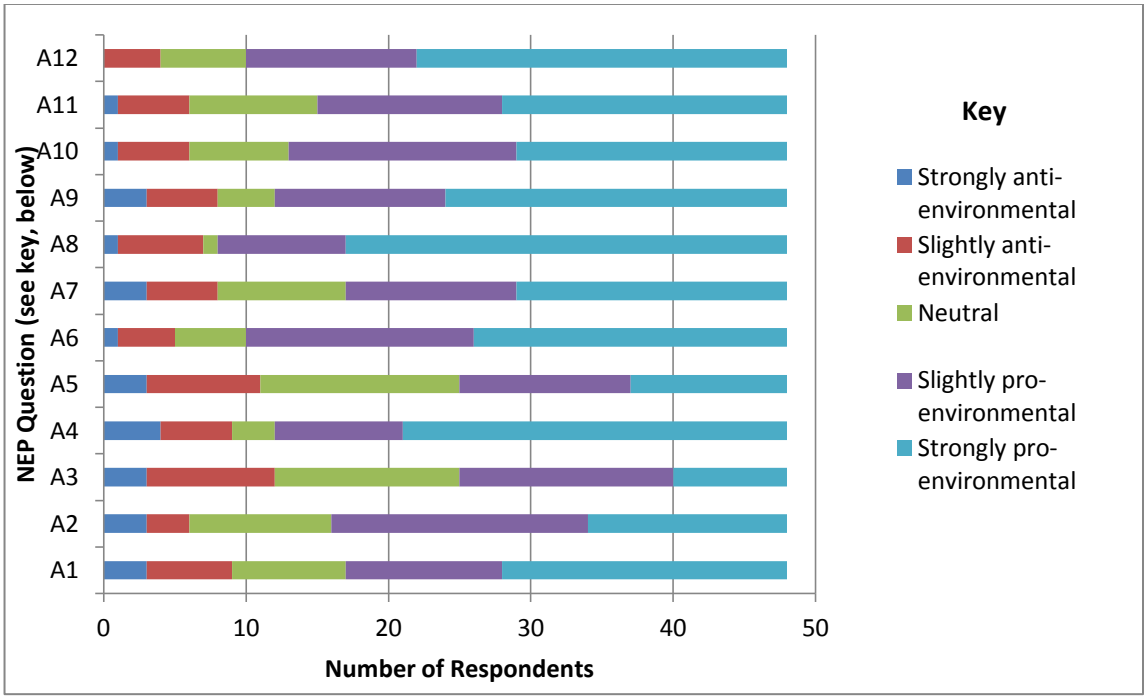

Figure 6.2: Environmental attitudes of questionnaire respondents

Key	Statement	Mean
A1	We are approaching the limit of the number of people the Earth can support	3.81
A2	The balance of nature is very delicate and easily upset	3.77
A3*	Humans have the right to modify the natural environment	3.33
A4*	Humankind was created to rule over the rest of nature	4.04
A5	When humans interfere with nature it often produces disastrous consequences	3.42
A6*	Plants and animals exist primarily to be used by humans	4.13
A7	To maintain a healthy economy we will have to develop a 'steady state' economy where industrial growth is controlled	3.81
A8	Humans must live in harmony with nature in order to survive	4.31
A9	The Earth is like a spaceship with only limited room and resources	4.02
A10*	Humans need not adapt to the natural environment because they can remake it to suit their needs	3.98
A11	There are limits to growth beyond which our industrialised society cannot expand	3.96
A12	Humankind is severely abusing the environment	4.25
Total	Overall Environmental Attitude	3.90

Table 6.3: Key for Figure 6.2, showing statements asked to questionnaire respondents

**denotes statements for which the values have been reversed, in order to ensure that '5' = strongly pro-environmental for all statements*

As this shows, respondents typically espoused pro-environmental values. This may have impacted on the sample's awareness of, and propensity to install, photovoltaic panels.

6.2.2 PV Installations

The questionnaire provided respondents with an opportunity to briefly describe their experiences with their PV installation. Figure 6.3 gives the average period of time participants had been using it.

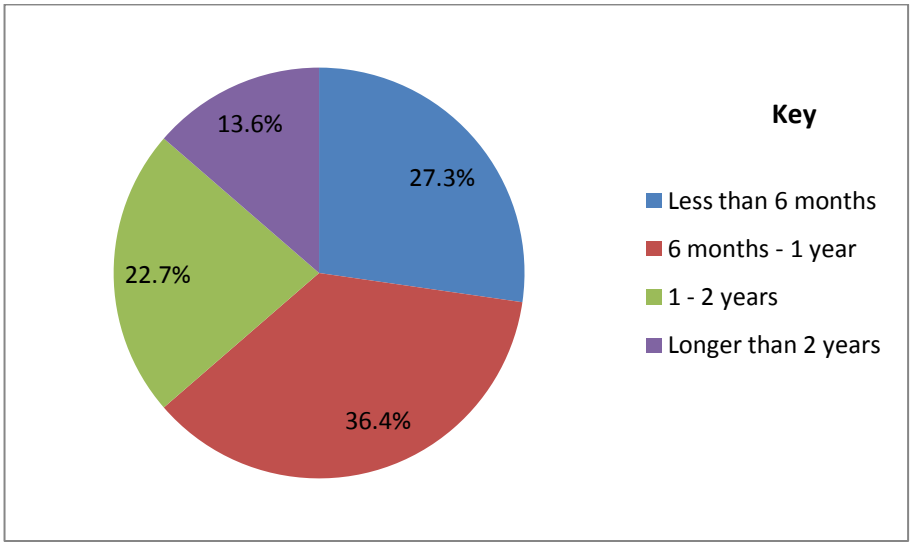

Figure 6.3: Age of PV installation for questionnaire respondents

As the FIT scheme only began on April 1st 2010 (DECC, 2011a) 13.6% of respondents installed their array prior to the start of the subsidy scheme.

Information surrounding how users funded their installations was also collected. This is presented in figure 6.4.

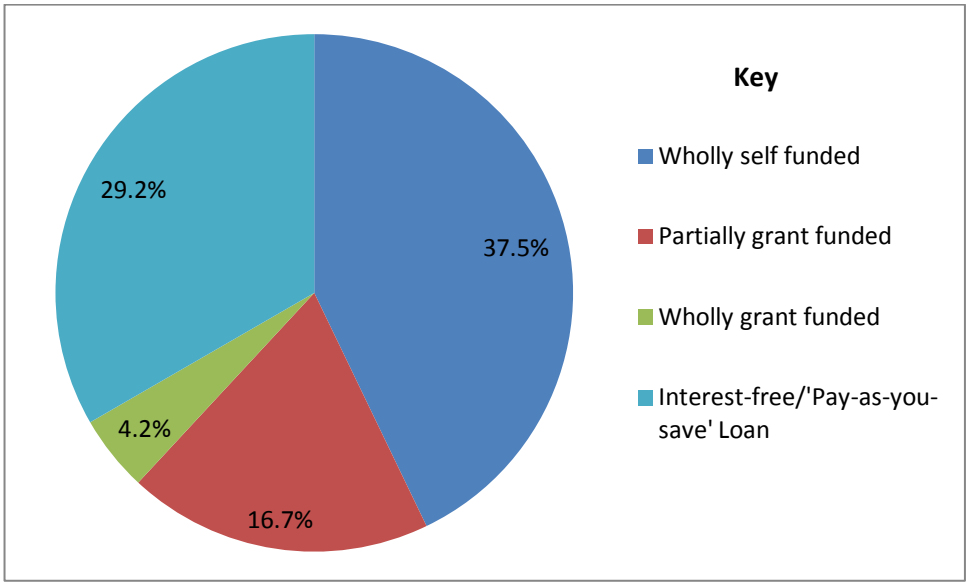

Figure 6.4: Methods of funding for PV installations of questionnaire respondents

No users had their panels funded by a third-party installer. The high proportion of interest-free loans is due to the number of responses received from the Stroud District Council scheme. In addition, all respondents decided to install PV themselves, indicating that none of the questionnaire sample are 'passive installers'.

Further quantitative information is presented throughout the remainder of this section.

6.2.3 Interview Participants

Thirteen participants were interviewed and were broadly representative of the questionnaire sample:

- All were homeowners living within towns and villages near to the two study locations

- Two participants had partially financed their installation through grants, the remainder fully financed the investment
- The majority were over sixty years of age, although some still had (adult) children living at home
- Some younger participants had young children, whilst others were living with their partner
- Four interviewees had also installed solar thermal capacity, whilst five had wood burning stoves. A number of others were considering installing these technologies
- Two participants had installed their array prior to April 1st 2010

6.3 Identifying Variables affecting an Individual's Choice to Install PV Panels

6.3.1 What makes an individual install PV?

The questionnaire allowed respondents to rank the motivations for installing PV capacity on their property. Figure 6.5 shows the sample's motivations for installing PV, ranked in order from least important to most important.

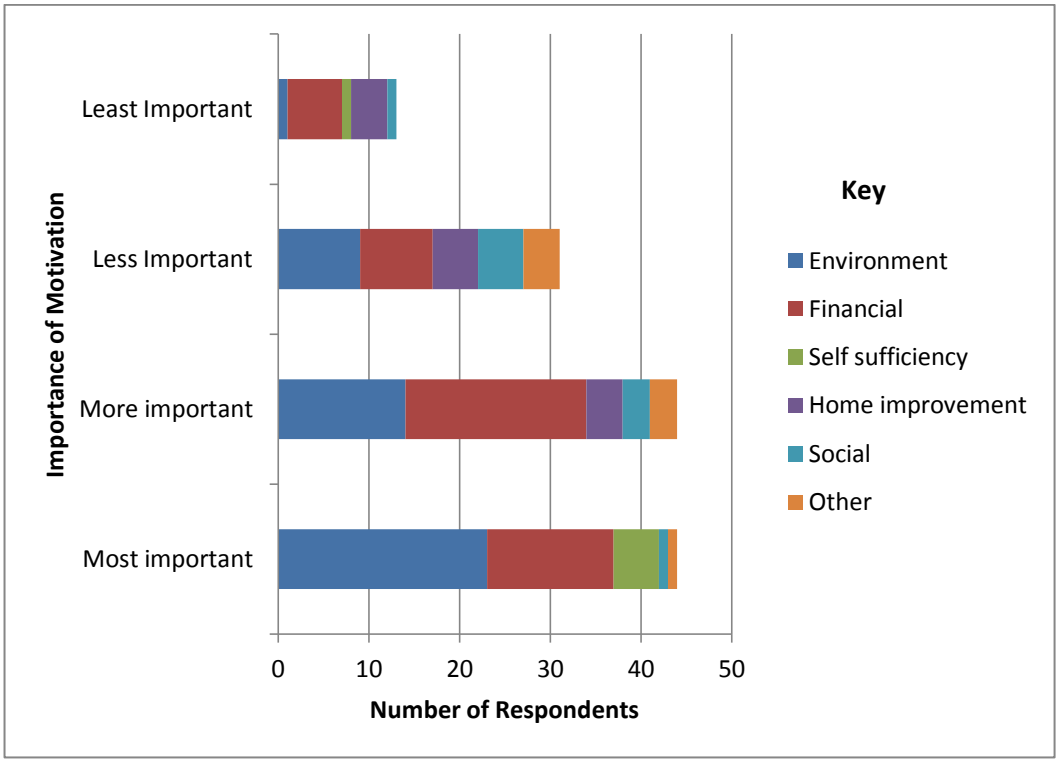

Figure 6.5: Chart showing questionnaire respondents' motivations for installing PV, in order from least important to most important

As this demonstrates, environmental drivers were the primary incentive for PV installation. Financial incentives were more commonly reported as the secondary driver across the sample and these two factors comprised 80.7% of the first two motivations.

The interviews showed that environmental values often engaged the participant in PV, whilst economic factors convinced them to invest in it financially:

> *"I think the environmental thing came first, and then all the other benefits kind of just encouraged one to spend the money [on PV] rather than elsewhere"* (Participant 11)

This reinforces the findings of the questionnaire (figure 6.5) and many participants espoused environmental concern and energy supply issues as drivers for installation:

> *"I think that the only reason we ever thought about it in the first place really was for environmental reasons"* (Participant 12)

> *"We're concerned about global warming and exhausting fossil fuels"* (Participant 8)

Similarly, one participant felt that installing PV would offset their high environmental footprint in other areas:

> *"I feel that I'm being rather unfair [...] warming a house of this size to perhaps a higher temperature than younger people would need [...] I thought if I generated some electricity it would be partial compensation for my consumption of gas"* (Participant 2)

Conversely, when asked about their drivers for installation, some participants' responses demonstrated that they were not particularly environmentally friendly:

> *"Not terribly, no"* (Participant 1)

For these users, financial reasons were the primary driver:

> *"Economically, you can't argue against it. And that's what convinced me to invest"* (Participant 13)

Even for users that demonstrated strong pro-environmental values, it was often for economic reasons that the panels were installed:

"From an investment point of view, there was no way you could invest your money any better" (Participant 12)

"[I wanted] to limit my expenditure on electricity for the next 25 years and I saw that as an alternative pension plan. The greater control I have on my outgoings or the more I can minimise my outgoings the better for me" (Participant 10)

This indicates that economic mechanisms are successfully stimulating demand in those users who were previously only 'engaged' with the technology for environmental reasons.

It is likely, however, that there are users who would have installed the technology regardless of economic benefit. For example, two questionnaire participants reported that they received no FIT, indicating that these users could have installed PV for other reasons such as the environment, home improvement, or symbolic motives. Similarly, one interviewee argued that the financial return was only an additional benefit, not a driver for investment:

"We would've done it anyway for environmental reasons if the cost hadn't been too much, but the added bonus of having the FIT payment and it making a good deal of economic sense - that inspired us to do it straight away rather than waiting around" (Participant 5)

6.3.2 Difficulties facing installation companies

The research provided evidence that installation companies face many challenges. It showed that users became aware of the possibility of installing PV through a number of methods. For example:

"I read this article in the Daily Telegraph which said if you've got ten or fifteen thousand pounds in the bank getting virtually no percentage you'd be better to stick them on the roof" (Participant 1)

"We were actually approached by someone from one of the specialist companies it turned out who...I think it was a cold call" (Participant 8)

No participants claimed to have followed up on traditional marketing techniques, such as leafleting.

Similarly, participants also showed some scepticism in the behaviour of salesmen:

"And of course he shot a line [...] it's all a great con trick" (Participant 2)

This mistrust of marketing techniques meant that researching both PV technology and the companies which install it, was typically done by individuals independently.

Similarly, it appeared that users were often unsatisfied with local installers. This was shown by the noticeable difference between individuals who used local installers to research PV themselves, and those who would recommend this action to others (figure 6.6).

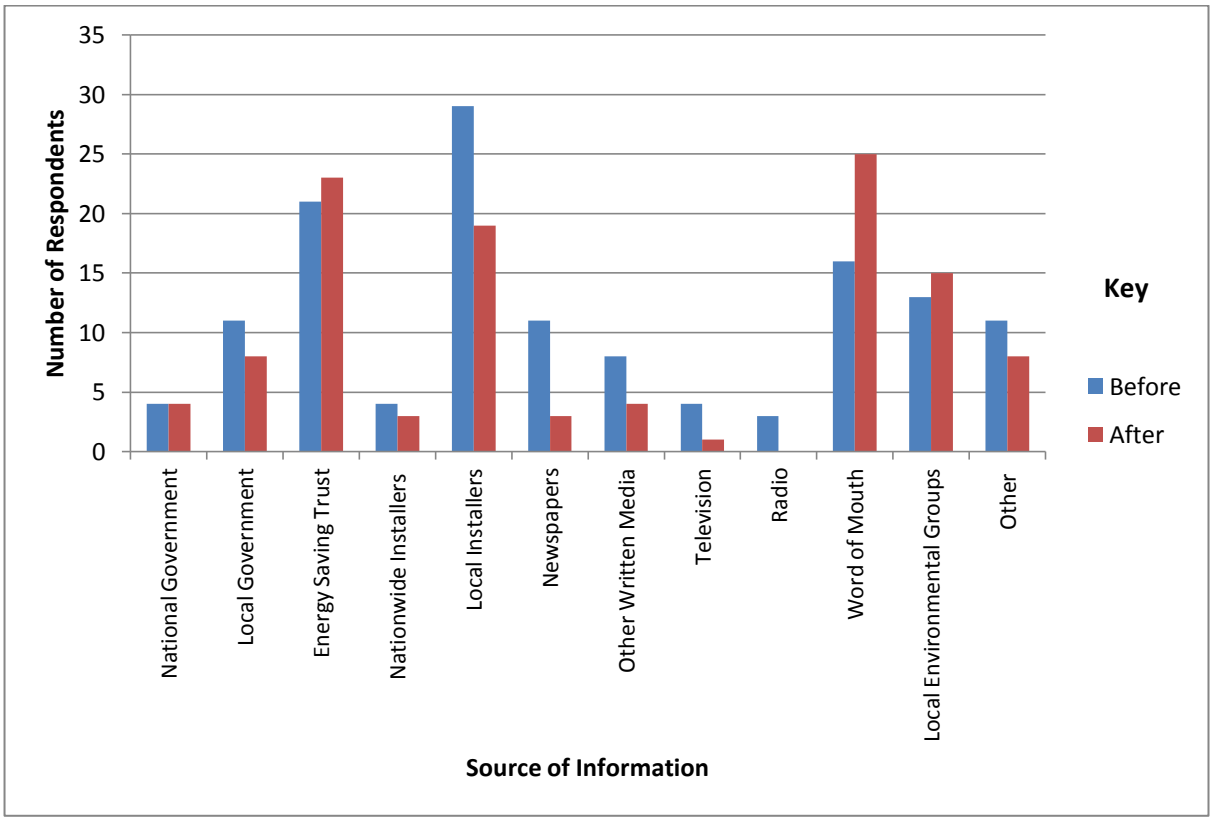

Figure 6.6: Sources of information that questionnaire respondents used to research PV prior to installation, and those that they would subsequently recommend to others

These responses also show that 'word of mouth' was the most commonly recommended source by users. This indicates that social discourses may play an important role in future technology dispersion. Furthermore, the importance of independent information provision and trustworthiness was highlighted by the common recommendations of local environmental groups, such as WREN and the Severn Wye Energy Agency.

Additionally, many interview participants identified that there is often little differentiation between installers and therefore the lack of research was unlikely to make a difference:

"Even if I went and looked at half a dozen companies, there's not going to be any great differences between them" (Participant 2)

"I bet it's like comparing, you know, utility companies: there's some where you'll get a better...a cheaper price but you won't get so much good kit or [...] it'll take longer to do it or there'll be more disruption" (Participant 8)

These observations show the challenges that marketers often face when trying to attract new customers. If all potential customers also identify with this lack of differentiation, this could suggest a perfectly competitive market. Further analysis, however, shows that some differentiation does occur for many users.

6.3.3 How to decide which company to use?

As noted earlier, the number of people who would recommend researching PV through installation companies decreased when compared to the number that had used them in their own research. One questionnaire respondent suggested that organisations were too forceful in their sales techniques:

"Some companies who came to do quotes made me feel as I was being "sold to" rather than giving me useful answers to my questions. I was not treated as an intelligent person!" (Questionnaire Respondent 6)

Interview respondents had very clear ideas of desirable traits when searching for a professional installer. Typically, these revolved around two points: the organisation's location and operating area; and their professionalism:

"I decided it would be nice if I could find a local firm" (Participant 1)

"There's a local company we contacted to sort of find out more about it, get a quote from them and they were just incredibly helpful and obviously knew what they were talking about" (Participant 5)

It is evident why professionalism is important in decisions involving large expenditure. The reasons why local installers were preferred, however, were less obvious. One respondent suggested that it was to promote local economic resilience:

"They used local people" (Participant 1)

Another possible explanation is that other people were likely to recommend local companies, presumably because of their continued presence in an area. These recommendations were the other main factor influencing decision making:

"Somebody I knew recommended the installers and so we went with them" (Participant 9)

"I think the fact that somebody else had used them" (Participant 1)

6.3.4 The influence of others

The role of social networks was also explored during the interviews. For some individuals, asking other users was a vital part of their research:

"I talked to a number of people and I went to see some of the Eco Houses [...] to see what they'd done and try to gauge the...you know...the successes of their installations" (Participant 10)

For others, installing PV was a way of promoting an environmental ethic:

"I'm not really too bothered about keeping up with the Joneses. But it's nice [that it] sorts of demonstrates our ethic and [...] if it influences other people...I mean being able to see that people are putting these on their houses and that it looks great and it's becoming quite a usual thing to do rather than something for loopy-do greenies to do then that can only be a good thing" (Participant 5)

Indeed, the majority of participants noted that the response to their installations from third parties had been predominantly positive. Overall, there was a willingness to encourage others to install PV:

"Anyone who asks me I'll very gladly tell them about it and be enthusiastic" (Participant 10)

"I mean we big it up whenever somebody asks about it because I think, genuinely think, it's a great thing – if you have got the dosh, you know? (Participant 11)

Despite this, few participants reported successfully encouraging others to invest in the technology, and the interviews allowed users to elaborate on what they felt were the main barriers to installation. Current users provide a useful insight, as they have overcome many of these barriers themselves. Unsurprisingly, cost was the most commonly cited barrier:

"We'd paid off the mortgage so we had a bit of capital [...] I suspect a lot of people don't have [spare] capital that they actually have to decide what to do with it" (Participant 8)

"I think for most people, you know, the initial cost is the major stumbling block...because unless you have that amount of money available, it doesn't matter what you feel" (Participant 9)

Ignorance about the technology or installation process was also cited:

> *"I think there's a load of things people don't understand [...] loads of people think that the electricity you generate, you're generating all the time, doesn't matter what the weather's like"*(Participant 12)

> *"A lot of people think [...] that it's a complete nightmare to have installed and they'd have to wreck their entire roof et cetera. So they're often really positive about [...] how easy it is and all that kind of stuff"* (Participant 11)

The latter quote shows that social contact can improve potential installers' opinions of the technology, yet it is apparent that other barriers remain. Further obstacles cited included short-termism, and one user felt that all of these barriers combined to make the cognitive investment in PV too great to overcome them:

> *"And they see all those little bits and pieces [and it creates] a sort of 'can't be bothered' attitude"* (Participant 4)

Despite this, users generally felt that PV markets would develop, and that current users had an important role to play:

> *"It's very important to see that other people are doing it, both from a fitting in socially point of view but also from an economic point of view. [...] I think that other people like to know that they're not going to be the guinea pigs"* (Participant 5)

6.3.5 Conclusion

This section has shown that environmental concerns are not the sole reason for the increase in the uptake of photovoltaic installations. It has been shown that the FIT has significantly increased individuals' propensity to install PV, to the extent that some users report little engagement with environmental concerns.

The merits of social groups, including environmental movements, are apparent and their recommendations are often viewed as more trustworthy than private installers during the research process. Current users seem to be keen to play a proactive role in the development of the photovoltaic market, yet often there are unavoidable barriers prohibiting investment. These include practical issues regarding installation, financial outlay, technological ignorance and apathy. When consumers were researching installers, their locality and personal recommendations were important factors in

engaging customers initially, whilst professionalism was important later in the installation process and for encouraging further recommendation.

6.4 To Explore Ways in which Awareness of Energy Generation and Consumption has Increased as a Result of Microgeneration Capacity Installation

The potential for consumer engagement in energy consumption becomes apparent when the questionnaire results are viewed. Of the self-reported behaviours in part five (see table 6.5, below), 'Monitor your energy usage' was the sole behaviour that was reported as increasing by more respondents than those answering 'no difference' by approximately a three-to-one ratio. This immediately shows the main impact that increasing the tangibility of energy issues can have on an individual. This section will examine how raising awareness occurs and what is stopping some users from becoming engaged.

6.4.1 Where are meters installed?

Table 6.4 provides some information regarding users' electricity meters.

Question	Answer	Frequency	Percentage of Total
Have you installed a new electricity meter?	Yes, a digital one	20	41.7%
	Yes, an analogue one	1	2.1%
	No	23	47.9%
	Missing answers	4	8.3%
Where is the meter located?	In a prominent household location	37	77.1%
	In a difficult to access location	11	22.9%
	Don't know	0	0%

Table 6.4: Questionnaire respondents' electricity meters

Many of these new electricity meters are likely to have been installed because old ones were running backwards (eg Participants 1, 5 and 10). Installing new meters presents companies with the opportunity to engage homeowners in energy consumption by providing new, more engaging models. The potential for engagement is further

increased for the majority of users who reported that their meter was in a prominent household location.

For many interview participants, meters were installed in garages or cupboards. This was rarely seen as a problem:

> *"Having a meter nearer or something wouldn't make any difference"* (Participant 2)

For users with meters in difficult to access locations, engagement was much more difficult. One participant showed the contrast between engagement with their consumption meter and their generation meter, which were located away from one another:

> *"[The generation meter]'s on the wall in the garage [...] I'm kind of obsessed with it"*
>
> *"[The consumption meter is] never observed. I mean it's under the stairs. The only way to get to it is to crawl under the stairs with a torch"* (both Participant 12)

The installation of meters in easy-to-access places should therefore be encouraged in order to increase user engagement in energy matters.

6.4.2 How are the meters used?

The questionnaire results showed that many users have suggestions of how to improve their metering system:

> *"[The meter should] show a net result i.e. electricity produced less electric used at any time"* (Questionnaire Respondent 28)
>
> *"Combine the generation meter with our electricity meter so that generated and used electricity can be compared"* (Questionnaire Respondent 6)

Whilst this technology (in the form of import/export meters) exists, it is likely that it is currently prohibitively expensive for individuals or energy companies to justify its installation. The rollout of smart meters within the UK is also more likely to get government attention.

One interesting observation was that the novelty of having an electricity meter go backwards seemed to significantly stimulate interest in energy usage:

> *"No, to be honest, I don't keep an eye on my energy use...as I say I did when it was going backwards and I was keeping a daily record of how it was reversing [...] In fact, having had the meter go backwards for a few weeks, I became more aware of what does use power quite a bit"* (Participant 7)

Once more, this shows that engagement can produce energy demand reductions, however this engagement period is often short. Indeed, 'honeymoon effects' of this sort were identified by participants themselves:

> *"At first we'd be checking them every day"* (Participant 5)

In contrast, some users have successfully integrated energy monitoring into their daily routine:

> *"I generally do it now in the evening and take all three lots [of meter readings]"* (Participant 3)

If users retain the knowledge that they can gain from a period of heightened consumption engagement, then overall energy demand reductions are likely to be achieved. This was demonstrated best by one user who had already used smart meters and acted upon the information in order to save energy:

> *"In my previous house [...] I made a number of changes as a result of having that Eco-Eye [energy] monitor...for instance I discovered that my freezer, which was 20 years old and had a broken thermostat, was hugely inefficient, so I bought a new fridge-freezer. I also limited [...] the extent to which I use my electric oven and the kettle as much as I could. [...] I've carried on knowledge from the previous house."* (Participant 10)

6.4.3 Non-engagement

Some users of PV still faced barriers to increasing energy awareness. These included meters in difficult to reach locations, energy saving gadgets (such as energy monitors) not working and technological complexity:

> *"So sophisticated I haven't quite mastered how you get it to work for you rather than to save the world"* (Participant 8)

Overall, however, most users could still quantify their electricity generation but were less concerned with their consumption:

> *"Not a very close eye, but we were aware that we were getting very high bills because this is quite a big house"* (Participant 6)

Once more, the necessity of the import/export meter was raised:

> *"In terms of energy usage it makes it quite hard to keep track, because obviously we're measuring what we're importing from the grid, but that's a part of what we're using because some of what we're using is generated by the panels"* (Participant 6)

6.4.4 Conclusion

It has been shown that by installing PV, users typically increase their energy literacy. This is achieved through metering systems for both generation and consumption purposes. Nevertheless, the magnitude of a user's awareness can differ to a great extent. This is often a result of daily routine, ease of access to monitoring equipment, and technological variables. The latter two points should be of note to policymakers and energy companies, as the replacement of old, difficult to access analogue meters with informative, pertinent smart- and import/export meters could raise awareness amongst users. Despite the 'honeymoon periods' identified by some participants, it appears that behavioural changes can be achieved in short engagement windows. Therefore the decline in engagement after a period should not be viewed as justification for failing to raise awareness.

6.5 To identify common changes in attitudes towards energy usage as a result of the PV, with a particular emphasis on double dividends and rebound effects

This section will explore the evidence for the presence of rebound effects or double dividends during this research. It should be noted that these are self-reported behaviours, and thus are susceptible to influences such as social desirability bias.

6.5.1 Evidence of Double Dividends

The questionnaire asked respondents to rate their behaviour for a number of environmentally beneficial activities prior to installation. It then asked whether these behaviours had changed. Table 6.5 summarises these results.

Key	Behaviour: How likely were/are you to...	Average likelihood of behaviour occurring prior to installation (1 = Never, 5 = always)	% of respondents answering 'Always' or 'Nearly Always'	Average reported change in behaviour post-installation (1 = less often, 5 = more often)
1	Install energy saving light bulbs?	4.34	82.9%	3.59
2	Switch off appliances at the mains?	3.86	68.6%	3.53
3	Monitor your energy usage?	3.37	48.6%	4.06
4	Seek to purchase more energy efficient household appliances?	4.29	88.6%	3.78
5	Use a green electricity tariff?	3.31	45.7%	3.31
6	Turn down/switch off your heating to save energy?	4.03	71.4%	3.50
7	Insulate your loft?	4.77	97.1%	3.81
8	Insulate your wall (eg Cavity wall insulation)?	4.00	71.9%	3.65
9	Install double glazing?	4.52	87.9%	3.63
10	Draught-proof your home?	4.38	82.4%	3.72
11	Save water by taking showers instead of baths?	3.64	57.6%	3.41
12	Save water by installing water saving devices (eg Toilet Hippo)?	3.12	41.2%	3.00
13	Save water by any other means?	4.00	72.7%	3.56
14	Recycle kerbside (eg as part of your weekly rubbish collection)?	4.71	94.1%	3.66
15	Recycle at a recycling centre?	4.18	73.5%	3.44
16	Compost organic waste?	4.61	93.9%	3.56
17	Use public transport instead of a car?	2.79	26.5%	3.00
18	Cycle or walk for short journeys?	3.79	70.6%	3.25
19	Consider the environment through purchasing decisions?	4.12	76.5%	3.56
20	Pay attention to environmental news stories?	4.09	79.4%	3.63
21	Reuse jars, paper or other household items?	4.45	87.9%	3.53
22	Donate clothes or other goods to charity instead of throwing them away?	4.59	88.2%	3.59

Table 6.5: Questionnaire respondents' environmentally friendly behaviours and the average change reported in behaviours after the installation of PV

This demonstrates that questionnaire respondents regularly engaged in environmentally beneficial behaviours before PV installation. The final column shows that there has been a slightly positive (>3) change for almost every behaviour in the

questionnaire. This suggests the presence of a double dividend. However, it is also apparent that many respondents reported their behaviour to be strongly pro-environmental beforehand. These individuals perhaps felt that it was impossible to change their behaviour to become any more environmentally friendly and therefore recorded an answer of 3 ('no change') on the scale, thus affecting the results.

The interviews allowed user behaviour to be examined further. This was important as, at first, many interview participants reported that their behaviour had not changed since installing PV:

> *"I don't really feel we've altered our lifestyle"* (Participant 8)

Further discussion, however, showed that many participants *had* engaged in load-shifting behavioural changes:

> *"I'll try to use things a bit during the day rather than during the evening"* (Participant 1)
>
> *"Where possible, [I] do my washing between twelve and three when the sun's out"* (Participant 10)

Participants also showed a commitment to load-shifting through purchasing decisions:

> *"The thing it maybe has influenced is maybe looking at how an appliance fits into our life with solar panels. For instance we've just bought a new dishwasher and we got one on purpose that has a time delay function on it so we can put it on when the solar panels are actually working during the day"* (Participant 5)

It is this kind of proactive engagement that enables users to optimise their system performance and create a smoother demand on the national grid. Unfortunately, it is difficult to envisage it becoming widespread throughout the population, particularly if it involves additional expense. For example, more expensive 'Green' electricity tariffs, were one of the least common green behaviours (table 6.5), even amongst an environmentally aware sample. Similarly, the difficulties consumers face when differentiating between electricity suppliers, as shown earlier, may have also contributed to this.

Another recurring theme amongst interview participants was the additional measures that have been installed in order to reduce reliance on grid-distributed electricity or gas. These included wood burners, insulation and low-energy appliances. Only for one

household was the change enforced by external factors, in this case as a prerequisite to receive a grant from the Carbon Trust.

The reinvestment of the financial savings made as a result of having photovoltaic capacity was also an area that could produce some double dividend:

> *"At the moment we've tried to keep it for things to do with the house [for example] we're putting it towards a new boiler"* (Participant 12)

For the majority of participants it appeared that environmental behaviours were high regardless of PV capacity, and that the installation of photovoltaic panels was facilitating their environmental commitment:

> *"I'd already begun to make changes in lifestyle to reduce my energy [...] consumption and so that's gone one step further here and of course I'm learning how to get the most from the PV panels"* (Participant 10)

6.5.2 Rebound Effects

It appeared that a number of participants were aware of the potential for rebound effects caused by their actions:

> *"There's also the offset of like 'well, OK, so you upgrade everything. Where's all that stuff gonna go? It's gonna go into landfill.'"* (Participant 11)

By asking respondents to rank the extent to which they identified with various attitudes, part six of the questionnaire explored the extent of any rebound effects caused by the installation of PV (Figure 6.7)

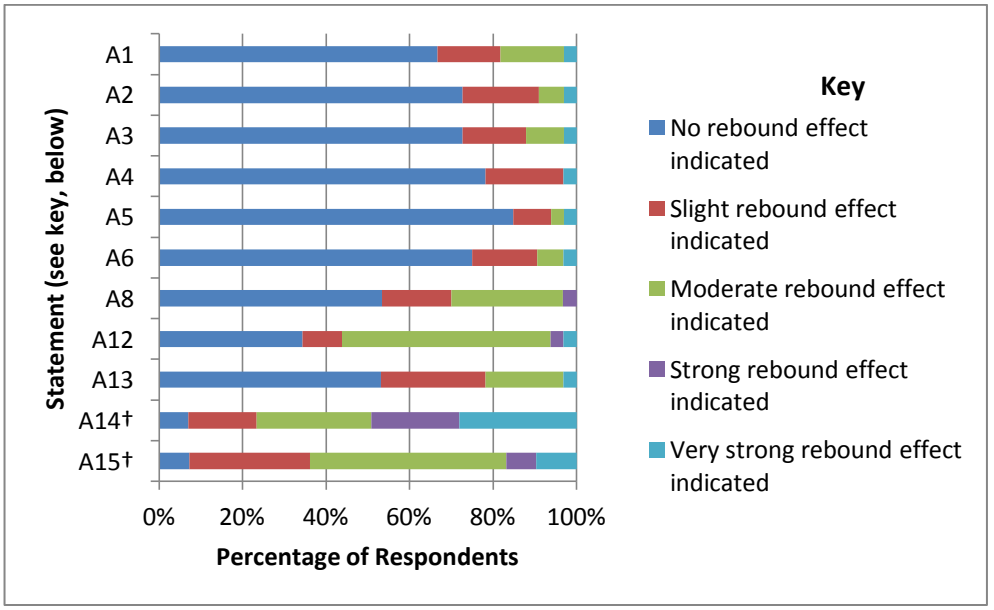

Figure 6.7: Graph showing the extent to which rebound effects were reported by questionnaire respondents

Key	Statement	Mean
A1	I can use more electricity now, because I am producing my own	1.58
A2	The money I am saving often gets spent on more electricity	1.42
A3	I am less worried about switching lights/appliances etc. off than I was before	1.45
A4	I can now use more gas and other energy in the home, because I am producing my own electricity	1.31
A5	I am less worried about using my car for short journeys, as I help the environment at home	1.27
A6	I would feel more comfortable about travelling abroad as I have reduced my environmental impact at home	1.41
A8	I am more careful about my electricity consumption than my gas consumption as I am not producing my own gas	1.80
A12	The money I save often gets spent on more household essentials	2.31
A13	I often treat myself or others with the money that I am saving	1.75
A14†	I often spend the money I save on other environmentally beneficial goods and services (such as organic food)	3.47
A15†	I save the majority of the money that I am no longer spending on electricity	2.83

Table 6.6: Key to Figure 6.7 showing the statements presented to questionnaire respondents. The mean values show the average value of the rebound effect for each statement, where '1' = no rebound effect indicated and '5' = very strong rebound effect indicated

This graph shows that, for the most part, rebound effects were marginal and that savings are most commonly spent on environmentally beneficial goods and services, or otherwise saved. For these two statements (denoted with a †), the results were reversed. Whilst these two values indicate high rebound effects, these statements correspond to environmentally beneficial activities, and are therefore preferential to the other statements.

For interview participants, the main causes of indirect rebound effects were found to be the substitution of electricity for gas:

> *"I'm thinking of ways of using the electric oven [...] for cooking dishes that I'd normally cooked...that I might previously have cooked on the gas hob"* (Participant 10)

> *"I turned the gas boiler off and put the immersion heater to come on a period in the morning"* (Participant 2)

Whilst it is beyond the scope of this study to fully identify the environmental implications of such a substitution, it is apparent that these users could have undertaken this action for economic gain. One participant had considered this action in detail:

> *"There's no practical way of storing it...so I feel I ought to be able to make better use of the electricity I'm generating and the most obvious way I'm storing it is as heat in the hot water"* (Participant 2)

This is more economical because using gas would increase their bill, whereas using home-generated electricity allows cost-free energy to be used.

Finally, some indirect rebound effects were identified through the financial savings that users make:

> *"Well I had to rob the new car fund to put the panels up! So [the savings will] go back in there in there for a new car eventually"* (Participant 7)

This, however, was an uncommon view amongst participants, with many claiming that financial savings were recycled into general household expenditure.

6.5.3 Conclusions

This section has shown that self-reported rebound effects are uncommon amongst users of PV. This could be because the sample used for both the questionnaire and the interviews had a high environmental awareness or were engaged in energy saving prior to the installation of the panels.

The potential for double dividend effects became apparent during the interview process. Again, environmentally aware participants reported to be acting as environmentally responsibly as they could (or intended on), and that the photovoltaic capacity was often installed to further reduce their use of grid-supplied electricity. However, this analysis has also shown that users can follow rational decision processes and conclude that it is best to substitute gas for electricity. This indicates that current policy can still be improved in order to reduce the incentive for such activities.

7.0 Discussion

7.1 Introduction

Having presented the analysis of the results, this chapter will discuss key themes that have emerged. It will also compare these results to other similar studies and identify the contribution that has been made to existing research.

7.2 Demographical Overview

The demographic traits of PV installers in this study were similar to those found by Bergman et al. (2009). Firstly, every participant was a homeowner and most had degree-level education. Many had also adopted long-term views of their installations, a trait identified by Faiers and Neame (2006) as one showing that PV users are likely to be innovators or early adopters. The environmental ethic of participants was also above normal, indicated by their NEP scores (Dunlap and Van Liere, 1978), and the presence of Solar Thermal installations.

The questionnaire sample used for this study did not align with the traditional view that photovoltaic users are typically wealthy. Although 20.8% of respondents had an income greater than £60,000, the modal group (27.1%) was between £15,000 and £29,999, with a further 12.5% of respondents reporting earnings less than this. This may be a result of those respondents on pensions receiving significantly less than they were earning prior to retirement. Alternatively, it could be because the 'Pay As You Save' scheme run by Stroud District Council provided households on lower-incomes with an opportunity to purchase PV. This indicates that there are individuals on lower-incomes who are willing to invest in and install the technology, but presently do not have the capital to do so. Schemes to assist these individuals can therefore have significant benefits for the environment and should be considered in future policy.

7.3 The success of the FIT and other economic incentives

Additionally, the analysis showed the extent to which economic incentives can convince engaged individuals to install PV technology. The introduction of the feed in tariff is perhaps the primary reason why the uptake of PV has increased significantly

and shows that, for some individuals at least, the economic barrier is often the final hurdle. This contradicts Jager's (2006) study, but supports the FIT scheme. Some interview participants, however, showed some scepticism surrounding the longevity of subsidies:

> *"The chances of the feed in tariff lasting 25 years are, I think, pretty miniscule [...] because of the whole thing about 'actually, this is ridiculous that basically the nation is paying a very small number of people to put PVs on their roof' you know? And everybody's subsidising that and it's making a miniscule contribution to national energy"* (Participant 12)

It also became apparent that environmentally conscious publics can now afford to engage with PV technology. This allowed the development of long-lasting, economically viable, environmentally aware behaviours. The FIT therefore acts as a durable motivation to support users through Van Houewelingen and Van Raaij's (1989) behavioural change model.

7.4 Barriers still remaining

Whilst overcoming financial barriers is a significant challenge, many interview participants expressed confusion at the lack of uptake within their social networks. It initially appeared that, by framing current users as 'nodes', potential installers overcame many perceived barriers to installation (Jager, 2006). However, the lack of further uptake seen by all participants indicated that other, more subtle barriers than those espoused by Palm and Tengvard (2010) and Knudsen (2002) are present. One respondent attributed it to apathy:

> *"and it's that sort of can't be bothered attitude"* (Participant 3)

This research has therefore shown that despite current users' efforts to demonstrate their satisfaction with their systems, some hidden barriers to adoption remain. For example a reluctance to invest in unproven technology. It is suggested that these difficulties are those currently prohibiting the technology from penetrating larger sections of the market.

7.5 The importance of Feedback and Meters

The results showed that the energy literacy amongst self-motivated users of PV has increased as a result of the actions individuals have taken to utilise the increased information available to homeowners. Whilst interview participants showed some awareness of energy saving behaviours, the range of results obtained from the questionnaire indicated that the potential to increase energy conservation behaviour varies greatly between households (Wood and Newborough, 2003). In many instances, users believed that the installation was a logical extension of their present environmental behaviours. For these users, a more tangible energy supply may not have increased their awareness as significantly as other, non-engaged, users.

This research suggests that providing consequential, direct feedback to users is vital to successfully producing double dividends from energy saving technologies. This is because users can engage with technologies at their leisure and therefore learn over a period of time suitable to their circumstances. The experiences that some users had with smart meters, consumption meters and generation meters show a willingness to engage with technology, providing the opportunity is available. This presents an important point for policymakers. It became apparent that there were many missed opportunities by both individuals and energy companies to improve home metering systems over the course of the installation of PV. If policy can direct energy companies to relocate meters to more prominent household locations whenever possible, then this would facilitate engagement amongst the general population. The possibility for installation of prominent home energy displays in social housing has been discussed elsewhere (Bahaj and James, 2006) and should be encouraged in order to increase awareness amongst non-engaged users.

Initially, the new experience of having electricity being generated locally to an individual seemed to promote high levels of engagement. This was also true of other unusual occurrences, such as meters running backwards. Once users became accustomed to new experiences, however, engagement levels varied between users. This again shows the heterogeneity of individuals. Policymakers should therefore not be discouraged from initiatives due to a few dismissive voices. The concept of 'honeymoon periods' should also be acknowledged as commonplace amongst user

behaviour. It has been shown that even short periods of heightened engagement can produce elements of enduring behavioural changes and should therefore not be viewed negatively.

7.6 Double Dividends and the Isolation of Electricity Supply

Neither the questionnaire sample or interview participants gave much evidence of the direct rebound effect. This is possibly caused by participants being unaware of behavioural changes or reporting them in a desirable manner. It is more likely attributable to the fact that many participants were highly engaged individuals and many espoused to have a moral obligation to look after the environment:

> *"Having the solar panels [...] is part of a sense that you ought to be looking after creation for everybody"* (Participant 8)

No fuel-poor households were involved in this study. Subsequently, the influence on households with a high propensity to create direct rebound effects (Hong et al., 2006) was not evaluated.

The most apparent behavioural change adopted by PV users is load-shifting. This is beneficial for all parties, as it maximises the economic gain of individuals and minimises the electricity demand from the national grid. One interview participant also showed that simple purchasing decisions can ensure that users benefit from load-shifting even as part of a busy daily routine (see section 6.5.1).

Many participants had also installed other energy saving technologies (such as solar thermal systems and wood burners), but it appeared that most were primarily engaged with electricity consumption. This aligns with Keirstead (2006) who showed that engagement only occurred with the energy type users were generating. The implication is, therefore, that further engagement strategies will need to be employed to reduce the UK's gas consumption, which comprises up to 14% of UK residential GHG emissions (DECC, 2011b). Furthermore, it was observed that some users substituted gas consumption for electricity consumption. Whilst this was done rationally for both economic and environmental reasons, it was clear to one user that the current FIT payment mechanisms were not performing optimally:

> *"The idea that I use a half of what I generate is a load of cobblers and therefore I think the feed-in tariff needs to be made fairer"* (Participant 2)

At present, the Feed-In-Tariff assumes that users consume half of all electricity generated and export the remainder (EST, 2011). This incentivises individuals to consume as much as possible and therefore encourages users to create direct rebound effects. Furthermore, if, like Participant 2, users store their electricity as hot water, this is likely to create *increased* fluctuations in both gas and electricity demand, depending on climatic variables such as cloud cover.

Whilst the present FIT system does benefit some users economically, this example highlights the heterogeneity of individuals' use patterns (Fischer, 2004). Policymakers should therefore take further action to reduce this homogenous strategy and address the sub-optimal performance of current infrastructure. Once more, this could be coupled with Home Energy Displays in order to increase engagement and system accuracy.

8.0 Conclusion

This study adopted a mixed methods approach to evaluate how photovoltaic technology adoption occurs, and ways in which policy can be refined in order to continue the UK's progress towards a more sustainable energy network. Previous extensive research into the subject was undertaken prior to the introduction of the feed-in-tariff in the UK (Keirstead, 2006). As such, participants in this study have had significantly more economic incentive to utilise photovoltaic technology than in the past. This chapter will highlight key findings of the research, and areas where further research should be conducted will be noted. Furthermore, recommendations for future policy making suggested by the research will be outlined.

8.1 General Findings

Overall, it was found that environmental concern was the most significant variable affecting an individual's choice to install PV panels. Whilst this was expected, the study revealed the importance of economic incentive for encouraging the uptake of photovoltaic technologies. This is because cost savings alone do not provide enough financial return to make the investment viable in the long-term. It has been shown that the duration and magnitude of the FIT contributions has successfully stimulated demand across the majority of users and it has been vital to the adoption of PV.

The interview analysis showed implicit traces of eco-localism within PV purchasing decisions. Users were keen to encourage local economic resilience through the use of local installation companies. Local environmental groups were often seen as reliable sources of information. This aligns with Curtis' assertion that "economic sustainability is best secured by the creation of local [...] community economies" (2003: 83).

Whilst no potential adopters of PV were included in the study, participants were well positioned to comment, as they had to overcome their own barriers to adoption and often engaged others in the technology. Despite the FIT benefits, the primary barrier is still financial, as PV remains a significant upfront investment for any individual. The success of the Pay-As-You-Save loan scheme, operated by Stroud District Council and the Energy Saving Trust, shows the potential that such schemes could have in providing

socially equitable distributed electricity generation. It appears, however, that such PAYS initiatives are unsupported by government, as any correspondence email addresses have been terminated (pers. comms. 1st September). Further research in this area should therefore be undertaken, in order to determine the extent to which financial barriers are dissuading potential users from installing PV. The results would show whether the PAYS initiative should subsequently be reconsidered by policymakers.

Current users felt that education and positive media influences can eliminate some other barriers, such as lack of technological awareness, preventing further uptake of PV. Additional study should investigate the validity of this claim by attempting to identify the extent of these barriers through engagement with the 'early majority'.

The potential to raise energy awareness is one of the main opportunities that increasing PV uptake presents to policymakers. As Darby (2008) notes, this is likely to reduce overall emissions, yet it appears that policy has ignored many opportunities to do this. It is suggested that, whenever possible, meters be relocated to prominent household locations in order to facilitate engagement between household members and energy issues. Furthermore, these meters should provide users with a multitude of direct feedback mechanisms, as this was shown to be an effective way of allowing users to learn about energy behaviours. This advocates the UK government's strategy to install smart meters in every home by 2020 (BBC, 2009), although it should be stressed that the new meters should be accessible.

This study produced no apparent direct rebound effects. This suggests that the present adopters of PV are reducing national fossil-fuel generated electricity demand by the estimated amounts. The study did, however, highlight a more pressing concern. It was demonstrated that individuals could maximise their economic gain by artificially increasing their consumption of electricity, often replacing domestic gas usage. In many instances this is likely to undermine policy and produce unexpected demand for both electricity and gas. It is therefore recommended that policy should encourage the accurate measurement of electricity exportation from each household. This technology does exist, but it is neither required nor is it common to find it installed for arrays. If

policy delays this implementation, it is likely to cost significantly more in the future, as homeowners will have to retrofit their existing systems with new technology.

8.2 Limits to this Study

This study did not conduct research with installation companies as no suitable organisation could be found. This is disappointing, as it is apparent that the continually evolving PV market presents many challenges for organisations. Many participants displayed a distrust of installers, together with a reluctance to respond to traditional marketing strategies. There is also a belief in the homogeneity of the professional services in the PV market. This suggests that existing customers and reputation are the primary marketing tools for companies. Future research into the marketing strategies and ethos of individual firms would enable more meaningful conclusions to be drawn.

There were a number of other limits to this study. Firstly, it relied heavily on the self-reported behaviours of individuals. Using this methodology inherently produces some social desirability bias. In order to overcome this, future research should undertake a longitudinal study of attitudes and behaviours, ideally both pre- and post-installation. Furthermore, the sample of this study reported themselves to be highly environmentally aware. This was as a result of the distribution methods used. Additional research into the behavioural changes of less environmentally aware users would enable policy to encourage greater adoption from the 'early majority' and thus further increase photovoltaic adoption. A number of social housing associations and councils have recently installed PV capacity on new buildings (bronafon.org.uk, saffronhousing.co.uk, eastbourne.gov.uk/solar). Studying how this affects residents there would indicate the effects that increasing the tangibility of electricity supplies can have on an alternative sector of society.

8.3 Policy Implications

Overall, photovoltaic technologies can make an important contribution to reducing the UK's reliance on non-renewable energy sources in order to produce a more sustainable energy infrastructure. At present, the FIT is succeeding in attracting wealthy, environmentally aware citizens into adopting PV technology. This is beneficial for three main reasons. Firstly, it allows the market to develop and therefore costs to decrease.

Secondly, individuals with a high propensity to installing PV systems are also most likely to engage in energy conservation behaviours. The potential to realise energy savings is greatly increased as energy literacy improves. As this study has shown, PV installations increase energy literacy amongst users. Finally, it allows publics and the media to reframe PV as something socially acceptable and not out of the ordinary, further aiding the distribution of the technology. This study also highlighted the importance that social discourses have to play in the distribution of PV technologies, and many participants expressed a willingness to help the industry expand.

There are some areas, however, where policy can still be improved. The current economic incentives still require homeowners to have large amounts of available capital. This excludes fuel-poor households who could derive health and wellbeing benefits from a PV installation, as well as additional income. Providing grants to suitable households or reinvesting in PAYS schemes would provide greater access to PV technology across more social classes.

Furthermore, the full potential of the FIT is only now becoming apparent. It is important that further research is undertaken into the direct implications of the FIT and, as highlighted above, how it can be applied to encourage adoption across all income groups.

The FIT has also come under scrutiny from the media recently (*The Guardian*, 2010b), as the subsidies are funded through energy price rises. Two interview participants expressed concerns about the social equity of this. In the current economic climate, however, funding is needed to drive the PV market in order to ensure that the economy, although turbulent, is not prioritised at the expense of environmental health.

8.4 Concluding Remarks and Recommendations

To date, the FIT has been successful in stimulating the UK photovoltaic market. It is important that policy continues to support this by displaying the economic and social viability of the technology. Despite the reduction of the FIT to 39.6p in April 2012 (Ofgem, 2011), this is likely to be maintained as technology prices continue to decrease. By combining the FIT with schemes to increase its accessibility across social

groups, greater adoption rates can be achieved, engaging many more publics in energy issues. This should be coupled with the antecedent promotion of energy sufficiency for individual households which will further reduce the demand on the national grid.

Photovoltaic technologies have the ability to make a successful contribution to the UK's carbon reduction targets, energy supply security, and individual welfare goals. This can be achieved through the direct substitution of fossil-fuel generated electricity with energy from sustainable sources. It provides households with a supply of cheap electricity and generates an income for those receiving a feed-in tariff. Photovoltaic technologies can also contribute to the creation of a decentralised electricity network, as well as producing energy demand reductions through double dividend behavioural effects. In addition, by developing a strong national PV industry, the UK could improve its economic development through exporting competencies surrounding the technology.

Appendix 1: Questionnaire

This is the questionnaire that was distributed to households by Stroud District Council. Due to the format requirements of this dissertation, some presentation errors may have occurred.

Introduction

PLEASE NOTE: There is an identical online version of this survey which you can complete at www.surveymonkey.com/s/solarpvsurvey

Thank you for taking the time to complete this questionnaire. In addition to having the chance to win an Energy Monitor for your home, your results will contribute to a research project examining the attitudes and behaviours of citizens with residential photovoltaic installations. This will inform local and national authorities of potential policy changes that could increase the uptake of photovoltaic capacity and reduce carbon emissions nationwide. Any data collected will remain anonymous during and after the study.

Please attempt to answer as many questions as possible and use the 'Any other comments' sections throughout the questionnaire to provide any further insight into the types of question being asked. These comments will highlight areas where further research should be undertaken. Overall, the questionnaire should take about twenty minutes to complete.

PART ONE: You and Your Home Details *This section aims to identify general details about the participants taking the questionnaire in order to inform discussion later on.*

Please indicate your answers by ticking the appropriate box:

Gender:

☐ Male ☐ Female

Age Range:

☐ 16-30 ☐ 31-45 ☐ 46-60 ☐ Over 60

Educational Attainment *(please tick all that apply to you)*:

GCSEs/O-Levels or Equivalent ☐ A-Levels/FE College or Equivalent ☐

Degree or Other Higher Education ☐

Household Income:

Less than £15,000 ☐ £15,000 - £29.999 £30,000 - £44,999

£45,000 – £59,999 ☐ £60,000 - £100,000

Pass Question Over £100,000

Number of regular household residents:

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 6 or more ☐

How would you describe the location of your house?

☐ Rural ☐ Suburban ☐ Urban

How would you describe your home circumstances?

☐ Owner/Mortgage ☐ Private Rent Rent from Council ☐ Rent from Housing Association

Are you connected to the national electricity grid?

☐ Yes ☐ No

Do you have mains gas supply?

☐ Yes ☐ No

How do you usually heat water? *(Please tick all that apply)*

☐ Gas ☐ Electricity ☐ Oil ☐ Wood

Other (Please specify) ☐

How do you usually heat space in your home? *(Please tick all that apply)*

☐ Gas ☐ Electricity ☐ Oil ☐ Wood

Other (Please specify) ☐

PART TWO: Environmental Attitudes *This section aims to identify your overall environmental stance by asking questions commonly used in environmental studies (for more information, see the New Ecological Paradigm).*

Please rank the extent to which you agree with the following statements where 1 = strongly disagree, 5 = strongly agree

We are approaching the limit of the number of people the earth can support	1	2	3	4	5
The balance of nature is very delicate and easily upset	1	2	3	4	5
Humans have the right to modify the natural environment	1	2	3	4	5
Humankind was created to rule over the rest of nature	1	2	3	4	5
When humans interfere with nature it often produces disastrous consequences	1	2	3	4	5
Plants and animals exist primarily to be used by humans	1	2	3	4	5
To maintain a healthy economy we will have to develop a "steady state" economy where industrial growth is controlled	1	2	3	4	5
Humans must live in harmony with nature in order to survive	1	2	3	4	5
The earth is like a spaceship with only limited room and resources	1	2	3	4	5
Humans need not adapt to the natural environment because they can remake it to suit their needs	1	2	3	4	5
There are limits to growth beyond which our industrialised society cannot expand	1	2	3	4	5
Humankind is severely abusing the environment	1	2	3	4	5

PART THREE: Your PV Installation *This section will gather some details about your PV system*

Who decided to install your PV array?

Current homeowners ☐ Pre-installed before moving ☐

A Third Party (external company, council etc.) whilst current homeowners living there ☐

How did you fund the installation?

Wholly Self-Funded ☐ Partially Grant Funded ☐ Wholly Grant Funded ☐

Third Party Installer ☐ Interest-Free/'Pay-as-you-save' Loan ☐

Other *(please specify)* ☐

If you obtained a grant, please indicate where from (eg Local Council, Low Carbon Building Programme etc.): ☐

If you answered 'partially grant funding' please indicate the percentage of the total cost: ☐

Are you claiming a Feed-in-Tariff?

Yes ☐ No ☐

Have you installed a new electricity meter since installing your array?

Yes, a digital one ☐ Yes, an analogue one ☐ No ☐

Where is your electricity monitoring equipment located? *(This could be an electricity meter. If you have multiple monitoring devices, then the one you use to measure your PV generation)*

In a prominent household location ☐ In a difficult to access location ☐

Don't know ☐

Please answer the following questions to the best of your knowledge

If you could change your monitoring equipment, what would you do?

.....

.....

How long have you been using your PV system?

Less than six months ☐ 6 months – 1 year ☐ 1 – 2 years ☐

Longer than two years ☐

Since installation, how much electricity has your installation generated (approx.)?

…….. Don't know *(tick box)* ☐

How do you feel this compares to what you were told before installation?

……

……

Please estimate your household electricity consumption *before* installation of your array:

Less than 2000 kWh ☐	2000-2999 kWh ☐	3000-3999kWh ☐
4000-4999 kWh	5000-6999kWh	Over 7000 kWh ☐
Don't know		

Please estimate your household electricity consumption *after* installation of your array:

Less than 2000 kWh ☐	2000-2999 kWh ☐	3000-3999kWh ☐
4000-4999 kWh	5000-6999kWh	Over 7000 kWh ☐
Don't know		

Please write any other comments you have relating to your PV array here:

……

……

……

PART FOUR: Information and Motivation *This section will seek to identify many of the reasons why your system was purchased, in order to find common links between PV installers.*

Before installation, where did you seek advice on PV? *(Please tick all that apply)*

National Government ☐	Local Government ☐	Energy Saving Trust ☐
Nationwide Installers (eg Anglian) ☐		Local Installers ☐
Newspapers ☐	Other Written Media ☐	Word of Mouth ☐
Television	Radio ☐	
Other NGOs/Charities *(please specify)* ☐		
Other *(Please specify)* ☐		

If you were to advise someone else on installing PV, where would you recommend they seek advice?

National Government ☐	Local Government ☐	Energy Saving Trust ☐
Nationwide Installers (eg Anglian) ☐		Local Installers ☐
Newspapers	Other Written Media	Word of Mouth ☐
Television	Radio	
Other NGOs/Charities *(please specify)* ☐		
Other *(Please specify)* ☐		

Please give details on any positive or negative experiences you had when researching PV, or any improvements you would make to the process.

.....

.....

.....

Please list your motivations for installing PV in order of importance (from most to least). *These could include saving money, improving my home, helping the environment etc.*

Most important: .....

.....

.....

.....

Least important: .....

Please rank the extent to which you agree with the following statements where 1 = strongly disagree, 5 = strongly agree

I understand how my PV system works	1	2	3	4	5
I am happy with my installation	1	2	3	4	5
Having PV saves me money	1	2	3	4	5
Having PV helps the environment	1	2	3	4	5
Other people often comment positively on my PV array	1	2	3	4	5
Other people often comment negatively on my array	1	2	3	4	5
I am fascinated by the technology	1	2	3	4	5
I like the fact that a visible PV array shows my commitment to environmental causes	1	2	3	4	5
My PV system is performing as well as I expected	1	2	3	4	5
Having PV makes my house more valuable	1	2	3	4	5

Please write any other comments you have relating to your information gathering and motivations for installing PV here:

.....

.....

.....

PART FIVE: Behaviours *This section aims to identify the extent to which installers undertake environmental action, and how behaviours have subsequently been affected by having microgeneration capacity installed in the home.*

Please indicate your answers by circling the corresponding value on the scale.

Before installation, how likely were you to... *(1 = never, 5 = always)*

Install energy saving light bulbs?	1	2	3	4	5
Switch off appliances at the mains?	1	2	3	4	5
Monitor your energy usage?	1	2	3	4	5
Seek to purchase more energy efficient household appliances?	1	2	3	4	5
Use a green electricity tariff?	1	2	3	4	5
Turn down/switch off your heating to save energy?	1	2	3	4	5
Insulate your loft?	1	2	3	4	5
Insulate your wall? *(eg Cavity Wall insulation)*	1	2	3	4	5
Install double glazing?	1	2	3	4	5
Draught-proof your home?	1	2	3	4	5
Save water by taking showers instead of baths	1	2	3	4	5
Save water by installing water saving devices *(eg Toilet Hippo)*	1	2	3	4	5
Save water by any other means	1	2	3	4	5
Recycle Kerbside *(eg as part of your weekly rubbish collection)***?**	1	2	3	4	5
Recycle at a recycling centre?	1	2	3	4	5
Compost organic waste?	1	2	3	4	5
Use public transport instead of a car?	1	2	3	4	5
Cycle or walk for short journeys?	1	2	3	4	5
Consider the environment through purchasing decisions?	1	2	3	4	5
Pay attention to environmental news stories?	1	2	3	4	5
Reuse jars, paper or other household items?	1	2	3	4	5
Donate clothes and other goods to charity instead of throwing them away?	1	2	3	4	5

Since the installation of your PV system, how has your attitude to the following changed? *(1 = much more negative now, 5 = much more positive now – For example, if you said "I am much more in favour of installing energy saving lightbulbs than I used to be" you would mark 5 If you said "I am much less likely to use public transport than I used to be" you would mark.)*

Install energy saving light bulbs?	1	2	3	4	5
Switch off appliances at the mains?	1	2	3	4	5
Monitor your energy usage?	1	2	3	4	5
Seek to purchase more energy efficient household appliances?	1	2	3	4	5
Use a green electricity tariff?	1	2	3	4	5
Turn down/switch off your heating to save energy?	1	2	3	4	5
Insulate your loft?	1	2	3	4	5
Insulate your wall? *(eg Cavity Wall insulation)*	1	2	3	4	5
Install double glazing?	1	2	3	4	5
Draught-proof your home?	1	2	3	4	5
Save water by taking showers instead of baths	1	2	3	4	5
Save water by installing water saving devices *(eg Toilet Hippo)*	1	2	3	4	5
Save water by any other means	1	2	3	4	5
Recycle Kerbside *(eg as part of your weekly rubbish collection)***?**	1	2	3	4	5
Recycle at a recycling centre?	1	2	3	4	5
Compost organic waste?	1	2	3	4	5
Use public transport instead of a car?	1	2	3	4	5
Cycle or walk for short journeys?	1	2	3	4	5
Consider the environment through purchasing decisions?	1	2	3	4	5
Pay attention to environmental news stories?	1	2	3	4	5
Reuse jars, paper or other household items?	1	2	3	4	5
Donate clothes and other goods to charity instead of throwing them away?	1	2	3	4	5

Please write any other comments you have relating to how your behaviour has changed here:

.....

.....

.....

PART SIX: Attitudes *This section aims to identify the extent to which attitudes surrounding overall environmental behaviour are affected by a PV installation*

Please indicate to what extent you agree with the following statements (1 = disagree strongly, 5 = agree strongly)

I can now use more electricity, because I am producing my own	1	2	3	4	5
The money I am saving often gets spent on more electricity	1	2	3	4	5
I am less worried about switching lights/appliances etc. off than I was before	1	2	3	4	5
I can now use more gas and other energy in the home, because I am producing my own electricity	1	2	3	4	5
I am less worried about using my car for short journeys, as I help the environment at home	1	2	3	4	5
I would feel more comfortable about travelling abroad as I have reduced my environmental impact at home	1	2	3	4	5
I am more careful about my electricity consumption than my gas consumption as it is more expensive	1	2	3	4	5
I am more careful about my electricity consumption than my gas consumption as I am not producing my own gas	1	2	3	4	5
I am proud of the fact that I have a PV array installed on my property	1	2	3	4	5
People often compliment me on my PV array	1	2	3	4	5

I see my PV array as an indicator of my innovative and environmentally friendly nature	1	2	3	4	5
The money I save often gets spent on more household essentials	1	2	3	4	5
I often treat myself or others with the money that I am saving	1	2	3	4	5
I often spend the money I save on other environmentally beneficial goods and services (such as organic food)	1	2	3	4	5
I save the majority of the money that I am no longer spending on electricity	1	2	3	4	5

Please write any other comments you have relating to your attitudes here:

.....

.....

.....

PART SEVEN: Contact Details and Feedback

Please write any other comments you have relating to the overall study here:

.....

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.....

This study may involve an interview stage. These interviews will be conducted by the researcher either in-person or over the phone and will allow participants to expand on their answers to the questionnaire, as well as providing the opportunity to discuss solar panel behaviours in more depth.

If you would be willing to undertake an interview, please fill in your details below and tick here: ☐

If you would like to be informed of the outcomes of the research and be entered into a draw to win an Energy Monitor, please fill in your details below. All details are optional and will not be used for any other purpose other than this research project.*

Name: .....

Address:.....

.....

.....

Email Address:.....

Phone number (inc. area code):.....

Thank you for completing this questionnaire. Please see the accompanying letter for details on how to return it. If you would like to know more about the study, please contact dg222@exeter.ac.uk

**The winner of the Energy Monitor (minimum value: £15) will be contacted during August or September and the prize posted to their home address*

Appendix 2: Sample Interview Transcript

Interview Date: **2nd August**

Interview Length: 27minutes

Participant: 8

(Interviewer: DG. Interviewee initials changed to ensure anonymity)

DG: So first of all we're just here to talk about experiences with your PV array. Erm, just like to explain to me a bit about what made you decide to install them in the first place?

MA Erm, my husband and I had talked about it because I think we're concerned about global warming and exhausting fossil fuels and all the rest of it. Erm... and... we knew we've got a house perched on top of a ridge in, you know, a very sunny area. Erm, and then we were actually approached by someone from one of the specialist companies it turned out. Erm... who... er... I think it was a cold call but looking back I suspect they've got scouts out looking for likely houses. Erm and somebody came, a technical person, and explained it all to us. And... I mean there was a certain amount of time pressure to get in before the tariff was withdrawn or modified again. And we found ourselves doing it... and... you know because we'd already talked about it we didn't feel we'd been bumped into it so we were quite happy to go ahead with it, it was just before Christmas.

DG: Last Christmas?

MA Yes, 2010.

DG: So did you fund it all yourself or did they pay for them and fit them themselves?

MA We paid for them; we haven't had any grant help. Erm, but the... erm... the maths, the calculations show that it should pay for itself I think it's 10 to 15 years they reckon we'll have paid for it. And... it's... erm... a better proposition at the moment than it might be otherwise because the usual thing you do with your savings is put them into a savings account and at the moment you get half a percent on that so you get two or three percent return on your feed in tariff. Erm, you know, that's better that what you'd get with it in the building society.

DG: Sounds fair. Erm so to what extent do you think that the economic side of things did influence your decision?

MA It's hard... it's hard to say, I think we were keen to do it... out of principle... erm but I don't think if it had been a lot... we're not so wealthy we can afford to ignore the economic side of things and I don't think we'd have felt it was right to sort of mortgage to children's future as it were to do it. So, yeah, I think there has to be a balance.

DG: Ok. But the primary driver was your environmental concerns?

MA Yes I think so, yes. I mean, I think, yes the decision to do that rather than any of the other things you might do to get a better return on your money, yes.

DG: Cool. So when you were looking for information about the installers or about solar panels in general... where did you look? How did you go about that?

MA Well, in the past, we'd had stuff through the door once or twice that I read and I think I once followed up an ad in the paper and got some stuff from them. But on this occasion, I'm afraid we just... we went with the cold call. They supplied a lot of information, leaflets and things and explanations of what it all was and we didn't... I mean I said at the time it was probably quite cunning, the time scale was quite short and it was just about Christmas so no, we didn't go out and get comparative quotes or follow anything up for ourselves I'm afraid.

DG: Cool. So did you have quite a good understanding of solar technology in the first place or?

MA Erm, I'm a great Radio 4 follower so I felt I did... I'm... also my father was an architect and surveyor so I would reckon that I'm... fairly well primed with the... base to build on. So, you know, yes. I don't think I understand how the things... generate electricity and I don't think I care how they do it. They sit up there and they get on with it. Erm, but if he said the roof was the wrong shape or the right shape or the aspect was wrong I could cope with that.

DG: Cool. So d'you think there'd be anything you'd change if you... would you... d'you have any regrets about the process... the research that you undertook?

MA Erm... no I really don't think I do have regrets. I think if you... there's a bit of you that says you ought to have got comparative quotes, but then there's another bit that says I bet it's a bit like comparing, you know, utility companies: there's some where you'll get a better... a cheaper price but you won't get such good kit or you'll... it'll take longer to do it or there'll be more disruption. Or maybe it won't work. I mean somebody came to the door to ask how we liked it and was it performing well and he was in the business and when we told him what we'd paid he said he reckoned we'd got a good deal so...

DG: Ok, so good news all round then. Erm so did you talk to anyone else beforehand? Like going round to other people and asking how they were doing?

MA No, frankly we didn't. As I say, it was Christmas and if you remember Christmas there was ice on the pavement and it was not the sort of time you go and pop round to your neighbours and say have you ever thought about solar panels.

DG: No, no, definitely.

MA No, I'm afraid we just... no we didn't.

DG: Ok, so you've already mentioned Radio 4. Erm, do you think... what role do you think the media can play in, I guess people's perceptions of solar panels or encouraging uptake?

MA Yeah, erm... I think they've got a job to do and I think in general they do it rather well. The one thing that I did have a few regrets about was I... just after we'd had it done there was a... erm... I think it was probably one of the saving the Earth Radio 4 programmes which was pointing out that the feed in tariff was being subsidised... that people with less capital were paying more for their energy in order to subsidise the feed in tariff for those with the capital to put up solar arrays and that is pretty unjust. I think they've... there's a tricky business... on the one hand... you don't want to put people off doing it... erm, but it must be quite difficult to do it through radio which has to be entertainment so has to be a bit unbalanced and I think there might be a danger that you send everybody out to try(?) and then have them all thinking this is terrible – the feed in tariff is a rip-off, we shouldn't be doing it. You know, rather than... but whether you can hope that Joe Public will actually embrace the... erm... the more technical details of it. Erm, and can anybody really? I mean, never mind sort of ordinary members of the public, it's such a complicated business, how much you can get from solar energy in England; how much you ought to get from solar energy in England; whether you ought to be putting the miners out of work and all the rest of it. Erm, yeah, I think they've got a job to do to inform... erm... try not to send everybody charging in one direction and then charging in the other but it's a minefield isn't it?

DG: Definitely, yeah. I've been speaking to a lot of people, somebody who did really understand the system but didn't quite understand how the feed in tariffs were working... erm... so it's almost as if he's got half the picture but not the other half and then a lot of other people understand how the feed in tariff works but not how the technology works so they're always trying to balance it in their mind I guess. Which is quite... yeah... there's a lot of information to take in.

MA Yes, yeah...

DG: Ok, moving on, just like to talk about how having solar panels has influenced your lifestyle. Do you feel that on the whole you and your house use quite a lot of energy?

MA Erm, I don't really think the solar panels make a lot of difference to anything. I mean we certainly don't feel that you... I cook electric, erm... we've got the ordinary appliances... I really don't feel we've altered our lifestyle thinking we're generating electricity up there so we don't need to bother about switching things off any more because, I mean that's just responsible energy use isn't it?

DG: Which is what I think you said during your questionnaire that you actually hadn't really changed it's just...

MA No, I really don't think we have, erm... because the complication is that where I perhaps do feel that we don't have to... we used to heat all our water by gas but we've now got the heating tubes on the roof so... because I know that during the day if you run the tap it's just gonna... on a day like yesterday it's just gonna reheat, you don't feel like it particularly matters. Except of course you might be wasting water. We shouldn't be wasting water in this part of the world so no, I

don't really think it's changed. I suppose... the sort of moral and philosophical principles that say you watch what you use are still there.

DG: Ok. So were you aware before of how beforehand of how much... like did you keep quite a close eye on how much you were using, both electricity and gas?

MA Not a very close eye, but we were aware that we were getting very high bills because this is quite a big house and... another complication that at the same time we were getting these fitted, we've also had the loft insulated and completed the double glazing so the things that are cutting the bills are not all to do with the solar energy or the heating tubes. But I suppose we're ordinarily sort of concerned householders, but no, weren't people who'd got little meters here and time clocks there and tried to shave another five units of the consumption.

DG: Ok. Erm, you mentioned the loft insulation and the double glazing. Was that installed for energy reasons again or was the double glazing juts to keep the sound out?

MA Mostly for energy reasons. It's a wonderful house to have from the point of view of solar energy but it is very cold in winter because the wind comes onto that end of the house. So the double glazing is quite important for heat loss.

DG: Ok, good. With regard to the... I'm assuming you have a generation meter...

MA No... we just have a... feed in... oh! We have one meter which is a feed in tariff meter which we read to unit off on.

DG: Ok, erm, are you aware... d'you check that that often to see how that's doing or?

MA To begin with the family were laughing at me because I was standing on a chair saying "ooh we've done another two units!" Now as it happens, knowing that you were coming I had a look yesterday. Also because it was a sunny day and you sort of think "ooh, it's ticking over". But in general no, the novelty soon wears off.

DG: Fair enough. Erm... d'you think there's anything more... is there anything you'd like to do to reduce your energy consumption further or so you think you're at a happy state?

MA Erm, I'd like to know... we haven't had this for a full year and we haven't really much idea of what would happen in winter. Spring, if you remember this year, came very early and very hot so it'll be interesting as we go into the autumn. I... I would quite like to know which of the appliances gobble. You can get these watch your consumption meters, I never had had one, I'd quite like to do the experiment and see what it is that really gobbles the electric. But otherwise not much more we can do. We can't cavity wall insulation because it's been put in the house by a cowboy before we bought the house and it's collapsed. They gave us as part of the deal a state-of-the-art computerised thingy which is supposed to reduce our overall consumption by much more sophisticated heat control in the house. Whether it really does or not, search me.

DG: Was that the solar panel installation?

MA Yeah. The deal was if you took both heating tubes and the solar panels and got it all done at once, you got this box of tricks in the hall that replaced the... ordinary thermostat. Erm... it is terrible sophisticated, so sophisticated I haven't quite mastered how you get it to work for you rather than to save the world. But that's all there. You know, I could do with a longer time span to see how we're doing but I can't think... there's nothing else specific that I can think of that we could be doing.

DG: Ok. So do you think it's altered other areas of your life? So do you in general and now you've had the PV do you purchase more environmentally friendly, or do you travel less and things like that?

MA No. We were already buying, gradually shifting to the ecologically friendly detergent things. Erm... most of them seem to perform alright, I was a bit reluctant at first, although this hard water... every so often you have to have one of the biological detergents... it just doesn't do the job. But yeah, erm... I probably am buying... I don't think it's because we've got the solar panels, I think it's just as you gradually become... alerted to the necessity for doing these things and that's it's not gonna happen, it's probably got to be a grass roots movement – lots of people doing a little will make a difference because at the macro level not much seems to get done. Erm... nothing else... no I'm afraid... no I haven't got the bike out... I'm too old for that...

DG: Lewes is too hilly for that.

MA Yes. And if I use the bus more it's because I've got my bus pass – it doesn't cost £3.50 to go to Brighton anymore!

DG: Ok. So would you say that just getting solar panels is almost something on a curve that you're doing to become more environmentally friendly?

MA Yes, yes.

DG: Do you have any other plans in the future that you've like pencilled in or considered?

MA When we next change the car, we have considered getting one of these hybrid things, whether we actually shall I don't know but it's... that is certainly a possibility.

DG: So would it be fair to say that you have a cleaner conscience about using electricity...?

MA Yeah, yeah, yeah.

DG: But not to the extent that you're carefree with your electricity, it's just nice to know that you're doing something to generate carbon free electricity.

MA Yes but... oh dear... I suppose I would regard myself as a religious person and... having the solar panels or the heating tubes is part of a sense that you ought to be looking after creation for everybody. And... you still go on doing your best to look

after it... you don't go round using it wantonly or whatever. And, you know, I think at bottom that... stays true.

DG: Do you think that's the same for your family or anyone else living here?

MA Yes I think so, yeah.

DG: So you try to install an environmental awareness at least?

MA Yes, I think we would all share the same philosophy, that it's part of looking after the environment. I suppose the generation that my husband and I belong to, erm... children of the 50s; we grew up with people being very frugal of resources for quite different reasons and.... the lifestyle... it's never changed in a vastly consumerist one, 'cos you know, it's built into your genes.

DG: Erm so moving onto finance, are you aware of any major financial savings that you've got through the feed in tariffs?

MA We got a very cheque from the feed in tariff in June, which I suppose... feels like... you get it in a cheque, you don't get it knocked off your bill. I mean, we haven't really worked out yet how our bills are altering because they're a bit all over and stuff...

DG: With the insulation and double glazing and stuff?

MA Yes, yes and that. And, of course, working out whether you're using a lot less when the tariff is going up all the time... it's...getting a comparison is really quite difficult, we haven't sat down with it yet.

DG: Ok. Erm, so are you happy with the cheques that you've been receiving? Are they what you were expecting?

MA Yeah, I mean they made us take a photograph of the meter, said it was higher than they were expecting. And I thought you know, you dumbos, I mean think what the weathers been like. But yes, it was very nice, yes we were very pleased with that. What the next one will be like who can say?

DG: So erm, have you earmarked that money for anything or has it just gone back to household funds?

MA Er, it sort of... I think we sometimes think… you know... that'll half pay for the holiday sort of thing. Erm yeah... I mean... it's nice to feel that you're... it's quite nice getting a cheque in the post.

DG: Yeah, I wish got some every month! Erm so finally, just gonna ask how you feel other people perceive your PV. You mentioned someone has come round and asked how it's performing, erm do many other people, friends and that, comment?

MA I mean we haven't had... when it first went up... we haven't had any complaints. Erm... several people asking us whether we liked it and whether it worked and who'd done it. Erm... some friends of ours... er... got us to explain it all to them but

their roof turned out not to face the right way so they've gone in with this Lewes community power station at the brewery. Erm... yeah, I mean in general people seem to be quite, sort of, happy... I mean I was a bit horrified when it first went up, it looks like the Starship Enterprise! You know, sort of, there's so many of them, but I mean, there's so many of them. But I mean they're absolutely... the roof is ideal for the purpose but to be ideal for the purpose it's got to be rather obvious. Erm, I think I, I was a bit self-conscious of it at first but you just get used to it after a while.

DG: Yeah, definitely. So have you now come to like that everyone can see you're doing this or are you still a little bit... wary?

MA Yeah, I'm a bit of my generation... I'm not sure about that. You know I'm perfectly prepared to tell people that I think it's the right thing to do and if they don't like to look at it then tough luck, but I'd rather not have to do that.

DG: Ok, so most of the comments have been positive?

MA Yes, yes. I mean somebody who lives behind us and presumably can see quite a lot of it said "oh well that roof was crying out for it wasn't it?" so I was quite relieved because I... I don't want to... I don't think it is an eyesore but it's like the satellite dishes, you have to get used to what they look like.

DG: And it's just the case that you're first I guess so you've gotta take the risk...

MA Yes, I believe in Germany and France the place is sort of peppered with them.

DG: Ok. Do you think you yourself have influenced anyone into considering or even getting the solar panels?

MA Well, I think the friends who probably would have had it if their roof had been suitable and one of the people from Lewes brewery came and asked how we found it or how the installation went and did we think it was a good this. Because she was considering... this was before they'd finalised the scheme... I think she was wondering whether she would be voting in favour of it or not, collecting opinions. So yes, I think in general... I think most of the people who've asked about it... probably had some input into persuading people that it's a good idea, that you can live with it... that it doesn't seem to have much in the way of adverse impact. In fact I don't think the solar panels have any adverse impact... erm... any minor inconveniences are to do with the hot water heating.

DG: How so?

MA Erm, because... they have... to make it work you have to have a much bigger... cylinder tank, so I've lost most of my airing cupboard and... or some of the stuff up in the roof space... some of it may have to do with the solar panels but I suspect most of it is to do with the water heating pipes and that's... we didn't have a very big roof space for storage to begin with and now there's less storage space and there probably isn't room for the loft ladder which we would like to have had to make it easier to get in and out. So, you know, there's hardly sort of... world

shattering problems but those things I think are mostly sort of to do with, you know, hot water rather than the solar, which as far as I can see is just a wire that comes down from the roof.

DG: Nice and straightforward.

MA Yes, into the fuse box.

DG: So do you think that people like yourself have an important role to play in driving other people to install them? Like would you like to see more people take it on?

MA I think I would like to see more people take it on, I think... as it was explained to us the south-east is one of the bits... the south-west is the best of all and southern central England is probably the next best. And Lewes with a lot of people with houses up on ridges has probably got a lot of properties that could do it. And yes, the more people who did it, the less outlandish it would look. But I am aware that it is quite a capital investment and it happened that we'd been here so long that we'd paid off the mortgage so we had a bit of capital that we could decide what to do with. And I suspect a lot of people don't have capital that they actually have to decide what to do with.

DG: That sounds fair. That's all my questions; do you have any back at me?

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