Renewable Energy Technologies and their Users: the Case of Solar Photovoltaic Technology

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ABSTRACT

In recent years, renewable energy technologies (RETs) have been increasingly recognised among a range of solutions for addressing climate change and reducing reliance on fossil fuels. However, their implementation in the UK has been slower than expected, creating a gap between the potential of these technologies and their actual deployment. Acknowledging the importance of users in the diffusion of RETs, this thesis examines how these users are conceptualised during RET implementation and use. Using theoretical perspectives from science and technology studies, it analyses the configuration of users during the design and implementation of photovoltaic systems, taking as an example two case studies that took place as part of the UK government's Photovoltaic Domestic Field Trial.

The study investigates the multiplicity of actors involved in the installation projects and demonstrates the negotiated nature of photovoltaic system design. During this process, the actors – the managers of the installation projects – constructed user identities based on the users' perceived expectations, preferences, behaviour and knowledge. These identities were materialised into the design of the system, thus creating a script that shaped the use of the technology. The study explored how the photovoltaics were appropriated within the home, highlighting the different modes of use and types of users in relation to the technology. In doing so, the thesis presents how the project managers 'write' the technology, and how the technology is in turn 'read' by the users. This perspective can be helpful in understanding the deployment of RETs, as it stresses their socially shaped nature. It shows how the design of the photovoltaic system was the result of a negotiated process of managers' knowledge and expectations regarding the users, the users' methods of appropriation, and the sociotechnical systems within which they operate. It also argues for the importance of situating the use of photovoltaics, and other related RETs in the domestic sector, within the wider sociotechnical landscape governing household energy consumption.

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ANT	Actor-network theory
BERR	Department for Business, Enterprise, and Regulatory Reform
BOS	Balance of System
BRE	Building Research Establishment
CABE	Commission for Architecture and the Built Environment
CHP	Combined Heat and Power
CTA	Constructive Technology Assessment
DCLG	Department of Communities and Local Government
DEFRA	Department for Environmental, Food and Rural Affairs
DFT	Domestic Field Trial
DNO	Distribution Network Operator
DTI	Department of Trade and Industry
EPOR	Empirical Programme of Relativism
EST	Energy Saving Trust
EWP	Energy White Paper
GHG	Green House Gases
GIS	Geographic Information System
HIP	Home Information Pack
LCD	Liquid Crystal Display
MDI	Multiple Deprivation Index
NIMBY	'not in my back yard'
NRA	National Rifle Association
NREM	New and Renewable Energy Programme
PV	Photovoltaic
QDA	Qualitative Data Analysis
RET	Renewable Energy Technology
SCOT	Social Construction of Technology
SPA	Social Practices Approach
STS	Science and Technology Studies
UK	United Kingdom

CHAPTER ONE

Introducing the Research: Context, Aims and Methodology

"A renewal of the social theory which informs energy consumption and conservation is called for in the face of environmental challenges. There is an urgent need for ... a more robust theory of consumption, one which incorporates social relations and cultural context, as well as individual agency and social change" (Wilhite, 2001: 331).

1.1 Introduction

Reducing carbon emissions to address the problem of climate change is one of the most pressing concerns for public policy facing western governments today. One approach to achieving this reduction is an increase in the deployment of renewable energy technologies (RETs) (Elliot, 2000). Indeed, increasing the share of RETs amongst energy sources has been consistently present in government policies of various countries in the developed world; where several of them have set ambitious targets for RET deployment and allocated funding for implementation (Wustenhagen *et al.*, 2007). Moreover, concerns about energy security have also led to additional interest in renewable energy sources (Helm, 2002a), and to more governments adopting RET deployment targets (Blok, 2006; Haas *et al.*, 2004) in order to reduce their reliance on imported fossil fuels.

In the UK government's Energy White Paper (DTI, 2007), the current national government has set out its international and domestic energy strategy in response to climate change challenges. A strong continuation of the earlier Energy White Paper in 2003 (DTI, 2003), it outlines the country's interest in major carbon reductions and the promotion of RETs for greener electricity generation (DTI, 2007). The White Paper conveyed an ambition of "at least a 60% reduction in carbon dioxide emissions by 2050, and a 26-32% reduction by 2020, against the 1990 baseline" (DTI, 2007: 8). Additionally, the government has renewed its policy on the provision of 10% of electricity sources from RETs by 2010, and by publishing the draft Climate Change Bill has indicated its commitment to addressing this environmental concern. In the most recent analysis of the UK's energy sources, it was shown that only 4.6% of the total electricity generated comes from renewable energy sources. Furthermore, 93% of the total energy produced from renewable sources comes from large-scale technologies such as hydro-power and wind (BERR, 2007). This suggests that much improvement is needed if the UK is to reach its targets, especially since the proportion of energy from RETs is significantly behind other European countries, such as Germany, Austria and Spain.

In recent years, and within the government's attempts to increase the deployment of RETs, more attention has since been given to small-scale renewable energy technologies, or microgeneration (DTI, 2005; EST, 2005a; Watson, 2004) which have the potential of increasing the amount of green and renewable energy provision. According to Sauter and Watson (2007), microgeneration technologies are energy generation technologies which could be installed in individual homes and include technologies such as solar photovoltaics (PV), micro wind, and micro combined heat and power (micro-CHP). The deployment of technologies like PVs and micro-CHP were expected to play an extensive part in the government's vision of the energy system in the UK by 2020 (DTI, 2003). According to a government consultation on microgeneration, these technologies can contribute towards a more reliable energy system and a more competitive market, as they provide energy needs for homes and residences (EST, 2005b). Most importantly, it is their potential in providing a sustainable and green source of energy, due to their zero or low carbon emissions[1], that makes them a significant technological choice for mitigating climate change (DTI, 2005).

The technical potential of these energy sources has been improving, where such technologies have shown expanded diffusion and cumulative growth worldwide (Jacobsson and Johnson, 2000). However, the situation in the UK indicates that the diffusion of these technologies is still in its early stage with only "80.900 installations of low or zero carbon technologies generating either heat or electricity" (DTI, 2005). The expansion of current deployment levels is hindered by several factors, most notably the high cost of technologies such as solar PVs

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[1] Micro-CHP is mostly gas fuelled; however, it does have the potential to be fuelled by greener energy sources in the future by running on hydrogen fuel cells or using biomass.

(Andersson and Jacobsson, 2000; Keirstead, 2007a) and the incompatibility of the technology with the dominant energy supply system, which favours large-scale, centralised technologies (Watson, 2004). Other barriers identified include the limited knowledge and experience of firms regarding microgeneration, as most of these technologies are relatively new. This lack of information is perceived as an obstacle to adoption as consumers are discouraged by the potential investment risks; this is especially the case for micro wind and micro-CHP (DTI, 2005).

Whilst the above barriers pertain to the technologies *per se* and to the energy system and market within which they exist, another perceived barrier to their diffusion relates to the RETs' potential users. Identified by Watson *et al.* (2006: 14) as an information barrier, the authors argue that the lack of sufficient knowledge and advice on small-scale RETs can prevent people from considering them as an option for energy generation in their homes. Furthermore, the issue of 'bounded rationality'[2] means that people are unlikely to make decisions based on economic and technical appraisals alone, and that constraints on people's time, resources and ability to process information make the provision of individualised and site-specific advice essential (Sauter and Watson, 2007; Watson *et al.*, 2006).

As with many of the arguments surrounding energy technologies, those pertaining to RETs are often built around a simplistic model for the diffusion of such technologies in society, based mostly on economic models where users are imagined as rational, profit-maximising consumers (Guy, 2006). Moreover, the assumption is that if individuals are provided with the necessary information, their attitudes may change (Jelsma, 2006b) and they would be more likely to adopt or invest in RETs. Recent studies have also looked at the influence that the introduction of RETs in the home might have on human behaviour, suggesting that its existence within the built environment can serve as a symbolic reminder about climate change and lead to environmentally friendly behaviour (Keirstead, 2007b).

These studies assume a linear process for the diffusion of RETs based on technical performance and economic feasibility, and fall within what Guy and

[2] The term 'bounded rationality' was coined by American political scientist Herbert Simon, in relation to the limitations that face the individual's rational choices. Hence, individual's face constraints such as the cost of information and uncertainty, which prevents them from making rational decisions (Simon, 1982).

Shove (2000) refer to as a 'technoeconomic paradigm'[3]. From this perspective, the analysis and policy making on energy is dominated by the technical and economic factors that impact on energy production and consumption, whilst neglecting other equally important cultural and political factors. Moreover, they imply that technologies are used precisely as their designers imagined, and do not take into account the context in which these RETs are used (Shove, 2002) and the different appropriation methods employed by the users (Silverstone and Hirsch, 1992), which could influence the environmental performance of these technologies in the built environment, such as through user resistance or re-interpretation (Rohracher, 2006a).

Acknowledging the limitations of the technoeconomic approach in explaining the gap between policy and implementation, this research aims at understanding the diffusion of RETs from a sociotechnical perspective – based on the view that science is a social and cultural product and that "the technical is always in relationship with wider social, economic and political processes" (Webster, 1991: 14). Hence, this study employs ideas within the field of science and technology studies (STS) to highlight the complex political, social, economic and cultural dynamics of technology implementation. It is thus interested in the role of users in the implementation and use of RETs. As such, it attempts at understanding how users are constructed by the various actors in the context of the technology's installation. This research is therefore interested in going beyond the technoeconomic paradigm, and thus situating the implementation and use of small-scale RETs in the context of the wider built environment. Since the majority of the expected deployment of these technologies is in residential buildings, I will therefore focus my study on the implementation of RETs in the domestic sector by taking as an example two installation projects involving one microgeneration technology, that of solar photovoltaics (PV). Generating energy from photovoltaics is not new and has been steadily commercialised as a green source of electricity since the 1970s (Green, 2000). Over these years, the technology has been developed further, and recent innovations within the field have improved its

[3] The use of the term by Guy and Shove (2000) should not be confused with the more widespread meaning of the concept of 'technoeconomic paradigm' as introduced by Freeman and Perez (1988), which refers to techno-economic paradigms underlying long waves of production cycles.

efficiency and feasibility (Andersson and Jacobsson, 2000; Jackson and Oliver, 2000).

However, when it comes to the deployment of solar technology, the classic reply is its expense and, consequently, its limited application options. This prompted me to further examine the arguments and discourses surrounding photovoltaics in the UK. Furthermore, photovoltaics' current level of deployment in homes was higher compared to other microgeneration technologies, making the possibility of conducting fieldwork more likely.

1.2 Researching RETs and their users: context and theory

In this section, I describe the context surrounding PV installations in the domestic sector. I will then outline the objectives of this study and my research questions, as well as a summary of the methodological approach adopted in this research.

1.2.1 RETs in the home: photovoltaics for the domestic sector in the UK

The domestic sector presents an enormous challenge for tackling climate change in the UK. According to the Energy White paper (BERR, 2007), the energy demand of this sector amounted to 30% of the total demand in the country. Further increases in the housing stock, to address projected population growth and resulting housing needs, mean that policies for energy efficiency and microgeneration are crucial for responding to these problems (in addition to investments in CHP stations and other sources of renewable energy) (DTI, 2006a).

Among the many different strategies adopted by the national government to promote the diffusion of RETs was the trialling of photovoltaic technology on buildings. This was done through the investment in the Major Demonstration Programme, which aimed at installing PV in large building projects; and the Domestic Field Trial for the housing sector (DTI, 2006b). Both these programmes resulted in an increase of over 60% in the deployment of photovoltaic technology in the UK (International Energy Agency, 2004). Despite this increase, energy from photovoltaics still constitutes a very small percentage of the total energy consumed in the country (BERR, 2007). Given the large contribution of the trial scheme towards the deployment of PV, the field trial became an interesting area for me to investigate.

According to the Department of Trade and Industry (DTI), the aim of the photovoltaics (PV) Domestic Field Trial (DFT) was to "use the design, construction and monitoring of the installations as a learning opportunity for utilities, building developers and other key players in the process of PV installation and operation" (BRE, 2005). Managed by the Building Research Establishment (BRE), the trial's objectives included the assessment of design and installation quality, monitoring the performance of the PV systems, assessment of the buildability issues (such as necessary modifications to the roofing in place), as well as "user responses based on inputs from the project teams" (Pearsall and Butterss, 2002: 1497). Under the DFT scheme, 32 projects which included two different types of photovoltaic systems (retro-fit and building integrated) were installed with a total budget of £5.4 million. The type of projects varied among clusters of dwellings (typically 5-25) in social, private and mixed-use developments that were either new built or part of refurbishments and featured various types of PV technologies (DTI, 2006b).

Two projects from the trial provided the case studies that constitute the empirical work in this thesis. Both installation projects were located in the north of England. One project included the installation of PVs on a new build, private development, whilst the other involved the installation of the technology on an occupied local authority block of flats (retro-fit). My intention was to explore the different processes that shaped the design of the installed PV system on the built environment, based on ideas from science and technology studies which argue that technologies are socially shaped and that their design is the result of various negotiations that take place between different groups of users during their diffusion.

Thus, the concern of this research is in examining the implementation of renewables from a sociotechnical perspective (Guy, 2004; Shove *et al.*, 1998), providing insight into the various meanings that can be given to RETs and their relationship with users. In doing so, the study avoids the limited views of the technoeconomic approach which assumes a linear process of technological diffusion based on technical and economic approaches to the analysis of society (Guy and Shove, 2000) and calls for a more central role of social science research, questioning the various conceptualisations regarding barriers to technology diffusion and behavioural change (Shove *et al.*, 1998).

It is worth mentioning at this point what is meant by the category user. Rohracher (2006a: 64) states that the concept 'user' is a "rather ephemeral category changing its shape depending on the context and perspective we look at it". When exploring the implementation of RETs like photovoltaics, one can argue that housing developers, as well as builders and technicians, are the users of this technology in addition to the individual end-users. It is therefore imperative to indicate who is defined as the user in this research. For the purposes of this research, the notion of the user is taken to be the end-users of RETs, those householders or residents that live in homes where the PV technology is installed. This does not mean that other actors involved in the implementation of RETs are not themselves users, but that would depend on the level of analysis employed. By focusing on the end-users of technology, the focus of the analysis is the installation of PVs on homes and residential blocks.

1.2.2 Configuring RETs and their users: a sociotechnical approach

The analytical framework adopted in this thesis stems from theories in STS which have explored the way users are constructed and configured during technological innovation (Akrich, 1992; 1995; Woolgar, 1991a) and extends their application to the phases of technological diffusion (Callon, 1995). It argues that the process of configuring the user into particular roles continues during the deployment of RETs, involving the decision-making, preferences and beliefs of additional actors and intermediary users.

In recent years, scholars in STS have been increasingly concerned with the role of users in the conception, development and implementation of technology (Aune *et al.*, 2002; Guy, 2002; Jelsma, 2003; Kline and Pinch, 1996; Mangematin and Callon, 1995; Oudshoorn and Pinch, 2003; Rohracher, 2003; 2005b; Shove and Chappells, 2001). Theoretical work within the STS tradition is interested in how the concept of users is constructed and represented in technological development and implementation (Akrich, 1995), aiding innovators in creating 'scripts' that prescribe the way technologies should be used from the perspective of the designers (Akrich, 1992).

1.3 Introducing the research

In this thesis, I argue that designers (in this research the project managers of the two case studies) configure the relationship between the users (the residents) and the PV technology by limiting their actions and creating boundaries between them and the users. During the use of the PV technology, the users could 'de-script' the technology, appropriating it by adopting different modes of use and relating it to their everyday practices in their homes. In the next section, I will outline the aims of this research and the questions that guided my inquiry on the role of users in RET diffusion.

1.3.1 Research aims and questions

The central aim of this research, therefore, is to analyse how users are constructed during the implementation of RETs by taking the example of PV installation. In this analysis, I attempt to move away from essentialist notions of users' identities by analysing the way the different actors involved in the implementation of photovoltaics interacted and in doing so, shaped the final design of the PV system. During this process, the project managers constructed various images of the users as they sought to install and technology on the buildings. Therefore, my second aim is in analysing the different user constructions that were employed by the project managers during their involvement in the installation projects. My third aim is to examine the way the users perceived and utilised the photovoltaic technology in their homes, as part of their day-to-day life. This research objective is related to my interest in exploring how users might have 'de-scripted' the technology, and appropriated it into their contexts.

Hence my research questions are:

1. Who are the actors involved in RET implementation?
2. What are the roles played by these actors in shaping the design and implementation of RETs?

3. How are users constructed during the implementation of RETs and how does that influence the technologies' design?
4. How do users interact with RETs in the context of the household?

1.3.2 Methodology

In studying how users are constructed at the implementation level of RETs in England, my research focuses on the actors involved in these application projects – including local authorities, housing managers, property developers, energy consultants and engineers. The two case studies show that un-packing the 'trial' – which connotes a straight-forward illustration of a technology in exemplar circumstance – consisted of far more complex activities, the purpose of which was to ensure the installation of the technology within project deadlines. As such, the design of the PV system embodies the assumption made by the project managers about the way the technology should be used and the residents' preferences, which in turn define and constrain the way the technology is used. As Grint and Woolgar (1997) note, the user is configured within a 'technological text' which attempts "to define and delimit the user's possible actions" (Grint and Woolgar, 1997: 71).

The metaphor of technology as text can be useful in understanding how users and technologies are co-constructed during the innovation and diffusion of technologies (Oudshoorn and Pinch, 2003). Akrich's concept of 'script' is particularly useful in analysing how the expected role of the user is written into the design of the technology by the actors involved. According to Crosbie (2004: 9), "this approach sensitises us to the ways in which technologies, like texts, are written with particular users (or readers) in mind, and how this shapes the technical capacities of technologies in the same way as the envisaged readership of a novel, textbook or newspaper shapes those texts". In this way, by examining how the PV systems are designed (written) and how they are used (read), the roles of both the project managers and users in the diffusion process can be uncovered, and the way the technology is shaped and appropriated is revealed.

Users, however, can challenge the reading of the text, or as Akrich (1992) argues, can 'de-script' the technologies according to the existing sociotechnical landscape that shapes and contextualises their everyday practices. By analysing how the design and use of RETs can be contingent on the local contexts in which they exist, we will be able to better understand these processes and develop strategies for RET implementation which are conducive to an effective adoption of these technologies and consequently lead to a reduction in carbon emissions.

1.3.3 Summary and conclusions

Energy issues have become increasingly important as pressures to tackle climate change and address energy security intensify. In recent years, energy and climate change featured strongly in western governments' policy agenda as they attempted to achieve their set carbon reduction levels. Whilst some countries in Europe have been successful in their energy strategies, the situation in the UK remains a cautious one. The current level of energy consumption, coupled with the comparatively limited deployment of RETs justifies further research and examination into policy measures necessary for achieving the country's goals. Moreover, with the domestic sector making up to 30% of the total energy consumption (BERR, 2007), the potential for micro-level RET deployment in the residential sector is emphasised.

Government policy has tried to tackle the domestic sector's energy consumption through various strategies, such as the promotion of energy efficiency regulations targeting new-build, encouraging the utilisation of insulation for homes and campaigning for a reduction in household energy consumption by appealing to households and individuals. Recently, a strategy for the implementation of microgeneration technologies was developed in a bid to tackle the problem of the domestic sector's consumption (Keirstead, 2007a). The current situation, therefore, raises an important question concerning the imagined role of individuals and householders in the context of the promotion and diffusion of microgeneration technologies.

In this context, understanding the role of users in the adoption of these RETs is vital for energy policy, if the goals set out in the Energy White Paper (DTI, 2007) are to be achieved. This thesis is therefore concerned with the implementation of RETs and their users. I focus, in particular, on the role of users in the diffusion of small-scale RETs, as these technologies are used and become part of users' homes. Hence, the interest of this research is the micro-level processes which take place and concern the implementation and use of this type of RETs. As mentioned earlier, this research will explore these issues by examining two case studies involving the installation and commissioning of solar photovoltaic technology as part of the government funded Domestic Field Trial.

1.4 Structure of the thesis

Chapters one, two, three, and **four** form **part one** of this thesis. Following this introduction, **chapter two** overviews the current literature on RET policy and implementation. The chapter includes a literature review of social studies on energy and presents the emerging themes within this field of research. In this chapter, I discuss the barriers hindering RETs' diffusion as they emerge from the literature and situate them in relation to energy users. In doing so, I seek to unpack the conceptualisation of the user in the academic debates surrounding RET implementation and use. In addition to that, this chapter presents the main arguments on user behaviour, which stem from socio-psychological approaches. This is followed by a critique of these studies in light of recent developments in social sciences on energy, namely the social practices approach applied to energy and sustainability as well as studies drawn from theoretical perspectives in science and technology studies (STS) and domestication of technologies.

In chapter three, I present the main theoretical approaches within STS which have, in recent years, influenced the direction of research in this field. The review of these approaches forms the basis on which theoretical work concerning users in STS is introduced. The chapter, therefore, introduces the main theories in STS that have shaped my analytical framework: actor-network (ANT) theory and the theory of the social construction of technology (SCOT). This is followed by a description of the three approaches that have informed research on users within STS, and include: the concept of 'script' developed by Akrich (1992), the notion of 'technology as text' as argued by Woolgar (1991a) and the underlying process of configuring the user, and finally the studies on the domestication of technology. From this point, an analytical framework emerges, which attempts to unpack the processes of configuring the user on the one hand, and those of appropriating the technology. I borrow the terms used by Jelsma (2005) by referring to them respectively as the 'design logic' and the 'use logic'. In this chapter, I situated these theoretical debates in relation to recent studies in STS on users and their role in shaping technologies and their use.

Chapter four outlines the methodology adopted in my research. After revisiting the research questions, I discuss the methodological implications of the theoretical approaches presented in chapter three. This is followed by an overview of the concepts behind the research method used in this thesis, the case study method. I then briefly present the two case studies that constitute my empirical work, followed by an outline and description of the data collection tools used. Finally, I discuss the techniques used in the analysis of the data.

Part two of the thesis consists of **chapters five, six** and **seven.** In **chapter five,** I describe the two case studies without presenting any analysis of the data. The technical and institutional characteristics of the two case studies are described. Each description consists of a detailed outline of the actors involved, including the residents, and the actions taken by these actors during the installation and use of the photovoltaic systems. This chapter, therefore, summarises the empirical work which I conducted through my studies, and attempts to contextualise the events described in the emerging policies and debates on photovoltaics' implementation.

Chapter six discusses the processes of configuring the user. In particular, the chapter describes the actor-networks surrounding the implementation of the photovoltaics and the resulting design of the PV system installation. Configuring the user during the design and installation of the technology entails the construction of user identities, or images of who the users are and what are their preferences. In this chapter, therefore, I present the main constructions of the users that were employed by the project managers as they sought to understand and anticipate the actions and behaviour of the residents. It concludes by highlighting the configuration process in relation to two components of the PV installation that emerged from my empirical data: the display monitor and the documentation concerning the PV system made available to the residents.

Chapter seven analyses the users' perspectives of the installation. Hence, this chapter explores the process of appropriating the technology, or the 'use logic'. It analyses the use of the PV system with respect to the home, the energy consumption and everyday social practices. From these analyses, four different categories emerge: the 'conscious user', the 'opportunistic user', the 'interested user' and 'non-users'. These categories are analysed in relation to the concept of 'script' and serve to highlight the different ways of using the photovoltaic technology. Moreover, in this chapter I show how the use of the technology was configured by the resulting PV installation design.

In **chapter eight**, I revisit the main themes that emerge from this research. In this final chapter, I outline the implications of this study on the design of photovoltaics and what it means for the implementation of RETs in general. I then discuss the position of this research with respect to the existing literature on users in STS. This is followed by the practical implications of my study before I conclude with some remarks regarding this study and its wider application in social science research relating to energy.

CHAPTER TWO

The Challenge of Implementing Renewable Energy Technologies in the UK

"The focus on end-consumers and their decisions, often with the aim of identifying policy levers with which to change behaviour, has the effect of excluding other questions about the social organisation of energy consumption" (Shove *et al.*, 1998: 301).

2.1 Introduction

Renewable energy technologies (RETs) are viewed as important in the effort towards a sustainable system that can meet the challenges of climate change and the projected depletion of fossil fuels (Ekins, 2004; Elliot, 2000). To tackle these issues, governments are encouraged to set national energy strategies that include steps to promote the development of RETs and their implementation (Haas *et al.*, 2004). The UK's current energy policy centres on four main objectives outlined in the Energy White Paper (DTI, 2007) which are the reduction of carbon emissions – marked by a target of 60% reduction of emissions by 2050, the maintenance of reliable and sustainable energy sources, promoting competitive energy markets and ensuring that every home is heated affordably. A recent review on the implementation of the Energy White Paper asserted that, along with energy efficiency, renewable energy is key in helping to achieve the carbon emissions targets mentioned above (DTI, 2006a).

The aim of this chapter, therefore, is to briefly present the main arguments surrounding the deployment and diffusion of RETs in society. In this first section, I will begin by outlining the elements of energy policy developed to address the diffusion of these technologies into existing energy systems, focusing in particular on the UK. With interest in the domestic sector and microgeneration technologies, I will then focus on the conceptualisation of users of RETs, paying particular attention to the consumption of energy in the home. In doing so, I illustrate how the main arguments used in policy analysis frame the users or energy consumers into specific roles. In the third section, I will introduce the main disciplinary perspectives that have dominated the analysis of energy technologies and their users such as psychological work on behavioural change, norms and attitudes.

However, recent developments in social sciences on the diffusion of energy efficiency and energy use in the home (Aune, 2007; Guy and Shove, 2000) have called for a more "socially sensitive analysis of energy" (Shove, 1998: 1106) that takes into consideration the complex situations surrounding energy use. Hence in the fourth section, I will review the literature from the social practices approach (SPA) (Spaargaren *et al.*, 2006) and science and technologies studies (STS), and argue how analytical approaches from STS are relevant to the study of RETs and their users.

In this chapter, I argue that in the prevalent policy literature, the role of the user is often sidelined and confined to being on the receiving end of energy innovation. Moreover, the issues raised with respect to energy consumers tend to be framed around the classic deficit model (Owens, 2000), and call for energy education and environmental awareness about the externalities of electricity from fossil fuels. The chapter concludes that the over-emphasis on technological solutions and economic approaches for the diffusion of RETs on the one hand, and the dominance of the socio-psychological perspective in analysing the role of users on the other hand, have resulted in a fragmented landscape concerning the relationship between RETs and their users. The outcome is the marginalisation of the role the users play with respect to RETs and the sociotechnical nature of RETs and energy consumption in society.

In the next section, I present the main arguments drawn from recent literature on the diffusion of technologies for energy efficiency and renewable energy, as well as studies that critique RET policies in the UK. In this review, my intention was to obtain a general overview of the main challenges, arguments and solutions for RET diffusion as perceived though the study and analysis of energy policy.

2.2 *Energy policy and institutional changes*

RETs include hydropower (including wave and tidal power), wind and solar power. These sources of energy can continue to be used without causing damage to ecosystems or contributing to climate change. A look at the current energy situation in the UK finds that only 1.8% of the total energy consumed came from RETs (DTI, 2006c). In terms of electricity generation, only 18,133 GWh (Giga Watts) came from renewable sources, amounting to approximately 4.6% of the total electricity generated (BERR, 2007). Therefore, achieving the target of 10% of electricity to be supplied from renewables by 2010 (increasing to 15% by 2015) requires a substantial step change in RET take-up in the next three years[4]. Table 2.1 details the amount of electricity generated by three types of renewable energy sources across Europe (wind power, photovoltaics, and solar thermal panels) and the performance of the UK in comparison to them.

Table 2.1 Wind power, PV and solar thermal capacities in some EU countries

Country	Electricity from wind power (TWh)	PV capacities installed (MWp)	Solar thermal capacities installed (MWth)
Germany	**30,500**	**2,863,000**	**6,001.8**
Spain	**22,924**	**118,100**	**477.2**
Denmark	**6,108**	**2,900**	**264.6**
United Kingdom	**4,225**	**14,042**	**176.5**
Austria	**1,738**	**52,705**	**452.3**
Netherlands	**2,734**	**25,585**	**1,987.1**

Source: Observ'ER (2007), available at: www.euractiv.com

According to Elliot (2000: 261), RETs face "an uphill struggle in trying to become established" in the current landscape of energy provision. He adds that whilst the technical development of RETs has been "relatively straight forward, the social and institutional implementation problems are often much harder to resolve" (2000: 261). In other words, the transformation of our current energy system, which relies heavily on fossil fuels into one that incorporates renewable energy sources, is fraught with various challenges. However, these challenges do not solely relate to the technology as such, but regard other matters referred to as "non-technical barriers" (Shove, 1998), which are meant to be resolved through effective energy policy and intervention. In the next section, I will discuss the treatment of these barriers in the literature on energy policy. My intention in doing so is to present the prevalent discourses used when thinking about users of RETs within energy policy.

[4] The renewables obligation underwent consultation in May 2007 alongside the "Energy White Paper – Meting the Energy Challenge". The consultation closed on 6 September 2007.

2.2.1 Markets, prices and distortions: the economics of RET

According to Guy (2004), whilst research on energy has acknowledged the role of factors outside technical development that influence its uptake in society, the response has been a reliance on economic concepts in seeking to understand the diffusion of technology (see also Shove *et al.*, 1998). For instance, the promotion of energy audits and feedback mechanisms to encourage users to save on their energy consumption is built on the assumption of rational users with profit-maximising interest. As a result, "a world of perfect information, on the one hand, and a definable logic of (utility-maximising) rationality, on the other hand, are posited" (Guy, 2004: 688). Moreover, research on energy policy emphasises a separation between the logical and efficient technological systems and the social and behavioural factors that hinder the diffusion of these proven technologies. Framed as "non-technical barriers" (Shove, 1998: 1106), this literature has attempted to address the challenges of RET diffusion by focusing on the economic and market incentives that are necessary to drive the move towards a more sustainable energy system.

Whilst it is not the intention of this study to ignore or trivialise the role of economic factors in the diffusion of technologies like RETs, it does argue that an overemphasis on economics risks neglecting other cultural, organisational and political factors that play a role in the diffusion process. From reviewing the literature on RETs, a number of these non-technical barriers appear in the analysis of energy and its users. For example, Mitchell (2003) argues that there are non-technical barriers in the UK that make it difficult for RETs to be adopted, and categorises them as: economic, institutional, market rule related, social and financial. The need therefore, according to the author, is to remove these barriers in order to achieve our targets with respect to electricity generation. Moreover, from a political point of view, Marsh and Rhodes (1992), argue that the regulation of the privatisation of services led by the conservative governments in the 1980s have limited the competitiveness of markets, where significant concessions were made to the private companies. As a result, fiscal policies like feed-in tariffs face barriers to their implementation, resulting in a slower diffusion of new technologies like RETs. Also, RETs are often conceptualised as new environmental innovations that face barriers to their adoption and integration within the existing energy system. Trudgill (1990), for example, formulated a model for the diffusion of environmental innovations that involves barriers to the acknowledgement of technology diffusion and barriers to its adoption, in addition to economic, social, and political barriers that should similarly be overcome through a host of policies and regulations.

Table 2.2 summarises these barriers as they appear in the literature and categorises them as market related, financial, institutional, societal and psychological barriers. The majority of the works reviewed for my research mention several market barriers, including for example the pricing of fossil fuels. According to this literature, the price of fossil fuels does not include the social and environmental costs of burning it and argue that including these aspects in the price is necessary if the quest is to mitigate climate change impacts (Beck and Martinot, 2004; Menz, 2005; Sonneborn, 2004). Conversely, the benefits of renewable energy sources are not incorporated into the prices of green electricity, leading to more difficulties for the rolling out of RET projects (Brown, 2001). Energy users, therefore, are not paying the true cost of electricity prices. Furthermore, the pricing system, which does not reflect the demand of electricity on the time of day, is distorted and does not encourage users to economise their energy consumption (Neuhoff, 2005).

Table 2.2 Existing literature on barriers to RET diffusion

Barriers	Examples	Study
Market	Immaturity of technologies Unpriced environmental costs of fossil fuels and unpriced benefits of RETs Inability of RETs to compete due to economies of scale (electricity market designed for conventional power plants) High cost RETs such as photovoltaics	Beck and Martinot (2004), Brown (2001), Faiers and Neame (2006), Foxon *et al.* (2005), Neuhoff (2005), van Rooijen and van Wees (2006).
Financial	Lack of sufficient financial backing for RET project and demonstration trials Subsidies supporting fossil fuels, making conventional energy cheaper	Foxon *et al.* (2005), Mitchell and Connor (2004), Sonneborn (2004)
Institutional	The divided nature of ministerial responsibilities and lack of coordination between them Legislative failures towards established technologies Obstacles to distributed generation	Helm (2002b), Jacobsson and Johnson (2000), Keirstead (Keirstead, 2007a), Sonneborn (2004)
Societal	Misplaced incentives for installation Perception of energy issue as low priority Lack of awareness on environmental issues The need for education and information provision	Bahaj and James (2007) Brown (2001) Fuchs and Arentsen (2002) Menz (2005)
Psychological	Energy as an invisible commodity Information deficit model Nature of prevalent energy supply systems Selfish and irrational individuals	Egan (2002) Kempton (1986) Pasqualetti (1999) Bosley & Bosley (1988)

From the perspective of energy innovation systems for RETs in the UK, Foxon *et al.* (2005) argue that barriers to the up-scaling of RET applications from demonstration or pre-commercial projects to full fledged commercial developments incur various types of risks. So in addition to the lack of necessary financing, RETs face a technology risk (a risk of RETs not achieving their expected performance and costs), a market risk concerning future levels of financial rewards, a regulatory risk which is dependent on government policies, and a systems risk which is associated with the inability of existing technological and institutional systems to accommodate new technologies (Foxon *et al.*, 2005). The last risk echoes with the notion that RETs, as new entrants in the current energy system, lack the organisational and political power that technologies based on fossil fuels enjoy (Fuchs and Arentsen, 2002; Jacobsson and Johnson, 2000). Hence, it becomes necessary for companies to form alliances to promote the technologies and achieve commercialisation in the energy market (Wustenhagen and Bilharz, 2006). This aspect relates to other non-market barriers that need to be overcome for the diffusion of RETs (Mitchell, 2003). In the next section, I will briefly present the institutional and regulatory context of RETs, as well as the perceived social barriers for their deployment.

In the paragraphs above, my intention was to briefly review the 'non-technical barriers' literature concerning RETs. It reflects the dominant viewpoints criticised by Guy and Shove (2000), mentioned earlier in this section. This literature also includes the analysis of other non-market barriers, which normally refers to the institutional and regulatory settings that accordingly influence the diffusion of RETs. It also categorises societal factors separately, focusing on market incentives, education and behavioural changes. The treatment of the societal and psychological factors is of particular interest for this research, since it reflects the literature's conceptualisation of RETs' end-users. In the following section, I will present the non-market barriers as discussed in this literature, before describing in more detail how it depends on particular constructs of users.

2.2.2 Non-market barriers: institutions, regulations and society

Several authors argue that conventional technologies are at an advantage due to experience and economies of scale, making RETs unable to compete in the existing market (Jacobsson and Johnson, 2000). Moreover, lack of information about new renewable technologies available to firms (Neuhoff, 2005), and the misplacement of incentives, means that buildings or homes are unlikely to incorporate RETs in their design (Brown, 2001). Accordingly, landlords are not interested in RETs like microgeneration which benefit tenants who pay utility bills. Similarly, construction companies are interested in immediate returns on their investments and do not have an incentive to invest in RETs. In addition to that, regulatory restrictions and planning permissions required for RET deployment make RETs such as small scale wind or combined heat and power (CHP) difficult to implement (Neuhoff, 2005).

The final hurdles app earing frequently in energy policy research is what are referred to as "societal barriers [which] relate to how individuals and society views the importance of a sustainable future" (Mitchell, 2003: 8). Accordingly, insufficient information on the benefits of RETs to the environment, as well as a lack awareness of the dangers of climate change and the threat that burning fossil fuels poses, hinders the adoption of new energy innovations like RETs (Brown, 2001; Dias *et al.*, 2004). Menz (2005), in a study of green electricity in the United States, cites "non-economic factors such as customer awareness of environmental and energy-conservation issues, and general awareness of renewable energy technologies" (Menz, 2005: 2406). These observations often call for the need to educate the customers on the energy-saving potential of RETs. Similarly, from studies in social-psychology, studies have indicated the individuals take energy consumption in their everyday lives for granted (Egan, 2002), and do not understand how energy technologies function (Kempton, 1986). Other authors have noted the nature of energy systems, where energy stations are effectively distances away from populations, resulting in individuals being unaware of the way the system works and how they are supplied with electricity (Pasqualetti, 1999), in addition to the view of selfish and irrational individuals that was prevalent in the literature on siting wind farms (Bosley and Bosley, 1988, cited in Wolsink, 1994).

In the sections above, I have attempted to briefly sketch the energy literature landscape surrounding RETs. However, this is by no means a comprehensive review as I have opted not to discuss policy mechanism designs or the management of energy innovation systems. Due to the macro nature of these studies, I chose not to include them as my focus is on end-users, which relates to more micro-level processes. Therefore I have concerned myself with energy policy research what relates to users and consumption, particularly energy consumption in the home. In the next section, I discuss in more detail the conceptualisation of users within this literature. As I have mentioned earlier, whilst not disputing the importance of the above studies in their effort towards a more effective energy policy, my purpose is to demonstrate and critique the overemphasis of these studies on economic and behavioural models when analysing users.

2.3 Users of RETs: conceptualising energy consumers

In general, energy policy analyses unanimously agree that to achieve the necessary carbon reductions at the international level (through energy efficiency measures and adoption of RETs) requires the support of people in the developed world (Owens, 2000). According to a survey by the Department for Environmental Food and Rural Affairs (DEFRA), consumers want to help improve the environment and 46% of those surveyed in the UK stated that they were "very worried" about climate change (DEFRA, 2002: 62). However, the level of actual energy-related behaviour conducive to carbon reduction (Boardman, 2004) does not match the stated support. As such, a perceived gap between the two is often discussed in studies on environmental behaviour and energy consumption. In this section I will discuss the various arguments presented in the literature on the role and policy requirements for a more active support towards the environment.

2.3.1 Educating users and raising awareness: knowledge and action for climate change

In an overview of research needs for the promotion of RETs, Ekins (2004) points to the potential role of information about energy consumption and the price of energy on changing consumption behaviour. The aim is to better understand and encourage social learning about climate change in this age. Indeed, several studies on RETs and the public echo an 'information deficit' model, as described by Burgess *et al.* (1998: 1447). Accordingly, people are perceived as lacking in environmental knowledge which is imperative for more environmentally friendly actions and attitudes. The belief, according to Owens (2000: 1141), is that "information is the key to public involvement and action". Implicit is the assumption that if people understand the relationship between their actions and their adverse environmental effects, they would be willing to change their behaviour. Referred to by Shove (1998) as 'conventional research', this body of knowledge argues that the purchase of energy efficiency products, energy conservation in the home and the installation of renewable and energy efficiency technologies are driven by people's knowledge of energy and the environment.

For example, in analysing how consumers can demand more energy efficient electrical products, Boardman (2004) argues that people have to "understand that it is their use of energy that is causing the carbon dioxide emissions, that results in climate change" (2004: 1928). Accordingly, policies should be aimed at promoting green labelling for white goods and providing feedback on energy consumption in an effort to motivate people to change their behaviour and habits based on their newly acquired knowledge. Since "energy is invisible, it is not possible to 'see' the wastage as you can with a dripping tap" (Boardman, 2004:

1931). As such, research on feedback for energy consumption argues that informing the public about their actual energy consumption in a clear way should promote energy conservation (Darby, 2006). Others have argued that whilst knowledge and information on the dangers of climate change and its anthropogenic causes have been provided, the obstacle remains the processes which block the understanding that individual action can indeed contribute towards necessary carbon reductions (Lofstedt, 1995). Accordingly, further research on learning, education and cognitive psychology is called for to fill the gap between available information and individual actions.

As the overview in the earlier section of this chapter shows, the focus of studies on the adoption of RETs remains, therefore, on raising awareness and education. The concern with awareness about RETs stems from studies on the diffusion of innovations (Rogers, 1995 cited in Fuchs and Arentsen, 2002). The work in this area argues that innovations, such as photovoltaics, are adopted by 'innovators' (which make up 2.5% of adopters) and 'early adopters' (12.5%) at the earlier stages of diffusion. This minority is then followed by the 'early majority' and the 'laggards', which constitute 35% and 15% respectively of the total adopters. Thinking based on this model suggests that raising awareness through marketing is essential to entice the early majority into adopting new innovations. The expectation, therefore, is that the environmental benefits of RETs can propel 'early adopters' who are environmentally conscious, however, other attractive attributes of RETs (such as savings on energy bills and aesthetics) should be promoted if adoption by the 'late majority' is to be achieved (Fuchs and Arentsen, 2002; Sultan and Winer, 1993). Similarly, analysis of PV diffusion stressed the need for addressing barriers to adoption as well as motives of consumers for purchasing a PV system. As such, the argument is that policy measures should target the majority with awareness campaigns regarding climate change, whilst supporting the "people with high problem-awareness" (Jager, 2006: 1943).

However, whilst providing information is important, its effectiveness regarding actions and behaviour is questioned. As Owens (2000) argues, "while greater knowledge may be worthwhile in its own right, barriers to action do not lie primarily in a lack of information or understanding" (2000: 1143). In other words, barriers to environmental action are not necessarily the outcome of lack in information or understanding, but are the result of mediating factors including the cultural, political and economic context, as well as personal and institutional constraints (Owens, 2000; Shove, 2003; Spaargaren and Van Vliet, 2000). I will be focusing in more detail on this argument in later sections of this chapter.

Another argument concerning users is the issue of social acceptance. The majority of this field of research concerns people's perception of environmental problems or risks such as nuclear energy (Lofstedt, 1995). With respect to RETs, social acceptance has focused on the public acceptance of wind energy projects and the NIMBY syndrome (Elliot, 1994; 2000). However, recent research into social acceptance has questioned these explanations for wind farm resistance[5] (Devine-Wright, 2004; Wolsink, 2000; Wustenhagen *et al.*, 2007). Concerning the social acceptance of photovoltaic systems specifically, Sauter and Watson (2007) analyse the acceptability of PV as a microgeneration technology[6]. In their study, the authors identify three aspects of acceptance: investments in microgeneration technologies, attitudes and induced behavioural changes.

Regarding investments, again a lack of knowledge on the part of users is argued to be a hindrance to social acceptance as well as the users' perception of the technology. Accordingly, people are reluctant to invest in PVs due to the perceived immaturity of the technology and the lack of experienced installers in the UK (Energy Saving Trust, 2005a). Two other aspects are found in the literature that relate to the social acceptance and adoption of microgeneration technologies such as PVs. These are public attitudes to microgeneration technologies and behavioural changes regarding domestic energy consumption. Having presented the arguments regarding user awareness and knowledge about climate change, in the next section I review the literature concerning the attitudes of the public regarding RETs and their ensuing energy-related behaviour and consumption.

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[5] See also the 'Beyond Nimbyism' project at http://www.sed.manchester.ac.uk/research/beyond_nimbyism/ conducted by a consortium of universities.

[6] Microgeneration technologies are defined as energy generation technologies which are installed in individual households such as solar thermal panels, photovoltaics, micro wind turbines and micro combined heat and power generators.

2.3.2 Winning hearts and minds: attitudes and users' behaviour towards RETs

In a review of the attitudes of users towards photovoltaics, solar thermal technology and micro-CHP in Germany and Austria, Fischer (2003) finds that the motives for adoption are often related to "autonomy [in energy generation], interest in the new technology and a desire to promote it, the wish to help the environment, and economic motives" (Fischer, 2003: 10). With respect to PV users, her study showed that they were usually high income consumers who have already invested in energy efficiency technology in their home. The pioneer user of such innovative technology, as Fischer (2003) suggests, is thus defined by various attitudes towards energy provision, technological development as well as the environment. The users are, in this case, synonymous with the 'early adopters' group defined by (Rogers, 1995), and characterised by their interest in technology and their attitude towards innovation.

In the UK, Sauter and Watson (2007) reviewed the results from two surveys carried out in London about people's attitudes towards microgeneration technologies. Though the percentage of favourable attitudes was high (80%), both studies showed that this was related to the availability of information about particular microgeneration technologies. Thus, according to the authors, consumers were more likely to approve of technologies that they knew about or were familiar with (Sauter and Watson, 2007: 2775). Another study looking into the general public's views found that the attitude towards social responsibility relating to energy use and the burning of fossil fuels indicated that the majority felt the government is responsible for reducing carbon emissions, suggesting a feeling of disempowerment regarding carbon reduction and action for climate change (Dobbyn and Thomas, 2005).

Such notions suggest that attitudes towards climate change need to change if further diffusion of microgeneration is desired. It is also argued that information and knowledge about microgeneration technologies would make people more likely to adopt them in their homes. However, as I mentioned before, the analysis employed in these studies focuses largely on people's level of education and their knowledge of technological options (Fischer, 2003; Sauter and Watson, 2007). They choose to leave out the cases where people, for example, installed micro-

CHP as a replacement for an older (and expired) heating system. Similarly, other studies have investigated the energy-related behaviour of households with installed microgeneration systems in an effort to understand the incentives behind energy saving actions. In a study on PV systems, the results show that households were likely to reduce their overall energy consumption if they were 'innovators' (Rogers, 1995), in other words if they had actively installed the PV system as opposed to having it installed through a local authority project (Dobbyn and Thomas, 2005; Keirstead, 2007b).

As such, it was argued that reduced consumption and load shifting (shifting the use of electricity to day time when the PV system generation is at its highest) was evident amongst those 'innovators'. However, the same study found that the second group of users were likely to adopt energy-saving behaviour if they were sufficiently introduced to the technology (by means of information packs or manuals). Furthermore, research on energy consumption and feedback has shown that supplying informative bills to consumers or using direct energy feedback systems such as smart-metering is valuable in terms of reducing energy consumption (Darby, 2006).

Further studies have investigated the relationship between attitudes and behaviour with respect to various environmental actions in the home (Barr and Gilg, 2006; Gilg and Barr, 2006; Poortinga *et al.*, 2004), including energy conservation behaviour (Barr *et al.*, 2005). Accordingly, three behavioural types emerge: purchase related activities (such as green consumption), habitual activities which occur in the home as daily routines, and highly structured and mechanised behaviour, such as recycling and composting garden waste (Barr, 2003). Moreover, according to Barr and Gilg (2006), individuals are divided into four categories of behavioural commitment: committed; mainstream; occasional environmentalists; and the non-environmentalists. Hence committed and mainstream environmentalists were both engaged with environmental causes and more likely to take up related action, including for example recycling. However, occasional environmentalists and non-environmentalists rejected these environmental practices, although habitual behaviour was sometimes adopted in the case of the former groups. The authors conclude that "socio-psychological constructs such as moral obligation, responsibility, social desirability and response efficacy are significant motivators for environmental action" (Barr and Gilg, 2006: 918). Whilst these studies are not mainly focused on energy and RETs, their argument with respect to consumer behaviour is relevant to other household activities including energy consumption and using RETs in the home.

Furthermore, a review by Jackson (2005) of literature on sustainable consumer behaviour and behavioural change distinguishes between two approaches to understanding and modelling human behaviour. Accordingly, an 'internalist' approach, predominant in the fields of social and cognitive psychology, studies behaviour as a function of the internal characteristics of the individual, such as attitudes, values, habits and personal norms. The 'externalist', on the other hand, which has been pursued in domains like institutional economics and behavioural analysis, analyses behaviour in relation to external processes, such as fiscal and regulatory incentives, institutional constraints and social norms (Jackson, 2005: 23). Aside from the rational choice model that we find dominates energy policy literature, cognitive psychology notes the importance of habits and everyday routines in determining our energy related activity. Therefore, understanding the take up of RETs and changes in energy consuming behaviour can benefit from an analysis of ordinary consumption, where individuals are 'locked-in' to unsustainable modes of consumption (Sanne, 2002), as well as social norms and everyday practices that influence our behaviours (Shove, 2003).

Hence, whilst studies from a socio-psychological perspective emphasize the importance of attitudes and values in explaining environmental behaviour, recent research on household energy consumption suggests that this explanation can be limited. Poortinga *et al.* (2004) state that "environmental behaviour is not only dependent on motivational factors but is also determined by contextual factors, such as individual opportunities and abilities" (2004: 93). In this view, behaviours that are difficult to perform are less likely to be related to motivational factors alone, indicating the importance of analysing behaviour in context (Barr, 2003). Therefore, circumstances that facilitate the adoption of micro-CHPs and the promising benefits of feedback in reducing energy consumption suggest that factors other than attitudes and values play a role in inducing environmentally friendly behaviours.

As the literature presented in the earlier sections shows, the human dimension of energy research has focused in general on awareness and knowledge provision in an effort to change attitudes towards the environment and instil a feeling of responsibility, which would consequently lead to positive behaviour towards climate change. However, as I mentioned earlier, such emphasis has been criticised by several researchers in the social sciences, particularly in geography, sociology and anthropology (Henning, 2005; Owens, 2000; Shove *et al.*, 1998). In the next section, I present some of these arguments as I attempt to make the case for a more contextual approach to energy research, including the diffusion deployment of RETs.

2.3.3 Fragmented perspectives: the need for an integrated approach?

As mentioned at the start of the chapter, the analysis of energy technologies and human behaviour remains separate from the social context (Owens, 2000) and everyday life (Shove, 2003). Inherent in this division is the treatment of users as rational individuals who can be motivated by economic incentives alone (Hobson, 2002), or as ignorant persons who should be educated about climate change and energy consumption before they can take positive action towards energy use (Burgess *et al.*, 1998; Guy, 2004).

Shove *et al.* (1998) argue that within the dominant approaches in social science research, policymakers and energy analysts construct their own understanding of the social world and the modes of social change. As seen in the literature review presented above, the dominant approach in energy policy-making is governed by economic principles that rationalise individual behaviour, and are supplemented by studies on individual psychology, market research and social attitudes. These approaches became prevalent and over the years, policy frameworks established an economic view of human behaviour which generally subscribes to economic rationality (Jackson, 2005: 29) and to a deterministic view of the role of technology. In other words, technological progress is perceived as inevitable and that a better informed individual behaving rationally would ultimately result in a more desirable world (Guy, 2004).

This has certainly been the case regarding the diffusion of RETs. According to Lutzenhiser (1993), an engineering approach dominated energy policy discourse, whereby the focus was on perfecting the technology and overcoming barriers that obstruct its implementation. Sidelining sociological research to the 'soft aspects' of energy policy has resulted in a gap between the two research agendas, whereby analysis of technological innovation on energy efficiency and RETs is separated from its social context. As Jelsma (2005) puts it, "there is an unproductive gap between the engineering approach seeking technical innovations to save energy, and its critics pleading for social factors to be included in analysis of (over)consumption by households" (Jelsma, 2005: 73). The result is a limitation to the way social research is conducted, which focuses on individual consumers with the objective of unearthing reasons behind their consumption patterns and ways of changing their behaviour (Shove *et al.*, 1998). Moreover, this focus isolates the individual consumer from their context (Spaargaren *et al.*, 2006) and simplifies the process of RET adoption and energy consumption. Indeed as Weber (1997) argues, "energy consumption is the last part of a long chain of decisions and actions. Therefo re, it is appropriate to discuss energy consumption within its social context" (1997: 835).

Furthermore, studies point towards a mismatch between the availability of technically proven solutions to the energy problem and the actual implementation of such technologies (Guy, 2004). This problem, explained as the 'human dimension' for the diffusion of energy technologies, is believed to hinder the realisation of an otherwise inevitable technical progress. Shove *et al.* (1998) argue that such a notion leads to a "conceptual distinction between the human and the technical or economic" (Shove *et al.*, 1998: 300). As such, the assumption is that technical solutions exist independent of the social context surrounding technologies, resulting in what Jelsma refers to as the 'Latourian Great Divide'[7] (2005: 75). Accordingly, the analysis overlooks the inter-dependence between technology and society and the ability of individuals to shape their environments, including the technologies surrounding them (Callon, 1987; Pinch and Bijker, 1987).

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[7] Jelsma calls the Great Divide as Latourian after the theory of the Great Divide developed by Bruno Latour in his book 'We Have Never Been Modern', where Latour describes the purification process that separated humans from the non-human realm since the 17th century. As such, the non-human realm was the subject of study by natural sciences and later on manipulated by technology (Jelsma, 2005).

To summarize, research into energy policy and RETs has often relied heavily on an economic view regarding behaviour, assuming a rational individual with an interest in profit maximisation at the receiving end of technology. Such a view has been disputed in social science research (Guy, 2004; Hobson, 2002), with several authors, for example, questioning the limited deployment of energy efficiency technologies despite being economically feasible and technically proven. Moreover, research from various disciplines in social sciences has noted the limitation of the rational choice theory and noted the multiplicity of factors influencing energy related behaviour.

This calls for a more context-driven conceptualisation of RET users in energy research, one that takes into consideration the sociotechnical nature of change (Guy, 2004) and a contextual view of energy use and consumption (Spaargaren *et al.*, 2006). In the next section, I review two social research perspectives that have situated energy use within the social and institutional constraints in which it exists. The first perspective, the Social Practices Approach (SPA) analyses energy and environmental consumption as part of the day to day routines and activities of households. The second perspective stems from Science and Technology Studies (STS), which argues that energy use is "intricately linked to science and technology" and that lifestyles have "coevolved with the energy-consuming technologies on which they depend" (Shove *et al.*, 1998: 296). My intention is to illustrate the influence of day-to-day practices on the meaning of energy in the home, particularly when studying the role of individuals in contributing to carbon reductions and the contribution of the domestic sector in overall energy consumption. However, the focus on social practices should not divert attention from the main objective of this study, which is the implementation of RETs. Therefore, analysing RETs as technological artefacts becomes necessary, especially as I try to avoid deterministic views on the diffusion of innovation.

2.4 Structure, agency and technology: researching energy in the home

Having argued for the need to acknowledge the social context of environmental actions and consumption, in this section I will present the two perspectives from sociological traditions that address the analysis of the social context and sustainable consumption. As such, the questions that these approaches try to answer are: how do social and institutional contexts influence consumption and how can an analysis of these contexts inform policy? Whilst it is not my intention in this thesis to evaluate the different methodologies developed regarding consumption and sustainability, I do however present the main ideas argued from ecological modernisation in the interest of eliciting relevant aspects to users and technology. In the next section, I will demonstrate the relevance of SPA in this review and some of the ideas in relation to technology and users.

2.4.1 The social practices approach and users

The SPA emphasises the need for a contextual analysis of consumption behaviours and lifestyles, hence, shifting the focus from processes of production to those of consumption (Spaargaren, 2000). Accordingly, perspectives from socio-psychological studies, discussed earlier in this chapter, provide an isolated view of action and lead to the neglect of the impact of social and technological structures on everyday behaviours (Spaargaren *et al.*, 2006). In other words, the socio-psychological model with its emphasis on attitudes and environmental values as the main driving force of environmental action, presents an atomized view of the social world and a misplaced focus on the individual in isolation. Moreover, SPA acknowledges the dominance of the technical paradigm in environmental policy and research. Hence, it situates itself between the technological approach and the socio-psychological approach. In doing so, it seeks to highlight the importance of both context (expressed by available technologies and systems of provision) and action (human behaviour and choice).

The SPA derives from structuration theory (Giddens, 1984; Spaargaren *et al.*, 2006), which stresses the influence of both structure and agency in shaping society. As a result, the focus point in SPA thinking starts with "the actual behaviour practices an individual shares with other human agents" (Spaargaren *et al.*, 2006: 108), instead of individuals' attitudes and norms studied in isolation. Consequently, changes in behaviours occur within people's everyday practices, such as buying food, living in homes, and consuming utilities like water and electricity. Accordingly, these changes depend on three factors: 'environmental heuristics', 'lifestyles' and 'systems of provision'.

According to Giddens (1991), the lifestyle of an individual constitutes a set of social practices that that person adopts, in addition to "the storytelling that goes along with it" (Spaargaren, 2003: 689). In this view, environmental lifestyles are seen as complex and comprising various social practices, and therefore cannot be measured by one scale. Thus, the different social practices, which constitute people's lifestyles, are in turn influenced by different systems of provision. These can include available technologies such as RETs and energy efficiency, public transport or organic food products. Moreover, these systems of provision are not stable and depend on different space-time situations that individuals and households find themselves in. To instigate environmental choices, the concept of 'environmental heuristics' is developed, which according to the authors, needs to be "established for all the major social practices that can be said to be relevant for environmental policymaking" (Spaargaren, 2003: 697; Spaargaren *et al.*, 2006). These include concepts such as buying organic or separating household waste. As such, the purpose of 'environmental heuristics' is to connect the technical rationale of sustainable living to the social life world, thereby reducing the complexity of environmental behaviour so that it corresponds with everyday social practices.

Thus, in the model presented above, it is argued that environmental behaviours, such as consuming less energy in the home or purchasing microgeneration technologies, depend on the choices individuals make within the structural constraints of the systems of provision. This results in various green lifestyles that could be conducive to more sustainable consumption (Spaargaren *et al.*, 2006).

The attempt at developing a methodology for analysing the social context of sustainable consumption (as presented by Spaargaren and colleagues) provides a possible perspective for thinking about users of RETs as situated in their day-to-day activities. However, several issues arise regarding the conceptualisation of technologies within this model. Considering the arguments by Shove *et al.* (1998), an assumption in the conventional literature assumes a linear model for the diffusion of innovation, treated in isolation from cultural or political processes. Similarly, the SPA does not present a critical assessment of the technologies that constitute the structure. Although it suggests the importance of technology in shaping human behaviour and consequently society, an assumption is made about the adoption of technological solutions. As such, the possibility of users resisting certain technologies and the complexity of technological diffusion (which is the result of various social, political and institutional negotiations) are left out.

Therefore, recognising the significance of the SPA in thinking about the social context and its value in situating behaviour within everyday practices, I now move on to present the view from STS. At this point, two important concepts emerge with respect to my research: the context of energy consumption and the nature of RETs. The former has been discussed in earlier sections of this chapter. In the next section, I discuss briefly the main arguments of the STS approach in an attempt to draw out recent theorisations on artefacts and technological innovation.

2.4.2 'Leaping the barriers': from a technoeconomic to a sociotechnical perspective

In conventional energy research, studies have focused on the linkages between attitudes and energy-related behaviour. The aim was on the need for and effectiveness of information and awareness campaigns in changing people's attitudes and consequently inducing the preferred environmental actions. However, such research has instead reported a weak relation between the two (Lutzenhiser, 1993). Moreover, the effectiveness of energy promotion was found to be dependent on several situational variables, such as the type of material, the timing of campaigns and its trustworthiness (Lofstedt, 1995). Other psychologists have pointed to the influence of social networks on behaviour (Stern, 1992) and the complexity of energy-related practices (Boardman, 2004).

Furthermore, research on energy consumption has found that individual actions related to energy use depended on socially acquired understandings of energy. Although they differed significantly from engineering assessments, they were argued to be a more suitable conceptualisation of energy as part of people's everyday experience (Lutzenhizer 1991, cited in Shove *et al.*, 1998). Another aspect of energy use highlighted is cultural variation. Research in anthropology looking into home lighting pointed at the importance of cultural variables, such as cosiness and social habits, in determining lighting consumption (Wilhite *et al.*, 1996).

Similarly, Henning's study on the adoption of solar thermal collectors in Sweden emphasised the socially and culturally constructed meanings of the technology, and the influence this had on its diffusion (Henning, 2000). In context, this means that the introduction of technologies and innovations in society is more complex and depends on various factors, such as the meanings users give to the technology and the problems that it claims to solve. Hence, energy policy should not only explore the social understanding of energy consumption, but also the meanings attributed to the RETs posited as solutions to the carbon emissions problem.

For that reason, it becomes necessary – according to Shove and colleagues – to challenge the linear and often deterministic view of technological solutions to climate change and their adoption in the developed world. Alternatively, the view from STS emphasises the complexity of technology diffusion, and highlights the socially constructed nature of technology (Pinch and Bijker, 1987) and the social shaping of many technological artefacts that we now take for granted (Latour, 2005; MacKenzie and Wajcman, 1999; Williams and Edge, 1996). Accordingly, technologies are negotiated in different social contexts among various actors. As a result, technologies and technological practices are shaped in a process of social construction and deliberation, which is affected by the changing social, political and commercial interests of actors associated with these technological artefacts (Bijker, 1995b; Latour, 2005).

Contrary to the technoeconomic view, Shove and her colleagues suggest that a sociotechnical approach that seeks to understand the cumulative nature of the interaction between technology and people offers a broader perspective in policy analysis, as well as in understanding the diffusion of technology in society (Guy, 2004; Jelsma, 2005). By adopting perspectives from STS, the focus in energy research can shift to technological design and the agency of technologies. Moreover, a sociotechnical approach to energy research provides an opportunity to challenge technological determinism, visualising users beyond their image as passive consumers subject to the signals of market regulations (Guy, 2004).

Moreover, STS research can investigate the role of users in shaping these technologies, as well as other actors such as institutions, norms, belief systems and knowledge capacity in determining the diffusion of innovation in society. As such, to understand RETs and the various factors that lead to its diffusion and implementation, a sociotechnical approach could provide a broader and more holistic insight into the micro-level processes taking place that influence the success or failure of technology. Based on studies on the social construction of technology and actor-network theory (which I discuss in more detail in the next chapter), RETs can be analysed by looking into how they are constructed, who is involved in their implementation, who the users are, and how are they co-constructed during their adoption.

Furthermore, approaches from cultural studies on technology (Silverstone and Hirsch, 1992) and consumption (Shove and Wilhite, 1999) allows a micro-level analysis concerning energy and RETs. From this perspective, research has argued for the importance of household consumption when thinking about energy (Shove and Warde, 2003). This is certainly an important point when thinking about renewable microgeneration technologies such as PVs. In her study on technologies in the home and energy consumption, Shove (2003) emphasises the embeddedness of energy use in cultural understandings of cleanliness, comfort and convenience. As such, cultural, social and institutional structures shape the logic of everyday practices relating to energy consumption. Similar research has investigated dustbins (Chappells and Shove, 1999; Hobson, 2006) and light bulbs (Crosbie and Guy, forthcoming) in relation to energy consumption and environmental action in the home.

Accordingly, Shove and Wilhite (1999) argue that energy policy must therefore acknowledge the complexity of domestic energy use and the centrality of household routines and consumption habits to energy issues. Alongside Shove, Aune (2007) investigated energy use in homes and argues that policy advice about expected behavioural changes and technology adoption should be more informed by the different meanings attributed to the home, as well as the common everyday activities that take place in it. Therefore, the view from STS and cultural studies can enrich energy research, and here I highlight three main arguments in favour of this perspective in energy studies: (1) the rejection of a linear model for diffusion and instead, a consideration of the different cultural and political processes that shape technology adoption; (2) the recognition of users beyond the notion of economically rational (yet ignorant and passive) during the technology adoption process and using instead the user "as an active social agent" (Shove *et al.*, 1998: 307); and (3) the importance of contextualising energy use in the domain within which it is being studied, and hence the focus on household energy consumption and everyday practices when analysing domestic end-users of RETs.

2.5 Conclusions

In this chapter I have attempted to present a brief overview of the research landscape on energy policy. In the first section, I discussed the conventional literature on the analysis of energy as it pertains to users and I showed how the conceptualisation of users was limited to two notions, assumed economic rationality and ignorance as an explanation to the apparent irrationality of users. These two obstacles that are believed to slow down the uptake of technological solutions for climate change are then referred to as 'non-technical barriers' that should be overcome to achieve greater environmental sustainability.

Following on from the concept of 'non-technical barriers', I argued that social science research has focused on understanding people's attitudes and values towards the environment in an effort to instigate environmentally friendly behaviour. In doing so, these studies – falling within the socio-psychological approach – have divided society into groups based on their commitment to the environment and related their attitudes to their environmental behaviours. This approach has two main disadvantages. Firstly, it asserts the need for education to change individuals' attitudes towards the environment, and secondly, it presents an isolated view of individuals, neglecting the social contexts that can influence their behaviours.

These disadvantages were then contrasted to other approaches in social sciences that have attempted alternative explanations to the implementation gap between rational human behaviour on the one hand, and the availability and proven effectiveness of environmental technologies on the other hand. Whilst the social practices approach (SPA) provided a useful methodology for analysing social contexts of consumption (and related environmental behaviour), the question of technology diffusion remained unanswered. Hence, I conclude that a rich analysis of RET implementation and users needs to include an understanding of technological innovation and diffusion (recognising its complexity and constructed nature), as well as a consideration of the everyday practices of households that influence domestic consumption.

In the following chapter, I will present in detail the main theoretical perspectives from STS, particularly those that examine the relationships between technologies and users, and from cultural studies on consumption and domestication. Subsequently, I will discuss the analytical framework that I developed for analysing technology and its users, and attempting to answer the research questions presented in chapter one.

CHAPTER THREE

Co-constructing Users and Technologies: Beyond Technoeconomic Models of Renewable Energy Technology Diffusion

> *"Technology does not spring, ab initio, from some disinterested fount of innovation. Rather, it is born of the social, the economic, and the technical relations that are already in place. A product of the existing structure of opportunities and constraints, it extends, shapes, reworks or reproduces that structure in ways that are more or less unpredictable"* (Bijker and Law, 1992: 12).

3.1 Introduction

In the previous chapter, I demonstrated how the conceptualisation of users in energy research assumes an economic rationality and neglects the influence of the social context on actions and behaviour. I also noted the assumptions implicit in these approaches, namely a separation between a 'technical' or engineering side and a social, 'human dimension' of the energy problem (Shove *et al.*, 1998), and the deterministic view of technological innovation and diffusion. I concluded that an approach from science and technology studies is needed to move beyond deterministic views on RET diffusion, which are usually based on a technoeconomic approach to RETs and energy research. I also argued that it is important to contextualise the adoption of RETs within processes of energy consumption. This chapter is, therefore, concerned with presenting main theoretical approaches in STS that have examined the role of users in the co-construction of technology, and illustrating how this approach is beneficial for the analysis of RET implementation, namely microgeneration technologies. This research tradition is interested in the way technological design and innovation involves a complex process of configuring the use and the user of a particular technology.

STS is a field of research within social sciences that explores the interactions of various actors during the innovation and diffusion of artefacts (Akrich, 1992; Callon, 1986; Latour, 2005). As such, it examines the ways in which social, political, and cultural factors influence the design, implementation, and adoption of technological artefacts (Bijker and Law, 1992; Bijker, 1995a; 1995b; MacKenzie and Wajcman, 1999; Pinch and Bijker, 1987; Williams and Edge, 1996). Several approaches exist, all influenced by different philosophical perspectives in analysing history, materiality and discourse. For the purposes of my research, I define three main theoretical perspectives which I refer to broadly as STS in this thesis. These are: the Social Construction of Technology (SCOT), actor-network theory (ANT), and the semiotics approach. Each of these perspectives presents their own analyses of the co-construction of technologies and users.

The theoretical framework that I use in this research draws on two main theories on users and technologies; the configuration of users based on the analysis of 'technology as text', and the 'inscription' of users and technologies stemming from ANT. The latter emphasises symmetry when thinking about technology and society, whereby agency is attributed to both human and non-human actors. The metaphor 'technology as text' emphasises the design processes that constrain how users interpret and interact with technology. In the sections below, I will present the different perspectives in STS and explore the various ways these theoretical perspectives approach the aspect of users with respect to technological artefacts. The rest of the chapter is divided into two sections. In the first, I will present the main theories concerning the construction of users in technological innovation and diffusion, including the perspective of technology consumption; afterwards I will discuss in detail the processes of technology adoption or implementation. I conclude with an analytical framework for analysing users and RETs, which I will use in the research presented in this thesis.

3.2 Users in science and technology studies

In recent years, scholars in STS and related disciplines have been interested in the role of users in the development and diffusion of technology in society (Oudshoorn and Pinch, 2003; Rohracher, 2005b; 2006a; Verbeek and Slob, 2006). The main argument in these studies is the active involvement of users in the technological design process, whereby the emphasis is on the different ways users can appropriate technology and also the way technology defines or configures its users. In later sections of this chapter, I will discuss in more detail the theoretical perspectives that inform studies on users and technology. However, at this stage, I argue that an approach based in STS affords a more active role to users. Seen this way, users are not merely passive recipients of technological innovation (Oudshoorn and Pinch, 2003), but can actively be involved in the design of technologies (Rohracher, 2005c). As such, innovation and diffusion are no longer viewed as separate areas of research, but "are seen as two sides of the same problem – as co-constructed" (Oudshoorn and Pinch, 2003).

This view necessarily implies the complex nature of technological innovation and the diffusion of technologies in society, and therefore rejects the deterministic view of technology (as an unavoidable force of progress in society) and the essentialist view of users (as rational consumers, unless ignorant and should otherwise be educated). As I demonstrated in chapter two, this perspective still dominates research on energy and RETs. Termed as the technoeconomic perspective (Guy, 2004; Shove *et al.*, 1998), with respect to users, this approach typically subscribes to the notion of the rational consumer and emphasises the importance of 'winning hearts and minds' by influencing people's environmental values and behaviours.

But how can theoretical approaches from STS inform a study on users of RETs? Approaches in this field of research provide a micro-sociological outlook that could be useful when looking at how users are constructed in the process of technological innovation and diffusion. For example, Akrich (1995) shows how firms construct various user identities as they shape the context of an artefact's use. Similarly, Wyatt (2003) illustrates the processes of constructing different types of internet users. Hence, research within STS has been informative in examining the different ways relevant actors socially construct the category 'user' by creating boundaries that shape the use of artefacts as well as their users (Callon, 1995). From this point of view, theories in STS can provide a useful analytical tool in analysing how users are constructed during the diffusion of renewable technologies, which is directly relevant for the research presented in this thesis.

More specifically related to research on energy and energy technologies, studies in STS are important due to the central role of technology in energy production and consumption. Accordingly, RETs are not only technological solutions for the growing climate change problem but active agents in the shaping of energy provision systems, leading to a change in the relationship between energy users and energy providers (van Vliet *et al.*, 2005). Moreover, energy consumption related to RETs can be examined in a more contextual manner. As mentioned earlier in chapter two, work by Shove has looked into energy consumption in the home, analysing how energy and its use is shaped by various cultural and institutional factors. Other scholars have similarly pointed out the importance of understanding energy consumption in context, by using the concept of home when analysing energy and its use (Aune, 2007).

An STS approach can therefore benefit energy research by exploring the intricate dynamics that shape energy consumption. Consequently, the analysis of RETs like microgeneration technologies should acknowledge such complexity and situate the interaction between users and the technology as part of a complex network of institutions, technologies, cultural practices and daily routines. For example, Rohracher (2003; 2006a) in his investigation of passive ventilation designs and smart homes, argues that users played an important part in the later stages of the technologies' innovation or at the early stages of their diffusion. The study found that users' actions determined the performance of these technologies as they were deployed in flats or homes, in the users' quest for convenience regarding air quality and energy consumption. The role of users in shaping the technologies, as they become part of the sociotechnical system, occurs "within the limits of the exiting sociotechnical regimes" (Rohracher, 2003: 189). In other words, users have been shown to have an important role in the shaping of the energy technologies during their implementation in buildings, however, such dynamics were limited by other actors (markets, institutions, organisations, etc.) that constituted the sociotechnical systems surrounding the energy technology and the users.

To summarise, studying energy through theoretical approaches based in the STS tradition has highlighted several important arguments. First, that the diffusion of RETs does not follow a linear process and is instead a complex development involving different actors (individuals, organisations, institutions, as well as cultural practices and political environments). Second, the users perceived at the receiving end of technology can have an active role in the diffusion (if not also the innovation) of technologies. Accordingly, attention is also drawn to the implementation phases of RETs as spaces where technologies continue to undergo negotiations pertaining to their final design. Thirdly, the notion of everyday practices as shaping energy-related technologies and services in the home is highlighted. As Shove states (1998), approaching energy research through the lens of STS "draws attention to the structuring of opportunity and the parts played by nonhuman actors, including existing infrastructures and technologies and embedded practices and routines" (Shove *et al.*, 1998: 287). A final point, which I illustrate in more detail later in this chapter, concerns the socially constructed images of RETs and users that actors involved in their development and implementation make. These images, or identities as Summerton (2004) argues, guide the actors involved as they try to promote and manage their technologies.

As I pointed out in chapter two, the research agenda on RETs is still dominated by questions on their diffusion. Assuming an uncontested acceptance of RETs and promoting them as solutions to climate change, the problem of their deployment is left to social sciences to create strategies for promotional and awareness campaigns. But as Guy and Shove (2000) argue, social science research on energy should explore in more depth the diffusion of technologies, such as RETs, in society. Hence, my research adopts a theoretical framework that attempts to examine the adoption and diffusion of RETs, in this case photovoltaics, and to focus on how the category of 'user' is defined and constructed, and how it consequently influences technology adoption. In doing so, this research presents an opportunity to investigate the adoption process of a technological artefact as a negotiated dynamic involving different actors. It thus provides a broader perspective on the complex and interlinked factors that shape technology and its use (Guy and Shove, 2000; Shove *et al.*, 1998), and the role the users play in this process (Rohracher, 2003) whilst questioning "the conceptual separation of the social and the technical on which conventional approaches depend" (Shove *et al.*, 1998: 297).

In the next section, I will present the main theoretical approaches that have influenced the analysis of the user/technology relationship; these include the social construction of technology (SCOT) approach, the semiotic approach, and actor-network theory. I then move on to theoretical developments in research on users and technologies, which inform my analytical framework. My purpose is to discuss the various concepts used in STS, the differences between them and how they relate to users, in particular the users of RETs.

3.2.1 The turn to technology – the SCOT approach

According to Oudshoorn and Pinch (2003: 3), the "old view of users as passive consumers of technology was largely replaced in some areas of technology studies, and along with it the linear model of technological innovation and diffusion". The importance of the social construction of technology (SCOT) approach lies in its focus on the interactions that take place among different social groups during the technology's design and early diffusion (Bijker, 1995a; 1995b). This early body of work conceptualised users as different social groups that were relevant to the interpretation and consequently the success of technology in society (Oudshoorn and Pinch, 2003).

The involvement of the social groups is defined by their attempts to construct different meanings for the same technology. To illustrate, Pinch and Bijker (1987) studied the historical development of the bicycle and showed how elderly men and young women (two social groups) gave a different meaning to the bicycle, constructing it as 'unsafe', unlike the group of young men who enjoyed the bicycle's speed. This process (the construction of different meanings to the artefact) facilitated the development of the safety bicycle (Pinch and Bijker, 1987). This approach argues that the safety bicycle did not develop necessarily because of its intrinsic technical characteristics, but followed a complex path whereby the meanings of this transportation method were challenged and negotiated. The act of giving different meanings to an artefact is what the authors describe as the technology's *interpretive flexibility*, however, the interpretive flexibility of a technology is impeded when the negotiations on its meanings develop and reach closure. At a later stage, the technology stabilises in society – acquiring a relatively stable definition and its interpretive flexibility vanishes (Bijker, 1995a; Pinch and Bijker, 1987).

The SCOT approach is based on the application of theories from the sociology of scientific knowledge and applying them to technological innovation, arguing that technologies should be approached from a relativist perspective (Pinch and Bijker, 1987). In doing so, proponents of this approach emphasise the constructed nature of technologies and the need to analyse technology "from the inside" (Rohracher, 2006a: 21). Applying concepts stemming from the empirical programme of relativism (EPOR) based in science studies, Pinch and Bijker stress the impartial analysis of technology and the rejection of any external point of reference when evaluating technological trajectories and the factors that lead to the success or failure of an artefact (Pinch and Bijker, 1987: 26-27). The EPOR approach emphasises the social construction of scientific knowledge through the empirical investigation of scientific developments and controversies. It stresses that in the first stage of scientific developments, findings have interpretive flexibility, making them open to several interpretations. In the second stage, these findings are gradually accepted as 'truth' and their interpretive flexibility is limited until it reaches closure. Hence, the transfer of the principles of EPOR on technology studies (Woolgar, 1991b), namely the emphasis on the interpretive flexibility of artefacts, the consideration of social influences that shape the technology before closure, and its consequent stabilisation are analysed in SCOT.

The focus of the SCOT approach is on the interactions and negotiations that occur among those relevant social groups, who can be organisations or individual users. As a result, the development of an artefact goes through various negotiations and interpretations among these groups, until it reaches the stabilisation phase, where the social groups begin to share the meanings attributed to the artefact. Thus, the development of technology is not linear, but depends largely on complex processes in which users and usages are defined, and the problems encountering the user of the technological artefact are resolved, thereby reaching closure and stabilisation (Bijker, 1995a; Pinch and Bijker, 1987). Therefore, according to the SCOT approach, the success of an artefact depends on the number of users who take it up and promote it (Sismondo, 2004: 81-82), but more importantly, it also depends on the associations that these users make with respect to the artefact itself (Oudshoorn and Pinch, 2003; Pinch and Bijker, 1987; Sismondo, 2004). As Rohracher (2005b; 2006a) emphasises, this process results in a landscape that consists of the artefacts, the various meanings attributed to them by the different social groups and the problems and associated solutions to the artefact's use. Accordingly, the linear model of innovation is rejected in favour of a "multidirectional model of innovation, which treats the development of an artefact as an alternation of variation and selection" (Pinch and Bijker, 1987: 28). These processes would result ultimately in certain designs being successful and others failing (Oudshoorn and Pinch, 2003; Sismondo, 2004).

The SCOT approach is fundamental to understanding the way technologies are constructed during their conception and implementation. The resulting final design would not necessarily be the objectively most efficient design, but a socially negotiated form. As this model shows – the relevant social groups play a significant role in deciding what the problems with a particular artefact are, how they are defined and what meaning is given to these problems. According to Pinch and Bijker (1984: 414), a "crucial role is played by the social groups concerned with the artefact, and by the meanings which those groups give to the artefact: a problem is only defined as such, when there is a social group for which it constitutes a problem". Therefore, it is crucial in the study of the development and success of technologies in society that we identify the social groups involved in its design and adoption, and the meanings these social groups give to the technology.

Various criticisms are directed at the SCOT approach, namely that it is design centred and "had closed down the problem of users too early" (Oudshoorn and Pinch, 2003: 3). In other words, by focusing on the early stages of a technology's diffusion, analysis in SCOT does not explain how users can actively play a role in negotiating the meaning and design of a technological artefact. However, later empirical studies and theory development within SCOT focused more on the role that users play in modifying or co-constructing the meaning of a technological artefact even after its stabilisation phase. For example, in a study on the adoption of cars in rural America, Kline and Pinch (1996) show how users appropriated the car, using it as a source of power for farm machinery or tinkering with the backseat to use the car as a small truck. The car, which faced resistance in rural areas when it was first introduced, was later appropriated by farmers and used for other functions. The technology, as such, was given new meanings and used for different jobs on the farm, and not just for transport. Their study shows how the users became partners in design and "agents of sociotechnical change", by shifting the focus of analysis from the producers of cars to their users (Kline and Pinch, 1996: 764).

The second criticism directed at SCOT is its neglect of the social structures, such as economic systems or political realities that influence technology use (Winner, 1993). In fact, such criticism has been pointed out in other approaches in STS that focus on actors at the micro-level (Rohracher, 2006a: 23). However, later studies within SCOT extended the analysis of the social shaping of technology, where the relationship between the technology's development and the sociotechnical ensembles, i.e. the technological frame in which it occurs, is explored. Technological frames, Bijker argues, form the structures surrounding a technology that occur between the different social groups and they are "built up when interaction around a technology starts and continues (Bijker, 1995b: 252).

Despite these criticisms, SCOT remains central in research within social constructivist approaches to technology studies in its rejection of technological determinism and the emphasis on the interconnectedness between the social and the technical aspects of technology. Hence, "the technical is socially constructed, and the social is technically constructed" (Bijker, 1993: 125). Thus, the principles of the SCOT approach are central to researching users and RETs, with the emphasis of SCOT on the blurring between the social and technical and the weakness of analysing innovation and diffusion of technologies as two separate entities.

3.2.2 Technology as text: a semiotic approach to technology studies

Stemming from the SCOT approach, and taking the concept of *interpretive flexibility* further, a semiotic approach to understanding technological diffusion is used to elaborate on the user-artefact interaction. It argues that technology is flexible and can be read the same way as a text, hence the metaphor 'technology as text' (Grint and Woolgar, 1997; Woolgar, 1991a). Rather than analyse the various negotiations or interactions that take place between the different social groups, as defined by Pinch and Bijker (1987), Woolgar focused on the process of technology design. The main argument is that technologies are like texts, they are written with particular users in mind. This process shapes the technical characteristics of a technology as it assumes certain capacities of the technology and the actors that come in contact with it. The 'technology as text' idea, similarly, rejects a deterministic view of a technology's diffusion. On the one hand, technologies are 'written' in particular ways, but they are then 'read' in different ways which are not necessarily those that the designer imagined (Grint and Woolgar, 1997; Pfaffenberger, 1992; Woolgar, 1991a).

According to Grint and Woolgar (1997), a technological artefact's capability is not "transparently obvious and necessarily requires some form of interpretation" (Grint and Woolgar, 1997: 32). An implication of this anti-essentialist view of technology is the need for the study and analysis of the processes of interpretation surrounding technology, instead of assuming that society is persuaded purely by a technology's effectiveness or its technical efficiency. Like Foucault (1980), the interpretation and persuasion processes concerning technological development and innovation take place within discourses, which reflect the relationship between power and knowledge. Thus, representations of the world are always influenced by power relations (Foucault, 1980), and consequently representations of technologies are the product of discourses shaped by the processes of power and knowledge in relation to how the technology should be used (Gri nt and Woolgar, 1997; Pfaffenberger, 1992).

Therefore when thinking about technology, it is important to highlight that the role and characteristics of a technological artefact are not determined by the artefact itself but are the product of the discourses concerning the technology. Hence, "we are faced with representations of technology, not reflections of technology. A reflection implies *the* truth, a representation implies *a* truth" (Grint and Woolgar, 1997: 33, italics in original). This entails an agnostic view of an artefact's meanings and a need to explore the ways in which some representations overcome other ones, consequently claiming to be a true reflection of a technology.

Similarly, Pfaffenberger (1992) argues that the political discourses surrounding technology is another affordance attributed to the artefact, which suggest how it *should* be used. A technology's affordances can be multiple, meaning that there are different ways for interpreting and consequently using these objects. As such, "an affordance cannot be sustained socially in the absence of symbolic discourse that regulates the interpretation" (Pfaffenberger, 1992: 284). This echoes Woolgar's conception of 'technology as text', where the "text's meaning changes as it falls into new hands and new situations" (1992: 284). This, accordingly, challenges intuitive assumptions about what machines are, what they could do and how they can be used (Jelsma, 2006a: 64).

The interaction between the technology and how the designers intended it to be used on the one hand, and the users on the other hand, results in what Pfaffenberger calls a 'technological drama', which is a technological form of discourse. This can lead to different scenarios such as "user appropriation, user modifications, sabotage, and revolutionary alternations" (Pfaffenberger, 1992: 285). The author thus stresses that it becomes imperative for the artefact to be "discursively regulated" (Pfaffenberger, 1992: 294) during its implementation. This is particularly relevant for the study of RETs' diffusion and use, as later chapters in this thesis show.

This is certainly the case regarding the interaction between users and technology, which I will discuss in more detail in section 3.3. The configuration approach developed by Woolgar (which further applies the metaphor of 'technology as text') will be discussed and compared to the concept of 'script' (Akrich, 1992), as well as ideas from studies on consumption and domestication. However, in the next section, I will briefly describe the main principles from another approach in STS, which is actor-network theory.

3.2.3 Reassembling the social and the technical: Actor-Network Theory

A third approach in STS of relevance to my research on users is actor-network theory (ANT). Viewed as "a radical shift" in the analysis of society (Jelsma, 2006a: 32; Rohracher, 2006a), it attempts to analyse human and nonhumans in a symmetrical way. According to ANT, the dichotomy between subjects and objects is misleading, and the focus should also be on the relationships between these entities (Latour, 2005). In its description of the world, ANT builds a new vocabulary: actants, 'heterogeneous associations', 'translation', 'delegation', and 'script' are some concepts developed in building an understanding of society. In the following sections, I will explain the relevance of some of these concepts to my research.

From an ANT point of view, actors or actants[8], regardless of whether they are human or non-human, should not be analysed as individual entities. Instead, actors should be studied in relation to networks, where they are linked together by 'heterogeneous associations' (Latour, 1987). To illustrate, Callon (1987) describes how Electricité de France (EdF) embarked on a process of building relationships and linkages between various separate entities in its efforts towards realising the electric car. To replace the internal combustion engine of conventional cars with fuel cells, the engineers had to construct a new social world inhabited by several different actants that would allow the new electrical vehicle to exist. As such, a different world to the one we inhabit today had to be imagined, where the cars that run on fuel cells become the normal mode of transportation. For the engineers in EdF, the cars would no longer be symbols of social class or a style of consumption, and public transport involving new actors would seek to apply new developments in science and engineering to the benefit of individuals. Although the technology did not succeed, the example of EdF shows the complex and hybrid nature of technology. In effect, the engineers at EdF had to become 'engineer-sociologists' as they constructed a new French society around the electric vehicle (Callon, 1987).

However, as the above example shows, the success of network building depends on the "degrees of malleability" of the actors that need to be recruited into the network (Law, 1987: 113). Seen this way, the failure of EdF in realising its new project was due to its inability to enlist the other actors that constitute the public sector network. From this perspective, the obduracy of existing sociotechnical systems is a function of the strength of the relationships linking the various actors that assemble it. Therefore, according to Latour (1987), the task of the social scientist is to follow these actants as they work towards building stable associations to ensure the success of new, as well as existing, technologies and innovations.

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[8] Akrich and Latour (1991; 259) define actant as "whatever acts or shifts action", through which competences of the actant are endowed. Actors are actants with an anthropomorphic character (ibid.). In this thesis, as with similar studies in ANT (Callon 1991: 135–142; Law 1992: 381–384), these two terms are used interchangeably).

As mentioned before, by understanding the associations between human and nonhuman actants, we can no longer accept a dichotomy that separates humans from the world, and objects from the subjects (Jelsma, 2006a), and as I will discuss next, technology from behaviour. The above example demonstrates the complex and hybrid nature of the processes that build and shape the world, with its many technologies, around us. Innovation is then a heterogeneous practice that is not delimited to the confines of science and engineering, but involves the building of associations between various entities (Latour, 1987).

This brings me to the central concept in ANT: 'translation'. This is the process whereby the relationships between actors are achieved, where these actors, their interest, goals and intentions are brought together. As a result, the actors' roles and identities are negotiated and defined and the possible associations that these actors can make are identified (Callon, 1986: 203). As Callon and Law (1982) put it, actors "seek to define their own position in relation to other actors", and work towards building their own version of the social structure through which they can "define (and, most importantly enforce) the institutions, groups or organisations that exist from time to time in the social world" (Callon and Law, 1982: 622). Four moments occur in the process of translation that Callon describes in his study on the cultivation of scallops in St. Brieuc Bay (Callon, 1986: 196). They are: (a) problematisation, which involves defining the nature of the problem and making oneself an 'obligatory point of passage'. "making it impossible to be bypassed if the problem should be solved successfully" (Rohracher, 2006a: 34); (b) interessement, which involves describing the roles through which the other actors can act; (c) enrolment, which are the strategies and activities that define the roles assigned to the actors (Callon, 1986); and (d) mobilisation, which involves making sure that the spokespersons (the delegate actors defined in the actor-network who represent groups) are adequate representatives of their communities.

In addition to the different moments of translation and network building described above, Latour (1992) emphasised the point that agency is not limited to the human actors *per se*, but becomes a product of the associations between the various actors, and can also be attributed to non-human entities. Despite the existence of a prime actor, agency of one actor cannot be isolated from the linkages and interrelationships that the actor makes with others. This symmetry is explained in

ANT as a process of *technological mediation*, where actions and intentions are distributed among actors. Latour gives the example of the argument on the public availability of firearms in the USA by shifting the analysis to the hybrid 'weapon-citizen' instead of citizens and firearms analysed separately. In this example, proponents of gun control argue that weapons kill people; whereas the National Rifle Association (NRA) argue that is the people who kill, and not guns. The first argument is a materialistic position, where the killing action is located in the operation of the gun as a machine irrespective of the social characteristics of the gunman. The NRA's argument is sociological, based on the view that it is the person holding the gun who acts whilst the gun remains neutral (Verbeek, 2005). However, from an ANT perspective, it is the interaction of the human (citizen) and the non-human (weapon) that should be the focus of the argument, where the mediation of the action through the 'weapon-citizen' hybrid is realised.

Another important process of technological mediation is what Latour calls 'delegation'. He illustrates this by the example of the door-spring technology, onto which the work of opening and enclosing a walled space is achieved (Latour, 1992). Delegation renders the responsibility of action on not just one actor, but on a collective of actors (a network) which is the result of the mediated action (that of opening and closing the door, in this case). Accordingly, humans delegate to the door-spring the action of closing the door after somebody had opened it (Verbeek, 2005). Latour terms this process as a 'programme of action' that is 'inscribed' through the collective (Akrich and Latour, 1992). Moreover, the resulting technology, in this case the door-spring, prescribes certain behaviours on the human actors that come in contact with it. This is referred to as 'prescription', and in this case is expressed through limiting the force suitable to push open the door (otherwise the user could risk injury), or not walking behind a person that is passing through the door. This brings up the concept of 'script' which I mentioned in section 3.2.2 and which I will describe in more detail in section 3.3.1.

Several points should be highlighted regarding ANT. The first one is the symmetry in the analysis of humans and nonhumans and the resulting agency which can be attributed to all actors regardless of their nature – hence removing the bias towards human actors (Jelsma, 2006a). Second, this agency is acted through the relations that different actors build among each other as they seek to achieve their goals. This results in a hybrid sociality consisting of heterogeneous associations, a network. The process of building associations is followed by 'punctualisation', where the hybrid nature of the network becomes invisible, and the network is stabilised. This is also referred to as 'black-boxing' of networks and technologies, however, it is reversible and open to challenge, as "it faces resistance, and may degenerate into a failing network" (Law, 1992: 385).

Like many theories, ANT has faced criticism. Concerning users, Rohracher (2006a) mentions two main criticisms. The first concerns the focus of the theory on primary actors who are powerful. This could result in an ethnography that is biased towards the story of the strong users, those who are able to manipulate and who have access to the needed resources through which they enrol other actors. As John Law argues (1991: 13, cited in Rohracher, 2006a: 36), there is a "chance that we will succumb to the perils of managerialism". The second criticism concerns the membership of networks. The stabilisation of a network is only relevant to some and not everyone affected by it perceives or enjoys this sense of stability (Star, 1991). Despite this criticism, there are two main concepts that I take from ANT towards forming my analytical approach. The first one is the notion of symmetry when analysing technology in society, and the second is technological mediation, where the responsibility of action is distributed among the different actors emerging from the network.

3.3 The interaction of users and artefacts

The sections above summarise the three main theories within STS that my thesis draws from. These three approaches provide an analytical dimension for understanding the design and innovation of technologies and their diffusion or introduction into the market and their use. In addition to asserting the interrelatedness of the social with the technical and, hence, the complexity of material contexts, these theories assert that innovation is not a simple, linear progression but a complex set of situations and opportunities. Whether they are different social groups that agree on a meaning for an artefact, or a collective of actors forming a network, the diffusion of a technology in society should not be explored in isolation.

Whilst none of these approaches directly address the role of users or how the way users are being constructed or enrolled affects technology's implementation, they do however provide a theoretical background for understanding how users are involved in a technology's early development or how they are enrolled into the networks surrounding these technologies. The following section briefly describes the two main strands in STS that analyse how users are configured by designers, and the 'scripts' that are built into technologies. It also discusses the ways users, in contrast, 'de-script' and appropriate these technologies.

3.3.1 User 'scripts' and technologies: lessons from ANT

Based on the ideas developed in ANT, in this section I will describe the concept of 'script', which is used to explain the programme of action designed into technologies. Akrich and Latour (1992) state that technological artefacts carry 'scripts', through which they "define a framework of action together with the actors and the space in which they are supposed to act" (Akrich, 1992: 208). This concept tries to explain how technological objects shape the relationships between the user and the technology. Like a film script, Akrich (1992) explains that technologies are delegated a programme of action on behalf of the network in which they exist, thus taking further the idea of delegation described in the last section. Technological artefacts can therefore create new "geographies of responsibilities", where competencies or actions are distributed according to the script inscribed in the technology (Akrich, 1992: 207-208)

As ANT tells us, technological artefacts embody the set of relationships and linkages between different elements that are maintained through the associations between several 'actors'. Moreover, they are also part of other networks that include all types of actors. Hence, a technological artefact is made of several components that are associated to each other in an actor-network and this network can itself become part of another network. The question that Akrich asks is how to understand or describe the role that these artefacts play within these networks. Two aspects of the technology emerge, how the artefact constrains and shapes its relationship with the user (another actor) and how these users (and the relationship they have with other actors in the network) are able to reshape this interaction. In other words, the focus is on how the objects can be used and in what way. But because Akrich's analysis follows on from ANT, with its emphasis on not distinguishing between human and nonhuman actors, a new vocabulary is needed: 'script', 'in-scription' and 'de-scription'. I will explain these terms below.

According to Akrich and Latour (1992), during the design phase, designers anticipate the interests, knowledge and behaviour of their imagined users. These representations become materialised into the design of the technology, whereby the technology contains the scripts or the scenarios that shape its use. According to Akrich (1992), this process is the 'in-scription' of the designers' beliefs into the technology design. It is therefore "an attempt to predetermine the settings that users are asked to imagine for a particular piece of technology and the pre-scriptions that accompany it" (Akrich, 1992: 208).

However, users may play the roles that have been originally intended for them as envisaged by the designers of the artefact or the technological system, or they may resist the intended use – a process called 'de-scription'. Akrich's focus is on this relationship and how it actually becomes the main factor in shaping the use of the technology at hand. As she states, the relationship between the user and the technology is materialised through "the user's reactions that give body to the designer's project, and the way in which the user's real environment is in part specified by the production of a new piece of equipment" (Akrich, 1992: 209). This is where de-scription takes place.

Akrich and Latour's work challenges the social constructivist approaches where agency is limited to human actors alone. From an ANT perspective, artefacts, like users, have agency in influencing the sociotechnical relationships that form the actor-network. The script concept explains how objects actually build those relationships and enrol users by constraining user scripts (Akrich and Latour, 1992). It thus attempts to build an understanding of how artefacts "participate in building heterogeneous networks that bring together actants of all types and sizes, whether humans or non-humans" (Akrich, 1992: 206).

In my explanation of the concepts of 'in-scription' and 'de-scription', I have shown how ideas from ANT are used in understanding the interaction between users and technology as part of an actor-network involving heterogeneous associations. At first sight, this idea echoes the notion of 'technology as text', which I described earlier (in section 3.2.2). However, there are subtle differences concerning the philosophical approach adopted in each of them. In the next section, I will describe Steve Woolgar's work on configuring the user, which derives from the semiotic notion of text. I will then follow that with a brief comparison between the two conceptual approaches: the 'in-scription' of technology use described above and the analysis of user configuration as developed by Woolgar (1991a).

3.3.2 Configuring users in technological innovation

By examining the design and production of computers through usability trials, Woolgar shows how the preconceptions of the designers regarding the "nature and capacity of different entities" affect the actions and behaviour of the imagined users. During the process of design, the identity of the user is presumed and constraints to the expected actions of the user are defined (Woolgar, 1991a). This process of configuration (defining, enabling and constraining) occurs within a social context, where the levels of knowledge and expertise are distributed accordingly. The result is a situation where the machine becomes an actualisation of its relationship with the intended users (Jelsma, 2006a). In other words, the design of the artefact reflects the various actions that the designers impose on the user. In effect, this leads to the creation of a boundary between the "insiders", those involved in the design and production of the technological object, and the "outsiders", the users.

Woolgar (1991a) in his study shows that the usability trials for the development of a microcomputer were not only used to make the computer more user-friendly, but were also used to find out how to define, educate and control its users – in order to make them computer-friendly. Accordingly, successful technologies require configuring the user, where its design constrains its users. The computer, in this case, was successful only in the context of the defined users (Sismondo, 2004: 82) and the result was a machine that encourages only specific forms of interaction with the technology (Woolgar, 1991a: 69).

A criticism of the idea of configuring the user was its bias to the power of designers and experts in shaping technological development. In his study, Mackay *et al.* (2000: 752) argued that designers are in turn "configured by both users and their own organisations". Because designers have to follow organisational structures, their ability to configure users is constrained by the decision-makers who direct the design projects (Mackay *et al.*, 2000; Oudshoorn *et al.*, 2004). Another criticism of this approach is the question of who is doing the configuration. Whilst Woolgar shows in his studies that configuration was in the hands of actors in the organisations producing the artefact, other authors extend this view and include the impact of outside actors, such as media, public sector organisations, and social movements. These actors become spokespersons on behalf of users and can play a significant role in their configuration (Epstein, 2003; van Kammen, 2003). Other scholars go further by focusing on the agency of users. The 'encoding' or scripting that is performed by designers and producers of technological artefacts is counter-balanced by the process of 'decoding', which is the work of the users in interpreting the machines through a process of identifying that codes that they receive from the machine and assigning them meanings (Mackay *et al*, 2000:750).

Both Woolgar and Akrich focus on the design process of technological artefacts and try to explain how the views of designers regarding the users and the use process shape technology. However, there are important differences. Woolgar's analysis gives more power to the designers during the design and innovation process. Nevertheless, this should not be understood as a form of technological determinism, as the textual analysis of technology entails that more than one reading is possible. It remains that the focus of the approach of 'configuring the user' is on the processes that designers use in constraining the users' actions.

The script approach, on the contrary, places the user in a more influential position and shows how he or she can be active in the process of technological development though building the needed actor-networks in order to achieve their goals. Thus, according to Akrich, using the script concept avoids a technological determinist view when analysing the use of technology by focusing on the users during an artefact's diffusion. In doing so, she stresses the fact that the relationship between objects and users is mutual and that the ability of the objects to shape this relationship may be resisted. It therefore becomes equally important to analyse the designer's role in imagining and representing the putative user, on the one hand, and the "real" user on the other hand (Akrich, 1992), where a process of de-scription can take place (Akrich and Latour, 1992: 261). I will discuss the analysis of representing the user in section 3.4.1 of this chapter.

Those differences aside, what I want to highlight here for the purpose of my research is the constructed nature of technology, and how it is shaped by societal interpretation. This interpretive nature of technology materialises in its textuality: technologies are texts that are written by designers and read by users. Akrich, however, points to the agency of technology, so artefacts have 'scripts', which can be de-scripted. But what is an RET's script? How can we write and read RETs? Can people resist the RET's script? This research has therefore been designed to answer three questions. The first is: who is writing RETs? From this question emerges the need to locate my analysis, whether in the innovation or the diffusion phase of a technology. Networks of adoption are different and wider than networks of innovation, a point that I detail later in section 3.4.2.

To unpack the script of RETs, a second question is important: how are the actors involved in the RET's diffusion imagining their projected users? Related to this, how are the users being constructed and how does that influence the design of RET implementation projects. The script approach is useful in my analysis as I relate the images of users as conveyed by the actors (the project managers) to the way the RET is implemented, and consequently the design of the project. The resulting design is, hence, the text. To complete the story, one more question is asked: how are RETs used? In other words, how are they read, de-scripted or decoded?

An important aspect that has been so far ignored in the STS approaches is the context of use, the space where the interaction between users and technologies take place. So far, the point of departure for approaches in STS has been the technology and its design. Alternatively, concepts from cultural studies on domestication analyse the use of technology from the user's end. This is important as it relates to my third question. In asking how RETs are read, I will have to think of *where* they are read. This is not new; in fact, previous work on energy has located its use in the home, in the space of everyday household practices (Aune, 2007; Shove, 2003). Along with Shove and Aune, in this research I will focus on the use of RETs in the home. In the next section, I summarise the domestication approach and briefly compare it to the approaches from STS.

3.3.3 Consuming technologies – users in cultural and media studies

Contrary to approaches in STS, scholars in cultural and media studies have long acknowledged the importance of studying users (Oudshoorn and Pinch, 2003). Whilst the focus of scholarship in STS was technology design and development, the interest in cultural studies was in modes of use and consumption. Inspired by the work of Bourdieu (1984) which emphasised the role of consumption in late modernity, cultural theorists maintain that technologies must be culturally appropriated to become functional. Whilst Bourdieu (1984) argues that the structure of consumption results in a reproduction of class relations, scholarship in cultural studies asserts that human relations are becoming increasingly defined in relation to consumption rather than production. Thus, consumption fulfils different aims, whether social or personal, and helps us express our identity or the desired vision we have for ourselves (Zukin and Smith-Maguire, 2004)

Analysing user-technology relations is also prominent in cultural and media studies. Most notably is the work of Stuart Hall who introduced the "encoding/decoding" model of media communication and consumption. Focusing on media, Morley describes its role in "setting agendas and providing cultural categories and frameworks", and the role of the user who gives meaning "to the signs and symbols that the media provides" (Morley, 1995, cited in Oudshoorn and Pinch, 2003: 13). This textual analysis of media communication argues that social, economic and technical factors shape the programmes and messages of media producers (encoding). Viewers, on the other hand, decode these programmes by making sense of them and giving them meaning. However, the symmetry between the encoding and decoding is not always achieved, and there is always the possibility of a misunderstanding (Smith, 2001). Therefore, within the field of cultural studies, an important approach to user-technology relationship emerges which emphasises how users can play an important role in shaping the meaning and use of technologies. Further studies on information and communication technology have focused on users by exploring the consumption of technologies. According to these studies, technologies have to undergo a process of 'domestication', where technological products become embedded in our culture and daily routines by becoming familiar to society, in contrast to the perceived threat and excitement that they generate when they are first introduced (Silverstone and Hirsch, 1992).

The process of domestication involves practical work, where users develop patterns or spaces of use and integrate that into their daily lives; and symbolic work, which involves users assigning various symbolic meanings to the technology (Silverstone and Hirsch, 1992). Accordingly, the process of domestication involves changing the meanings and uses of technologies whilst also enabling or constraining (in some cases) the activities of the user. In this respect, the concept of domestication is relevant to researching RETs as it allows a focus on the meanings residents give to the technology and the activities they undertake in relation to it.

Four phases during the process of domestication take place: appropriation, objectification, incorporation and conversion. Appropriation is the first step when households or individuals purchase and become the owners of a technology. Objectification occurs when the user attains a sense of themselves in relation to the technology and the rest of the world (Silverstone *et al.*, 1992: 22), followed by incorporation whereby technologies are incorporated into the routines of the user's daily life. Conversion describes the process in which the use of the technology shapes the relationship between the user and others in society. As a result, technological artefacts become status symbols and express specific lifestyle choices to the others in society (Haddon, 2002; Silverstone and Hirsch, 1992).

Having briefly overviewed the concept of domestication, it is important to state that there are important differences between the approach of domestication and that of 'de-scription' as described by Akrich (1992). In explaining the process of technology diffusion and uptake by users, domestication approaches focus on the dynamics of use and so their point of departure is the user. On the other hand, de-scription stresses the importance of the technical design and conception and, therefore, departs from there to build a framework for understanding user-technology dynamics. Thus, the cultural aspects of technology use are more thoroughly expressed in the domestication approach, in contrast to the semiotic approach in Akrich and Woolgar's work that puts more weight on the direct interaction between the technology and the user.

By highlighting the concepts of the domestication approach, I have to this point presented the main theoretical perspectives that guide my analysis of users and RETs. As mentioned earlier, theories from STS examine the co-construction of users and technologies by analysing the technologies' scripts. Technologies are thus texts that are read by users in different ways. But STS approaches tend to isolate the user/technology interaction, so I have reviewed the domestication approach as I attempt to locate RETs use in the home.

In the next section, I present the work of Akrich, which analyses how designers or firms imagine users and in so doing, construct user identities in relation to the technology. This is very important as these processes uncover the way that designers or producers imagine the user and consequently 'script' these notions into the technology's design and diffusion. Akrich (1995) refers to such processes as 'user representations', which are in other words user constructions produced by the designers. Following that, I will then discuss the work by Callon on networks of adoption, where the diffusion of technologies occur in more complex and diverse actor-networks, compared to those surrounding a technology's conception or innovation. This is significant for my research. Because I focus on the implementation of RETs in the UK, I refer to this work as I situate the actors and the emerging networks involved in the RET projects that constitute my empirical work.

3.4 Users and technologies in action: constructed/real users in networks of adoption

Having described the theoretical framework which guides my analysis of the user/technology relationship, in this section my intention is to focus on the tools which designers and producers of technology adopt in imagining their users. For my research, this is particularly relevant as I explore how the project managers in charge of implementing RETs construct or imagine their users.

3.4.1 Representing users in technology adoption: constructing RET's users

In this study, I attempt to understand how the users are imagined or constructed by the project managers involved in the RET's implementation. Accordingly, the mechanisms involved in the construction of users are important as they can influence the process by eliciting certain information about users and neglecting others. As mentioned earlier, this process is what Akrich (1995) refers to as representing the users, and is undertaken by the designers or producers as they script the use and users into an artefact's design. In this work, Akrich describes the methods that firms and designers employ to represent their users.

In her work on scripts, Akrich (1992) argues that designers imagine a projected or theoretical user and consequently inscribe the assumptions that they make into the design of their technologies. Thus, a theoretical user is drawn up by the designers in the process of anticipating the potential use of the technology. This is particularly the case in the early stages of a technology's diffusion, when the design of the technology has not yet stabilised (Akrich, 1992). These representations are then materialised in the technical choices, not only in the design of the technological artefact but also in the expectations of use and in shaping the relationship between designers (or the firms) and the user (Akrich, 1995: 168). Therefore, designers represent users through different means using different methods, which are important in the developing of technological scripts.

According to Akrich (1995), users can be consumers, citizens, members of households, political parties, churches or religious groups or professions. In technological design, much debate goes on that aims to mediate between these different positions of the user, which could be incompatible in a single technological system. Accordingly, successful innovation does not follow a simple or straight-forward model, and cannot follow on with technical choices based on one line of user representation. In order to ensure the success of their design, designers often have to "tune in to several wavelengths simultaneously" (Akrich, 1995: 167). Therefore, a successful innovation will have to cope with different types of users for their technology, with each type of user having a different set of skills, as well as social and technical aspirations.

Representing the user is therefore a complex process that is achieved through different methods, which include both: explicit techniques, such as market surveys, consumer testing, and costumer feedback; and implicit techniques such as the personal experience of the designer, the experts who have experience with similar technologies to those that are being developed, as well as the user representations that are generated in the development of other comparable products (Akrich, 1995). Whilst implicit techniques are based on special skills or qualifications in the area of defining or interpreting consumer representations, the former address the "real" users, as opposed to the imagined users. I summarise these methods in table 3.1.

Table 3.1 Methods of representing the users (Akrich, 1995)

Method	Description	Problems
Explicit techniques		
Market surveys	These form the main method for obtaining information on users. The survey, thus, can identify buyers and refine the sales argument.	Sometimes used to persuade high-level management on decisions, rather than design. The marketing teams often find themselves having to sell a product "as found".
Consumer testing	Directed to a sample of people believed to be representative of the users. In some cases, it is carried out with the personnel when secrecy is needed.	They sometimes "rely on typical and simplified situations for demonstrating particular user responses", can make the tests irrelevant.
Feedback on experience	Occurs after the purchase of the product. The users feed back information to the designers through costumer follow-up and costumer services. However,	Information is filtered twice: by the users (who only give the information that they think is relevant to use) and by the suppliers who only feed back comments they judge to be relevant to the product.
Implicit techniques		
The 'I' of the designer	The designer relies on personal experience. As such, he replaces his/her professional hat with that of a layperson. In cases when testing procedures are too complicated, the arguments based on the designers' own experience can be influential.	A limited and biased view of who the users are. The resulting design can exclude users dissimilar to the designers.
The experts	These are experts and specialists that speak on behalf of users. The technical designers and the marketing specialists represent the technical side and the consumer side of the user, respectively.	Whilst the involvement of the latter depends on the organisational procedure of every firm, the collaboration of the two departments show that the "user" is not a single entity, but has many facets that do not necessarily combine to form a definitive end-user.
Other products	These are representations existing in similar products to the one being developed.	A continuous exclusion of users not represented in other products.

However, despite the use of both explicit and implicit techniques, there remains a conceptual chasm between the represented user – the imagined user in the mind of the designer – and the real user who is actually using the technological artefact (Akrich, 1995; Rohracher, 2006a: 93). For example, market surveys – as the empirical work by Akrich shows – are sometimes used to persuade higher decision-making authorities in firms or organisations about the use or the existing market for a technology rather than being an informative method for developing a construction of the potential user. Therefore, many problems occur in predicting the uses of new technologies. For example, the case of the development of safety devices for the elderly shows (Hyysalo, 2003), that market research was used to support the innovation process by predicting the size of the market and the restrictions that might face the technologies concerned. The interviewees who participated in the market surveys were faced with a brief and sometimes ambiguous concept of the design. As a result, market research failed in anticipating the actual use practices that might occur with the new designs of the safety devices (Hyysalo, 2003). Accordingly, some scholars note the futility of market research sometimes as "there is no point in asking users what they wanted because they [the designers] themselves didn't know" (Woolgar, 1991a: 74).

Designers have always been involved in a range of activities that aim at constructing an identity of the intended or potential user of the technology. Oudshoorn *et al.* (2004) show in their study how designers in a telecommunications technology project who adopted a user-centred design in the interest of including the users, resulted in constructing a user identity in line with the designers' vision of males with expert knowledge in communication technology. Such a representation – using the 'I methodology' in Akrich's terms – is prevalent in many cases of technology design, however, the constructions of users produced through these implicit techniques are in some cases not shared by the different groups of actors involved in the innovation process (designers and others). In Woolgar's study on personal computers, it appeared that the various actors involved in the innovation of this product (such as hardware engineers, product engineers, managers, salespersons, technical support, etc) "at different times offered varying accounts of 'what the user is like'. Knowledge and expertise about the user was distributed within the company in a loosely structured manner, with certain groups claiming more expertise than others in knowing what users are like" (Woolgar, 1991a: 69).

Therefore, as the two examples above show, neither explicit nor implicit techniques necessarily generate an accurate account of who the user is. Consequently, there is room for contestation and negotiation regarding the identity of the user intended in the design and use of technological artefacts. These negotiations are possible and can occur in the spaces generated by the number of actors involved in the innovation process and the type of involvement maintained by these actors. These possibilities can, therefore, "be both enabled and constrained by specific (inter)national or institutional policies and by material practices that have evolved" over time (van Kammen, 1999: 309).

Constructing user identities is an important aspect in technological innovation and implementation. Summerton (2004) shows how Swedish utility companies use various branding programmes to co-constitute user identities. By promoting new images of both artefacts and users, managers were in fact constructing 'scripts' that reflected their expectations regarding the preferences and actions of users. Moreover, in doing so, managers were not only constructing user representations but also created identities for themselves and their firms (Hall, 1999 cited in Summerton, 2004). An important finding by Summerton, however, shows that the branding programmes described above failed to enrol or engage users effectively, indicating user resistance to the attempts made at representing their identities, preferences and practices. As Akrich and Latour (1992: 261) suggest, the users in this case, were involved in the de-scription of the companies' intended programmes. Whether users actively rejected the branding or were passively uninterested, the example above demonstrates that users have agency and are not simply passive recipients of the designers' assumptions (Akrich, 1992; Akrich and Latour, 1992; Summerton, 2004).

3.4.2 Assembling networks of adoption

Analysing the diffusion of RETs by focusing on the implementation phase provides an opportunity for researching technology at its level of implementation (Akrich, 1992) as it highlights the role of users in this process and the resulting shape of the technology. Furthermore, as Mackay and Gillespie (1992) suggest, it is important to extend the social shaping of technology approach towards issues of marketing and appropriating technology. The authors argue that "to suggest that once a technology is produced, or even sold, it reaches the end of its social shaping, however, is to ignore both its marketing and how the technology comes to be used or implemented" (Mackay and Gillespie, 1992).

Therefore, my research is an attempt at analysing the social choices involved in technological innovation and how these choices are influenced by the sociotechnical processes in constructing users and configuring them along the lines of implementation plans. Such an attempt requires a shift of focus from conception to adoption, and therefore a widening of the actor-networks that these technologies are embedded in (Rohracher, 2003). Actor-network theory provides a suitable framework for analysing how actors recruit a network of supportive actors that lead to the success of their technologies. This concept can be extended in order to analyse the diffusion process as well. According to Callon (1993) a unified approach is needed to analyse the conception as well as the adoption of technology because "the adoption dynamic is generally dependent on the conception dynamic and that, reciprocally, adoption networks permanently redefine the foundations on which the future conception networks will be built" (Callon, 1993, cited in Rohracher, 2003). This shift in focus, however, implies that a more diverse group of actors – of differing interest and professions – and the networks they build, will have to be analysed. According to Rohracher (2003), transforming an actor-network from the innovation level to the diffusion level means a change of practices concerning the artefact. In this case, the practices surrounding RETs, such as specialised engineering, experimentation and monitoring, will be replaced by potentially less competent installers, builders and maintenance personnel. Similarly, the practice of use can sometimes shift from highly motivated users in pilot schemes to a wider community of perhaps less motivated users.

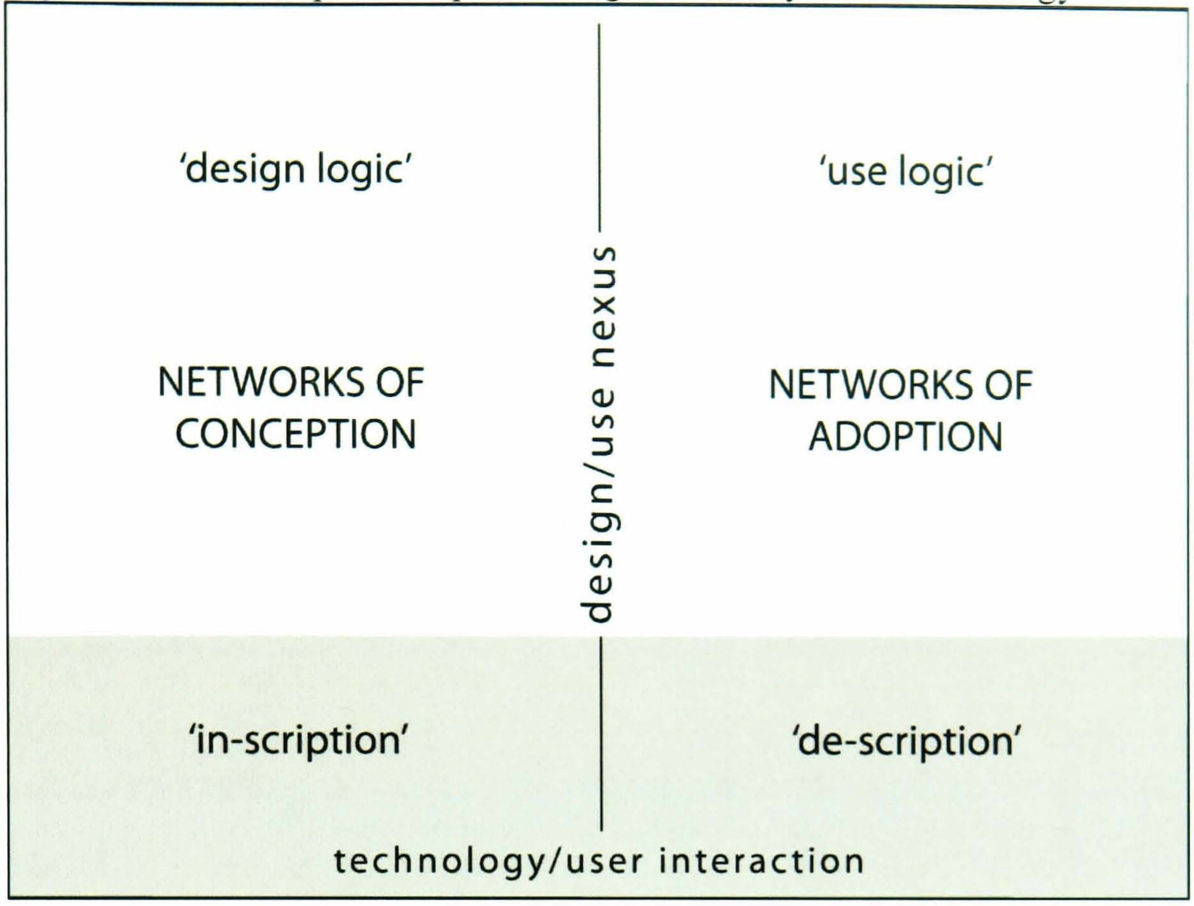
3.4.3 Toward a theoretical framework for analysing RETs and users

Bridging the gap between technology and behaviour, Jelsma (2005) presents a model that analyses the 'scripting' or configuration work that is conducted by designers on the one hand, and the actions of users as they interact with the technology on the other hand. Useful for understanding these processes are two concepts: *design logic* and *use logic*. Central to this model is that the script embedded in technologies, which as I mentioned earlier, can facilitate or constrain certain user behaviours. Design logic, therefore, is the logic that exists behind the creation of these scripts, i.e. the 'inscription' (Akrich and Latour, 1992). It constitutes the "whole of ideas, beliefs, values, intentions, estimations etc. that becomes inscribed into a specific artefact during the process of its design" (Jelsma, 2005: 93). The process of inscription, I argue, takes place in an actor-network, where the relationships built among designers, engineers, producers, firms, etc. result in the final design of the technological product.

The use logic involves similar processes from the user's side. Hence the 'de-scription' of technologies takes place within the "consistent whole of the heterogeneous rationales that consumers mobilise in their interaction with scripts in everyday practice" (Jelsma, 2006b: 225). These rationales or mental processes are embedded in everyday routines and activities and are shaped by technical, cultural and material stimuli and constraints (Jelsma, 2005; Shove, 2003). The result is the domestication of technology whereby the meanings and uses of a technological artefact are embedded in the user's life-world.

In studying how users are constructed at the implementation level of RETs in the UK, I focus on the actors involved in these installation projects. These include public authorities, project managers, housing developers, energy consultants and engineers. As Akrich (1992: 208) suggests, the actors involved in the implementation projects can construct different identities of the users who will be receiving and thereby using the technology, and as a result, materialise these constructions in the technical choices they make regarding how the technology is implemented, in what form and in which way. The expectations that they have with respect to the users derive from their representation of users, their past experience in working with similar users and extend to include anticipation regarding the users' homes, lifestyles (habits), their socio-economic level and their beliefs and attitudes regarding the environment and climate change (Henning, 2005). This side of RET implementation represents the design logic. The use logic is represented by the end-users of the installed technologies. These are householders or tenants, as owners or occupiers of homes where RETs are installed and used. What we have, therefore, is a framework that allows a clear analysis of the design/use nexus, as illustrated in figure 3.1. Hence, the 'inscription' or the writing of technologies will constitute the analysis of the design logic, whilst the 'de-sciption' or the reading of technologies will indicate the analysis of the use logic.

Figure 3.1 A conceptual map for design/use analysis of technology



3.5 Conclusions

I started this chapter by introducing the main theoretical approaches in STS that have influenced my analysis of the role of users in technology design and diffusion, the SCOT approach, ANT and the semiotic approach. In doing so, I have highlighted the main concepts that inform my studies on RETs and their users. My purpose was to discuss the active role that users have in relation to technology and thus, rejecting deterministic interpretations of technological diffusion and user acceptance. Accordingly, the social and the technical are co-constructed in the design and use of technologies.

I argued that the theoretical perspective of configuring the users and the concept of 'script' provide a useful framework for analysing the diffusion of RETs, and in effect, challenging the conventional assumptions relating to social acceptance of technologies, environmental values, and the need for education. Instead, the focus will be shifted to the design of RET implementation projects, where the decision makers (who I refer to as project managers in this study), script the technology according to the different user constructions that they employed. This script is then materialised into the design of the installation project, which subsequently influences its use. The result, then, is what Jelsma terms as the 'design logic' (Jelsma, 2006a), which involves not only the project managers' images of the users, but also their knowledge and the meanings they give to the RETs. the project priorities and the constraints that define and shape they work. This constitutes the first stage of my research.

The second stage is concerned with the users and the RETs, or what is described as the 'use logic' (Jelsma, 2006a). This involves the interaction of the users with the RET, and how they appropriate the technology into their home and their everyday activities. Both stages of my research will be in line with the central perspectives on technologies and users that I discussed earlier. As such, the concept of symmetry means that agency is attributed to the managers and users, as well as the RETs and the buildings they are installed on. Also, the interpretive flexibility of the technology – and the semiotic approach of treating it as text – is central to my analysis of the technology and its use.

The next chapter builds on the arguments presented here concerning symmetry and the constructed nature of technology. These ideas evidently inform the methodology and research strategy, which I use in conducting my empirical work. The chapter also outlines the data collection methods adopted in my work and consequently, the analysis that I present in part II of this thesis.

CHAPTER FOUR

Methodology: Designing a Research Strategy

"If designers and users are configured in networks and if this configuration constrains their inscriptions and readings systematically, at least some learning about and anticipation of incongruity must be possible" (Jelsma, 2006a: 68).

4.1 Introduction

Research within the STS tradition has for decades prided itself with its heavy emphasis on empirical work. As such, STS literature is rich with empirical research on scientific and technological innovation that follows through the various developments in, for example, a technological artefact's innovation and use. As my research revolves around the co-construction of RETs and their users, the research design in this work contributes to this tradition, having argued that exploring the questions of design and use logics can only be answered through empirical investigation (Jelsma, 2005). At this point, it is important to revisit the research questions as outlined in chapter one. My main focus is on how users are constructed in the implementation of photovoltaics, and therefore this research asks (1) who are the actors involved in the RET implementation debate – this necessitates the scoping of the different stakeholders (individuals, firms, organisations, etc.) that constituted the actor-networks surrounding the implementation of PVs. Moreover, I am intere sted in exploring (2) the roles played by these actors in shaping the design and implementation of RETs. This meant a focus on the role given to users by the project managers during the PVs installation. As explained in chapter three, configuring users entails the production of user constructions and so the third question is (3) how are users constructed during the implementation of RETs and how does that influence the technologies' design. Finally, my research attempts to explore the ways in which users interact with the RET technologies (in this case, the example of photovoltaics) and how they appropriate them into their daily lives.

To answer the questions above, it was necessary to study the various factors that shape the context within which photovoltaics are debated and used. As such, the first step was to identify empirical examples of photovoltaics deployment, and from there to develop a heuristic approach to explore these dynamics and how they influence and shape the meaning of photovoltaics in society. Moreover, since my research interest is in analysing how the users of photovoltaics are configured in practice and in the discourse on this technology, using approaches from science and technology studies (STS), a holistic method was needed to understand the various processes taking place, the decisions being made and the reasons behind them, as well as the arguments made about and on behalf of the PV technology and its users.

4.2 Methodological approaches in science and technology studies

As mentioned in the previous chapter, adopting a so ciotechnical approach to analysing the way users are constructed within the debate on renewables entails a methodological approach that is appropriate to this objective. According to Guy (2004), using the sociotechnical approach in the analysis of RET implementation necessitates a qualitative research agenda that will bridge "the theoretical gap between the social and technical features of energy use" (Guy, 2004: 691). Indeed, most research in STS employs various qualitative research methods, such as ethnographic approaches, participant observation, ethnomethodology, analysis of historical documents, and textual analysis, to name a few (Bowden, 1995). Moreover, an interest remains among recent scholars in attempting to learn about society and technology by following the actors involved in the innovation and diffusion of technology (Callon, 1987; Latour, 1987), and in doing so "peering over the engineer's shoulder" in order to understand the different roles of the actors involved (Callon, 1987: 98).

Because my research is focused on understanding the various roles played by the different actors and technologies that relate to the implementation of photovoltaics in society, I opted for a qualitative approach that would allow me to observe and understand the actors as they try to install photovoltaic technology on buildings. My first attempt was to "embed" myself into a housing regeneration project that included the implementation of solar panels on homes. However, this later became impossible because the project involving the implementation of the technology was not realised due to lack of funding. I then turned to recently completed projects involving the installation of solar photovoltaics on buildings in the UK. As a result, I chose the case study method, whereby the case would be centred on the technology (in this case, photovoltaic panels installed on buildings) and the various actors associated with its installation and use. This research design provided me with a framework to collect data, using various methods which I detail in later sections. In the next section, I will introduce the main philosophical thinking that underpins the theoretical approach adopted in my research: social constructionism and actor-network theory. Both approaches have influenced and shaped my research perspective as I sought to unpack the social meaning attributed to RETs (and to PVs in the particular case studies), and in my research strategy where my investigation attempted to reconstruct the story of two photovoltaics' implementation project.

4.2.1 Social construction of technology

The social constructionist approach centres on the assumption that the concepts through which our world is understood are actually social artefacts, produced as a result of historical interactions that have taken place over time (Gergen, 1999). Social constructionism has become fairly well established in the field of STS since the late seventies, especially with the publication of Latour and Woolgar's work *Laboratory Science* (1979). Since then, more studies and later developments in theory have attempted to show how knowledge, phenomena, science, technologies and societies are socially constructed. Nowadays, this school of thought has become the philosophical approach that characterises the common theoretical standpoints within STS (Sismondo, 2004: 51).

However, how social constructionism was interpreted in STS has differed, resulting in many "social constructions", which have different implications for our understanding of science, technology and society. With relevance to my research is Pinch and Bijker's (1987) work on the social construction of technology. As I mentioned earlier in chapter three, their work asserts that the interpretive flexibility of technological artefacts leads to various social constructions by their relevant social groups. Accordingly, the success or diffusion of technology in society is not in its intrinsic features but rather depends on its interpretation by different users. In the case of photovoltaics, the premise of my research is exploring how this technology is socially constructed during its implementation, and I therefore examine through my case studies how the different user groups involved in the implementation process interpreted the technology in different ways resulting in the final installation. My intention, therefore, is to unpack these meanings by exploring the different processes that the actors use in making sense of the technology and its implementation.

The other interest in my research concerns the representation of users of PV technology during its implementation. Applying social constructionism, this approach entails "the construction of the objects of thoughts and representations" (Sismondo, 2004: 55). Accordingly, what the project managers (responsible for PV installations) thought about the users is socially constructed through the means by which they (the managers) use to understand and subscribe the users roles. As Jelsma points out, "in every design process there is a consistent mental reflection of what is proceeding on drawing boards, on the shop floor or at the construction site" (Jelsma, 2005: 94). This is the basis from which Woolgar builds his work on configuring users, and in applying it to my research topic I attempt to explore the processes that take place during the implementation of technology.

4.2.2 Actor-Network Theory

In addition to the philosophical principles of social constructionism that guide my research, I have applied a number of methodological concepts that originate from research within ANT. The reasons behind thinking through these concepts are twofold: first, the interest of my thesis in the implementation of RETs and hence the work of Callon on the shift from networks of conception to networks of adoption (Callon, 1995) and second, the work by Akrich (1992) on the building of 'scripts' in technology that shape its use and users. Both works are based in the ANT approach and both build on its main principles of translation and symmetry, as I explained earlier in chapter three. Though my research falls broadly within the category of social construction of technology, and I would not consider my thesis to be a study following the ANT approach strictly, however, I have been inspired by the main methodological principles outlined by Callon (1986) in his study of scallops and fishermen of St Brieuc Bay. These principles are agnosticism, generalised symmetry, free association and letting the actors speak, which I summarise below.

Agnosticism implies that the researcher does not form any preconceived distinctions regarding the technical and managerial arguments made by the different actors. According to Callon, this principle is crucial in ensuring that the researcher is not only "impartial towards the scientific and technological arguments used by the protagonists" (Callon, 1986; 200), but that this impartiality is extended towards the actors' understanding of the social environment that surrounds them. This is important as it challenges the traditional sociology of science, as it introduces the basic principles of a new sociology of translation. Thus, through the principle of agnosticism, the researcher's role is to understand how the actors analyse the technological as well as the social and cultural aspects of their work. Furthermore, agnosticism is important as it prevents the researcher from categorising the actors into fixed groups, which is rejected from an ANT point of view (Latour, 2005), as "science and technology are dramatic 'stories' in which the identity of the actors is one of the issues at hand" (Callon, 1986; 199).

Like any novice researcher, I first found it difficult to understand 'generalised symmetry' as explained by proponents of ANT. This concept stresses the necessity of not distinguishing between 'social' and 'technical' aspects when studying phenomena in society, unlike what I have learned for years. However, whilst investigating my case studies, I have come to realise the agency of non-human actors. As mentioned in chapter three, actions and responsibilities are distributed among actors in a network, and hence we can talk of 'guns that kill' (Verbeek, 2005). I have adopted this principle because it helps me to apply the concepts concerning the complexity of technological diffusion and the formation of sociotechnical relationships, which shape the context of technical change. As such, 'general symmetry' was helpful for me in unveiling and analysing the processes of configuring the users during the implementation of photovoltaics in the domestic sector, by paying attention to the roles of not only the project managers but also the technologies that constrain or facilitate certain actions and behaviours.

Following on from 'general symmetry' is the principle of 'free association', which consists of not imposing a given grid of analysis that separates between natural and social events. This view maintains the argument that such divisions are artificial and "are a result of analysis rather than its point of departure" (Callon, 1988; 201). This position allows the researcher to follow the actors (Latour, 1987; 2005), where there is no pre-defined conception of the process being studied, and by doing so, the researcher would be able to "identify the manner in which these [actors] define and associate the different elements by which they build and explain their world, whether it be social or natural" (Latour, 1996: 201).

Based on the above principles, ANT attempts to 'let the actors speak' involves following the interpretations of the actors that form the part of the network that is under study, rather than impose a theoretical framework to the event in question. As such, the researcher allows the actors to define their own frame of reference, their own analysis of the social and technical relationships and its limits. For my research, and in applying ideas from ANT, I have considered relevant what the actors deemed important to the cases under study (actors being both human and non-human), rather than impose boundaries stemming from prior knowledge.

Silverman (2005: 127) states that one of the characteristics of a case study research is its boundedness, and in designing my research, I have sought to 'bound' my case studies with what *the actors* described as relevant to the implementation of PVs. Whilst the principles of ANT indicated above are an attempt by its proponents to distinguish it from traditional sociological research in science and technology, it does not entail that the researcher is objective. Hence, these principles do not indicate the researcher's position towards the actors they are studying, but only point to the importance of rejecting *a priori* distinctions between the technical and the social (Latour, 2005).

At this point, it is important to mention ANT as method. Through his analysis of the development of scientific facts, Latour (1987) emphasises the process of following the actors and of abandoning any distinction between nature and society, such that there is "no clear separation between the social realm of subjects and the realm of objects, scientific facts and things" (Rohracher, 2006a: 32). Whilst this perspective calls for a new approach to social theory (Latour, 1996), in another place Latour rejects the label 'theory' (Latour, 1999), insisting instead that ANT is "a method and not a theory, a way to travel from one spot to the next" (1999: 20). The focus, therefore, in doing ANT is in tracing the actants as they move and work in networks of associations. This entails a distinctive philosophical approach to inquiry and a realisation that researchers do not know the truth, but rather that "actors know what they do and we have to learn from them not only what they do, but how and why they do it" (Latour, 1999: 19).

I have paid particular attention to these philosophical principles because, as I mention in chapter three, theories on the 'scripting' (of users and technologies) as developed by Akrich and Latour (1992) are based on actor-network theory, and therefore the analysis of actor-networks is important in my research approach. Hence, when conducting my enquiry, I adopted these principles as they clarify my position with regards to the subjects being studied empirically. Moreover, the principles have aided me in establishing my research strategy, which was helpful in developing the necessary methods and data collection tools described in later sections of this chapter. Guided by the philosophical and methodological concepts described above, I started to develop my research design. As I have used a case study strategy, the sections that follow describe the historical and methodical characteristics of case study research. I then briefly summarise the two empirical case studies and the various data collection methods that I have used.

4.3 Case study as a research strategy

Research on users of technological artefacts in STS asks the questions of what, by whom and how does the co-construction of users and technology occur (Lindsay, 2003), questions which the case study research strategy attempts to answer (Yin, 2003: 5-11). As my research concerns the construction of users and their relationship to technology, it is therefore important to explore how the project managers construct the users of photovoltaics and how these constructions influence implementation activities. According to Feagin *et al.* (1991), a case study is the preferred method of research if a holistic, in-depth investigation of a social phenomenon is needed. Therefore, adopting such as strategy allows me to conduct my inquiry into the underlying assumptions and knowledge that the project managers use in envisioning who the users are, and what their role should be.

According to Guba and Lincoln (2000), qualitative research is often based on the view that social phenomena are influenced by the context in which they occur. Hence, the case study approach typically investigates the interaction of different variables within this context in the aim of providing a complete and contextual understanding of a social situation. Its value, thus, lies in the fact that it is the most suitable method used when the researcher wants to know how and why certain phenomena are taking place and when she/he has little control over the events under study (Gillham, 2000; Yin, 2003). Behind this research approach is the realisation that the case "is a complex entity operating within a number of contexts, including the physical, economic, ethical, and aesthetic" (Stake, 2000: 239).

Such a premise is congruent with the requirements of research in STS, namely that the context is central to the study of technology (Pinch and Bijker, 1987) and that a multiplicity of variables act concurrently in shaping the design and use of technology (Bijker, 1995b; Callon, 1987; Hughes, 1987). Moreover, the methods that the case study strategy provided me with were practical tools in approaching my fieldwork. In other words, it has assisted me in designing my fieldwork by limiting my investigation to two case studies in England and in designating the relevant actors in relation to my research focus – the photovoltaics and their users. In the next section, I will briefly describe the different types of case studies that exist, and that informed my research design.

4.3.1 Types of case study research

However, there are different types of case studies, as different authors or contributors to literature on methodology would note. Whilst some authors prefer to describe case study types as ranging from the simple descriptive case to the rigorous experimental case, where different research questions demand different levels of description, analysis or experimentation (Hakim, 2000); others, such as Yin (2003: 11), classify them into three groups depending on the purpose of the research activity. These are: exploratory, explanatory and descriptive case studies. Accordingly, an exploratory case study is useful in generating hypotheses in the early stages of the research process; explanatory case studies, which can "explain the presumed causal links" that are too complex for survey or experimental methods to answer; and descriptive case studies that seek to illustrate certain situations in detail, paying attention to the context and historical circumstances (Yin, 2003: 15-16).

Whilst the above categorisation emphasises the type of results sought from the research, Stake (2000) categorises case studies into three types: the intrinsic, which is when the researcher has an interest in the case due to its particularity), instrumental (when the case is used as a tool to further understand a phenomenon in question), and collective (which follows from the instrumental case study but incorporates more then one study). This categorisation emphasises, according to Stake, the "variation in the concern for and methodological orientation to the case" (Stake, 2000: 238).

Whilst some researchers reject the idea of an intrinsic case study as one cannot generalise from it and as such the value remains descriptive in nature (Silverman, 2005: 127), generalisability has always been one of the criticisms aimed at the case study as a research strategy. However, in defence of the case study, it is argued that generalisation should not be emphasised in research (Feagin *et al.*, 1991; Flyvbjerg, 2004), indicating that "formal generalisation is overvalued as a source of scientific development, whereas 'the force of example' is underestimated" (Flyvbjerg, 2004: 425). Yin (2003: 3) also counters criticism regarding generalisation by stating a difference between analytic generalisation and statistical generalisation. Contrary to quantitative or statistical research, where a sample is assumed to be randomly drawn from a larger population, case study research allows the comparison of the empirical results of case studies to the theory that has been developed previously.

Other researchers, nonetheless, prefer more conservative methods of dealing with generalisability in case studies. Silverman (2005: 128-136), for example, suggests combining qualitative research with quantitative measures of populations, purposive sampling (guided by time and resources) and theoretical sampling (guided by the theoretical background of the research question), or conducting several case studies to be able to generalise on a social phenomenon (Giddens, 1984: 328). Stake (2000: 238) resists these attempts, stating that it can be counterproductive if "the commitment to generalise runs so strong that the researcher's attention is drawn away from features important for understanding the case itself". Having briefly described case study types, I will now explain the applicability of the intrinsic case study for my research.

4.3.2 Selecting the case studies

Since beginning my study, I have come to recognise the value of intrinsic case studies, especially since many examples of STS research constitute theory building and rely heavily on single case studies conducted using different data collection techniques. In designing my research strategy, I have often thought about the issue of generalisation. However, as my research is theory driven with an interest in examining the co-construction of users and photovoltaics, it was only natural to choose case studies that will help me in answering the research questions that stem from previous research on users in the field of STS. Termed theoretical sampling, Bryman (1988: 90) argues that the generalisable quality of the case study should be tested against the theoretical propositions rather than to populations (Bryman, 1988: 91). As such, theoretical sampling is a useful tool to ensure that selecting groups or categories for study is relevant to the research question or the theoretical position adopted for the research, and the explanation that is being developed (Mason, 1996: 93-94). The necessity of theoretical sampling to achieve generalisable research is also evident in Hakim's account of case study research, where their "strength and weaknesses...depend on the degree of fit between the questions to be addressed and the particular case, or cases, selected for the study" (Hakim, 2000: 62). Furthermore, the choice of a case study is also affected by more practical considerations, such as accessibility to the researcher (Stake, 2000) and their feasibility in terms of time and financial resources that are available in the research project.

In choosing case studies as a basis for my research, I followed the arguments from theoretical sampling. I was, therefore, interested in cases that involved the implementation of RETs in the domestic sector, with an interest in exploring the dynamics that shape the design of the technology and the interactions between the actors involved in the implementation, the end-users and the technology itself. Such cases would allow me to ask my research questions, whilst providing the opportunity to explore the implementation of technologies in practice. By taking the example of photovoltaic technology, I was interested in researching examples of their deployment in the UK, where it would be possible for me to have access to the actors involved. The two case studies, which I will detail in later chapters, are part of the Department of Trade and Industry's (DTI) Photovoltaic Domestic

Field Trial (DFT). Both are located in the north of England and have been completed recently, making it possible to contact the stakeholders involved in the projects. The following section briefly overviews the two case studies that formed my empirical work, before overviewing the data collection methods employed.

4.3.2.1 Trial and error: photovoltaics demonstration programme

At the start of my degree programme, the funding for my research was based on researching carbon abatement technologies in British cities. As my work progressed, the focus shifted to the implementation of RETs, with the example of photovoltaics within a policy context that seeks to reduce carbon emissions in the UK. As I mentioned in chapter one, the domestic sector in the UK brings forward an important issue regarding energy: the portion of energy consumption of the sector and the expectations of further growth in the future. Accordingly, researching this aspect of energy use in the country presents an opportunity to contribute to the knowledge necessary to tackle the increase in energy consumption and the problem of climate change (DTI, 2003).

Among the projects funded by the DFT are located in the north, I chose two that have been completed recently and which were based in urban areas. The next step was to ensure that studying them both would be sufficient in representing an exemplary case within the DFT scheme. Including both cases in my research design supports my research with empirical examples regarding the type of housing under study (social housing or private homes), the type of installation projects taking place (retrofit or new build), as well as different types of photovoltaic systems (PV tiles or panels). Table 4.1 below summarises the main characteristics of the two case studies employed in this research. Thus, the selection conforms to the guidelines on purposive sampling as described by Silverman (2005) earlier in the chapter.

Table 4.1 Installation characteristics of the two case studies

	Case one	**Case two**
Characteristics		
Development type	Social housing	Private development
Installation process	Retrofit	New build
PV system type	Roof integrated panels	Roof integrated tiles; and Bolt-on 'Sun in a Box'

The publications resulting from the completion of the DFT scheme have highlighted the importance of the type of development, suggesting the difference that a refurbishment project or a new-build development would have on PV designs. Moreover, the distinction between private developments and social housing meant that different stakeholders, or actors, were involved in the installation projects. The type of PV technology is also important, as each involves specialised installers and could include additional actors and decision-makers. In this way, my interest is in conducting research on cases that would cover some of the different contexts identified by the DFT in their reports (BRE, 2005) and evaluation studies (Pearsall and Butterss, 2002). In the next two sections, I will briefly outline the two case studies before I begin by describing the data collections methods. As mentioned before, a more detailed description of the two case studies will be provided in chapters five and six.

4.3.2.2 Case one: the social housing project

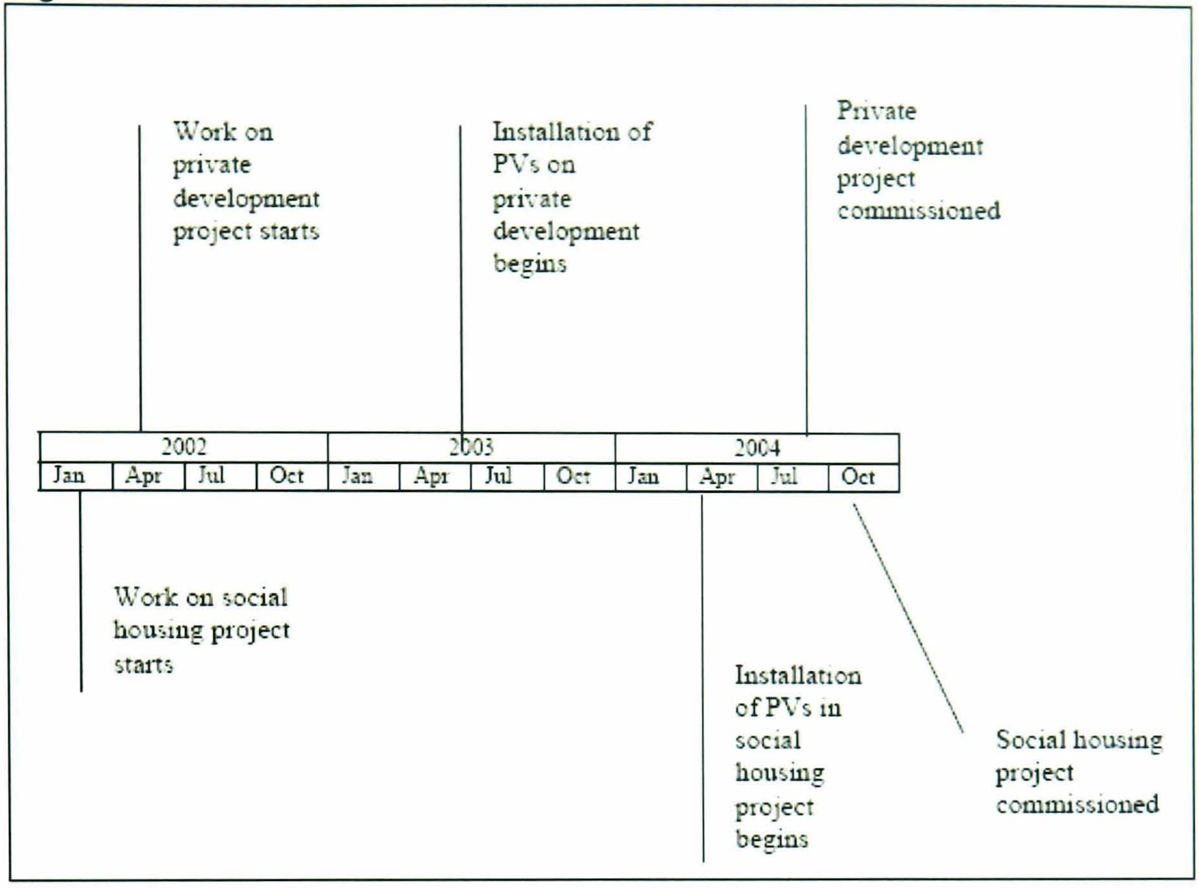
The photovoltaic panels were installed on the roof of a three-storey block that constitutes 25 individual flats. The flats are former council houses that are currently managed by a local housing association, and are located in a high Multiple Deprivation Index (MDI) area. Work on the project started in January 2002 and the PV system was finally commissioned in October 2004. The installation was funded partly through the DTI's DFT scheme and partly by the local City Council. In addition, the project also involved a PV installer, an energy consultancy firm that assisted in the funding proposal and other departments in the City Council that were responsible for the design and construction of social housing.

The panels were installed as a roof-integrated system, with a total capacity of 38.25 kWp (kilo-Watt power). The display monitors – which indicate to the users the amount of electricity produced and the percentage being used in real time– were installed in the ground floor communal hallway next to the meter cupboards. By doing so, the installation was done in a relatively short time, avoiding the need to obtain permission to enter individual flats in order to install the individual display monitors. The project included reroofing the property, installing the panels and fitting in the necessary equipment for the monitoring of the energy production. Additionally, it involved erecting the needed scaffolding, providing the legally required working site for the builders and contracting of 24-hour security services throughout the six weeks of installation.

4.3.2.3 Case two: the private development

The private development project is located on a green-field site, where the developers sought to build a prestigious suburban mixed-use development. The residential part involved the construction of 2,500 houses, including twelve onto which PV systems were installed. Ten roofs have PV tiles installed (which integrates into the design of the roof) and two have a 'Sun in a box' system that is mounted onto the roof. The project began in March 2002 and the PV systems were commissioned in June 2004 (see figure 4.1 for a timeline of events concerning the two case studies). According to the DFT, the purpose of this installation design was to compare the performance of the two different systems and the consumer preference with respect to their aesthetic value (Munzinger *et al.*, 2006). An additional aim was to compare the two types of installations during the construction process as well. The project team was led by a local energy consultancy agency and involved two housing developers, PV design consultants, the installers and the distribution network operator.

Figure 4.1 Timeline of events for the two case studies



4.3.3 Data collection methods for case study research

The methods of data collection used in case study strategies vary. In her evaluation of the approach, Hakim (2000) notes that most research adopting this strategy relies on various sources of data. However, it is important to distinguish between case study approaches and other methodologies that incorporate different types of primary data. The added value of case studies is that the principle idea behind the various sources of evidence is to triangulate information, forming, as Yin puts it "converging lines of inquiry" (2003: 98-99). In doing so, the researcher will be able to produce a more convincing and accurate account of the situation under research when the evidence is based on different sources of information.

Furthermore, collecting data using different methods allows this approach to present a more holistic account of the situation under study that the case study strategy aims at (Hakim, 2000), resulting in a method of data collection that is both, robust and sound in terms of maintaining a chain of evidence linking the research questions to the methods chosen, and consequently the resulting reporting and analysis (Silverman, 2005). This should also reflect the objectives of the research underway. In the case of this study, the research questions and objectives informed the design of the data collection strategy and the main sources of information used. The data for my research was collected in two stages: in stage one it consisted of interviews with individuals from the companies and organisations involved in the two PV installation projects which form my case studies, and stage two was the interviews with residents currently living in the homes constituting the two implementation projects. Table 4.2 details the research aims, questions and data collection methods employed at those two stages.

Table 4.2 The case studies: questions and methods

	STAGE ONE (January 2006 – March 2007)	**STAGE TWO** (April 2007 – August 2007)
Research objective	Exploring the 'design logic': examining how the project managers designed the installation project and how they intended the technology to be used	Exploring the 'use logic': examining what happens when the users interacted with the technology in their homes
Main questions	What kinds of assumptions were made regarding PVs and their users? How were these assumptions materialised into the design of the PV system?	How do users interact with PVs in their homes and to what extent are they configured in the way the project managers intended?
Main sources of data	Interviews with individuals from the companies and organisations involved in the PV implementation projects which form the focus of the case studies. Documentary evidence in the form of reports, leaflets, letters, memos, etc.	Interviews with residents in the two implementation projects who are currently living in the houses or flats where the PV technology is installed.

Yin (2003: 86) summarises the various data collection sources that are available for the case study researcher. These include documentation, archival records, interviews, direct observations, participant observation, and physical artefacts (such as cultural features or technical operations). These data collection methods will then be accompanied by associated tools of analysis (Silverman, 2005). The result is a package of data that provides the basis for a holistic inquiry into the nature of the phenomena taking place. The following section details the various types and sources of evidence that I have collected for my research.

4.4 *Investigating photovoltaics: collecting the evidence*

In investigating the issue of PV implementation in England, I have used a number of data collection methods that I describe in the following sections. The use of different techniques was influenced by the principle of 'following the actor' as advocated by Latour (1987). This methodology is as Latour states, "like detective stories" (Latour, 1996: 47 cited in Austrin and Farnsworth, 2005). Such a metaphor is productive in illuminating the way innovation in science and technology takes place, and the networks and associations assembled through this process. In my case, I was interested in finding as much information as possible about the two implementation projects that I was investigating, and in tracing the actors as they built their associations in order to complete the installation projects.

At the start of my fieldwork, I began with contacting the different actors involved in both PV installation projects. The contact details of most of the involved companies were available over the internet or on the documents and literature regarding the two case studies. However, acquiring the home addresses and postal codes of the houses in both areas was different in each case. In the social housing project, I was provided with the addresses of the flats on which the panels were installed, and accordingly, I was able to establish contact with the current tenants and visit them for interviews.

In the case of the private development, I was not provided with any addresses as my respondents did not wish to disclose personal information. I therefore used satellite imagery and aerial photos available on Google Earth™, which are available for free on the internet. Through the aerial photos, the PV panels were visible on the roof tops of individual houses, which helped me in locating the houses, their numbers and the street names during my field visit. The addresses were then used to post letters to the homeowners where I described my research project, requested their participation and informed them of the times of my field visits. In my letters, I assured the residents that they would remain anonymous and I did not seek to obtain their names or any personal data from them. As I mentioned in the letters (see appendix A), the purpose of my interviews was to speak to them about the PVs on their building block and their homes.

4.4.1 Semi-structured interviews

According to Rapley (2004:15), interviews are "currently the central source through which contemporary social science engages with issues that concern it". Indeed, Silverman indicates how the interview has become increasingly the centre of social interaction in the public realm (Silverman, 2003). However, the purpose behind conducting interviews in social research is that they allow the researcher to scratch beneath the surface of the issue under study and hence obtain more 'textured' and 'authentic' accounts of the problem that he/she is investigating (Rapley, 2004: 15).

Despite the abundance of handbooks on methodology and data collection, very few provide a 'how-to' for conducting interviews in social science. However, most authors stress the main principles that should guide the researcher during the interview process, and these include building rapport with the respondents, insuring that the interviewer facilitates the production of information and remains neutral throughout the process (Fontana and Frey, 1994; Rapley, 2004; Silverman, 2005). In preparation for interviews, Mason (1996) suggests taking an interview guide or an outline of the topics that the interviewer wishes to cover with the respondent. According to Rapley (2004: 17), the list of questions or topics is generated from the relevant literature that is reviewed at the start of every social research activity. However, this list can change over the life cycle of the research project, and in my case, the questions that I prepared for each interview became more detailed and specific as I moved along from one respondent to the next and from my first case study to the second. Whilst I made every effort in preparing my main questions and producing a check-list of the topics that I required information about (see appendix B), quite often the discussion during the interview would take on a life of its own, due to unexpected issues that were brought up and probing done on my part that was derived from my interviewee's answers.

The selection of interviews began with those whose contact details were provided in the reports of the cases, which were available on the internet. These formed my main respondents, or 'gatekeepers'. Through them, I was later able to obtain contact details of other individuals that were deemed relevant by my initial respondents, or individuals that were mentioned during the interview. All interviewees were contacted through formal letters and then later on by e-mail.

When I did not obtain any response, I would then contact them by telephone to explain my research project and request an interview.

The use of initial contacts to inform me about further individuals was done in line with ANT's principle of following the actors as they tell the story of the PV installation. For actors as well as non-human actors, my intention was to understand the connections or associations (Latour, 2005: 66) that were formed as a result of installing the solar photovoltaic panels on the roofs of houses in these two projects. Through these interviews, I was able to build up a description of the situations that existed as a result of the different associations that took place. Such an approach allowed me to uncover the 'making' of photovoltaics on buildings and the different circumstances the led to the 'associations' taking place and the formation of a network (Latour, 2003; 2005), and ultimately the resulting design of the PV installation. This formed stage one of the data collection, where I wanted to examine how my respondents viewed the role of the users with respect to the photovoltaic technology. This was analysed from their responses regarding the technology, their views on the residents and their assumptions about the use of PV technology.

An important aspect of my empirical research that needs to be highlighted is that it was based on retrospective case studies (two events that took place in the last five years). Such a research strategy meant a limited scope of interviews and particular persons that I could to speak to. This was mainly due to some of them moving on to different jobs, whilst others did not want to participate in this research. Most of the potential respondents did not want to report on projects that were already completed by the time I was conducting my interviews. As a result, I was only able to interview three individuals among the project managers in the private development project, and only four individuals from the managing team in the social housing project. This meant that I had to limit myself to the interviews I was able to make (see appendix C-I for a detailed list of interviewees). I then sought to triangulate this information with other sources, including documentation material and information from interviews conducted with the residents.

In addition to the in-depth interviews with the project managers for both case studies, stage two of my research concerned the way that users 'de-scripted' or reinterpreted the technology, as they used it in their homes. Hence, I have interviewed at least one person from nine out of the twelve households in the private development, constituting 75% of the total households in that case study. For the social housing block, I initially planned two focus group discussions that were to be held at the local library, which was a five minute walk from the block of flats. The two sessions, one in the morning and a later one in the afternoon, were timed to enable residents with different work shifts to attend. However, only one resident arrived to the morning session. As time constraints on the research schedule meant that I was unable to organise further focus groups, I opted to interview the residents individually. I was, thus, able to speak to at least one person from nine out of the 25 flats connected to the PV panels, which amounted to only 36% of the total residents in that case study (see Appendix C-II). The lower response rate from the social housing block was due to the fact that some of the flats were not occupied at the time the fieldwork too place, in addition to others who did not wish to be interviewed and those who were not available at that time.

As mentioned before, the purpose of conducting these interviews was to explore the interaction between the residents and the photovoltaic system installed in their homes or block of flats. In doing so, I sought to analyse the 'de-scription' processes that shape the use of photovoltaics in the day to day activities of the residents within the context of their homes. I wanted to explore the various meanings that the users gave to the technology and the way they appropriated it into their lives. As such, I was interested not only in how the users domesticated the photovoltaic technology but also how their use of it coincided or contrasted with the intentions and expectations of the project managers.

Moreover, for my research, I have sought to build rapport with the respondents who managed and implemented the projects by providing them with information about my position, the research project, and its general aims and objectives. My interest was to establish relations of trust that would eventually allow me access to the knowledge of the implementation process of PVs. This was crucial, as the respondents described the actions and decisions of other actors and their thoughts and opinions on these processes. In the next section, I will outline the other sources of data that I collected for my research. In section 5, I will explain in detail the techniques that I used in analysing the empirical material collected.

4.4.2 Documentation

According to Yin (2003: 85), documentation should always be the object of data collection plans in case studies. Documentation can include letters, memoranda, agendas, announcements and meeting minutes, as well as other written reports of events relevant to the case being studied. It can also be administrative documents, such as proposals, progress reports, or formal studies or evaluations of the case studies.

In this research, I have sought all appropriate sources of information that could be relevant to my topic, especially reviewing these sources prior to interviews in order to maximise the benefits of the interviews themselves. Hence, for example, I collected the progress reports of the PV DFT scheme from the DTI. These were rich sources of information about the cases, including detailed technical information and also functioned as value texts that represented the meanings and discourses prevalent in the wider PV implementation scheme.

Moreover, I have analysed press releases and articles about the case studies that were published in a widely circulated local newspaper, as well as press releases in professional newsletters. These sources of information gave me insights into how the technology was constructed and represented by the different actors, and how they chose to frame photovoltaics and their subsequent installation. Through my respondents, I was also able to obtain access to emails, memoranda and letters that were circulated throughout the PV implementation for the social housing project. In addition to that, I had access to meeting minutes and progress reports that were produced by the respondents. Other relevant documentation included leaflets that were directed at the tenants, which were designed to promote the PV installation project, as well as a homeowner's information pack that included information about PVs, which my respondents decided were relevant to the end-users.

In collecting data for my case studies, I also used archival records, such as postal code lists, planning documentation and GIS maps. These were mainly to obtain more information about the buildings and home on which the PV systems were installed. For that, I accessed the electoral registry and the postal records service, which are both available online and can be used after paying a fee. Organisation records from actors that I was able to access (after my respondents' permission) included maps of the area where the PV project took place, project budget plans and expenditure records. These records were useful in triangulating the data obtained through other data sources, as well as assisting me in developing a timeline of events. Additionally, I was able to contact the homeowners and tenants for both cases for interviews, whilst maintaining their anonymity throughout the research process.

4.5 Data analysis

In line with the social constructionist approach that underlies the direction of my research, I am also aware that knowledge produced from interviews is the product of the local interaction of the interviewer and the interviewee(s) (Rapley, 2004; Seale, 2004: 202). As such, interviews are not seen as objective sources of information but are rather "by their very nature, social encounters where speakers collaborate in producing retrospective (and prospective) *accounts* or *versions* of their past (or future) actions, experiences, feelings and thoughts" (Rapley, 2004: 16). As Brand explains in the methodology adopted in his research, subscribing to a constructionist tradition accepts the view "that what appears as fact always has interpretive slack that needs to be narrowed in a dialogue between researchers and the people of the setting they study" (Brand, 2005: 35) . In doing so, the researcher does not take at face value the information obtained from interviews, but should triangulate the interview data with the literature and archival material. Accordingly, in analysing my research, I seek to triangulate the information obtained from the project managers with those obtained from the tenants. Similarly, the interview data would be reviewed against evidence from the documentation and literature review. In the next section, I will describe the process followed for transcribing the data, using the Atlas.ti® computer software to assist me with data analysis and interpretation.

4.5.1 Transcribing Interview Data

Most of the interviews conducted for my research were recorded using a digital audio recorder, which produced audio files that could be transcribed using audio player software that can play, edit and organise audio files. For my research, I chose to transcribe all the interviews that were recorded and therefore followed natural transcription processes, generating verbatim accounts that are as close as possible to what was said in the interviews. In transcribing my interview material, my aim was to represent on paper the most accurate account possible of the conversation that took place (Kowal and O'Connell, 2004). Despite those efforts, the researcher will have to be content, or – as McLellan *et al.* (2003: 65) put it – "settle on" the textual form of the data that was produced because it will never fully encompass all that had taken place during an interview. In my transcriptions I have recorded long pauses, facial expressions, and actions such as laughter or sighs.

The level of transcription depends on the level of analysis needed (McLellan *et al.*, 2003; Oliver *et al.*, 2005). As such, because I am interested in exploring my respondents' knowledge, attitudes, values, beliefs and experiences, I transcribed the whole interview. My objective in doing so was to understand how the respondents viewed the photovoltaic technology and what notions or ideas they attached to it. I was also interested in the mechanisms and materials through which the respondents interacted with the technology. In doing so, I sought to understand how these thoughts and processes materialised as relationships and associations (Latour, 2005) and how they were framed and articulated.

Due to the nature of my research, it was important for me to identify the speaker and their significance regarding the PV's installation. As such, my interview transcripts were complemented with background information about the respondent as well as the place and date of the interview. In addition to that, I followed a standardised system of documenting and storing my transcripts. In the following section, I describe the software that I used, and the processes that I adopted in analysing the transcripts and documents in my research.

4.5.2 Computer assisted qualitative data analysis: using Atlas.ti[R]

There are many advantages to using qualitative data analysis (QDA) software. According to Seale (2005), it provides speed in handling large amounts of data, thus giving the researcher more time to focus on the analysis, and it can provide rigour, help in sampling decisions and team research (2005: 189). Whilst not all of the above advantages apply to my research project, I found using Atlas.ti® very useful in handling transcripts files and organising them in an efficient way. It has hence saved me from mechanical tasks needed for the organisation of textual data. Moreover, by using this software, I was able to generate outputs in the form of segments in the text, which corresponded to analytical categories assigned by me. As such, the process of developing codes from the output data became an easier and more organised process.

Additionally, I was able to include explanations of analytical categories and codes that I developed and used, as well as assigning memos to the transcripts, codes and quotations that I highlighted. Moreover, the software was helpful in organising them into families of transcripts, documents and codes, thus making further analysis and theory development a more ordered process. It was in this way that I used Atlas.ti®, appropriating it according to the needs of my theoretical approach and my analysis, whilst avoiding 'losing' my data during the course of my research. In the next sections, I describe the basic procedure followed in the analysis of the data collected.

4.5.3 Analysis and interpretation

There exists a wide range of analytical techniques for qualitative data. These are normally associated with the specific theoretical approaches that are adopted and that guide the collection and analysis of the information gathered (Thomas, 2003). However, a generic analytical approach that I used in order to tackle the process of data analysis in my research is what is described as a general inductive approach (Bryman and Burgess, 1994; Silverman, 2005; Thomas, 2003). This method is useful in linking research objectives as outlined in my research questions to the raw data (Schmidt, 2004; Thomas, 2003) obtained from interview transcripts and documentation. In the following sections, I will describe the basic principles followed in analysing the empirical data gathered on the two case studies in my research.

4.5.3.1 The analysis of semi-structured interviews

According to Schmidt (2004), the choice of analytical techniques for the analysis of semi-structured interviews depends on the research objectives, methodology and the questions used in the interviews. As such, it was important for the analysis to develop a process through which I would be able to summarise the main themes apparent from my raw data (the grounded themes) and linking them to the theoretical background adopted in my research. As Thomas (2003) maintains, data analysis is influenced by both the research objectives set out at the start of the research, understood as the deductive element, and the reading and interpretation of the raw data, the inductive element. The outcome of the research should be the result of both of these processes occurring during the analysis phase. As such, there is a constant "interchange process", which "begins not only when the data are available in a transcribed form, but at the beginning of the data collection – as a kind of interplay between, on the one hand, theoretical considerations in reaction to the literature and theoretical traditions, and on the other hand experience and observation during exploration of the research field" (Schmidt, 2004: 253).

Therefore, my analysis started with a careful and detailed reading of the interview material. During this process, I was guided by the theories developed in STS research and my knowledge and readings on the subject of photovoltaics and renewable energy technologies. As such, I began assigning analytical categories (Schmidt, 2004; Silverman, 2005; Thomas, 2003) or themes (Ryan and Russell-Bernard, 2003) to the text material, in order to bring to the fore the richness of the data and to avoid "neat and fitting quotations" (Schmidt, 2004: 255), whilst overlooking important data that do not apparently fit with the general theories adopted for my study. These analytical categories were later summarised, merged and developed into a guide for coding, and the coding applied to the material being analysed. These codes were consequently informed by my theoretical approach to the study of PV installation and the themes that have emerged in my empirical research.

4.5.3.2 The analysis of documents and literature

Using documents for my research has two main purposes. The first one, as I mentioned earlier, is to be able to verify the information from the interviews. This was specifically my interest in obtaining meeting records, reports and memoranda from the social housing project, for example. For the same reason, I sought government reports, statistical digests, as well as consultation reviews. These, along with newspaper cuttings and stories from news websites, helped in contextualising the arguments that appear from my interviews.

The second purpose was to analyse the underlying meanings and assumption made regarding entities like photovoltaics (their role and advantages), RETs and the DFT scheme from my theoretical perspective. These serve to convey to me the interpretive nature of RETs as it is introduced into buildings' construction and refurbishment programmes. As Atkinson and Coffey (1997: 47) argue, documents are "social facts that construct particular kinds of representations with their own conventions". Therefore, it is important to analyse documents as "methodologically created communicative features" (Wolff, 2004: 288) and not just as basic sources of information (Silverman, 2003). So in this research, I attempt to understand how the actors involved in the implementation projects chose to represent the photovoltaic technology and its users. I also had the same objective when overviewing the reports published on behalf of the DFT scheme, in order to bring out the different ways the trials, homes, buildings and the users were represented in the literature and understood by the actors involved in managing the scheme. This objective is at the same time informed by my theoretical position when thinking about who speaks for the actors, and in what way do they represent them.

Considering those two points, I treated the data from documents in terms of the information that it contained and also the story that it told. For the purpose of my research, I therefore analysed two documents: the PV DFT *Good Practice Guides* (in two parts) produced by the building research establishment and published by the DTI, and the final technical report prepared by the PV DFT consortium. As with the interview data, copies of the reports were scanned and reformatted so as to be able to upload them onto Atlas.ti®. Whilst some of the original formatting was lost, I maintained the structure of the published report for analysis and interpretation. I also used the software to analyse letters, emails and meeting minutes that were provided by the managers of the social housing project.

4.6 Conclusions

In this chapter, I reviewed the design of the research strategy used in my study. This design, based on the use of qualitative methods within a case study strategy, was based on theoretical approach adopted in my research, namely the co-construction or configuration of users and technology during the implementation of RETs. Accordingly, in designing this research my goal was to explore two points. First, how the project managers construct images of the projected users and in doing so seek to configure users into specific roles. Second, how the users interact with the technology and reinterpret it in their own use contexts. In doing so, I have built on the theoretical framework presented in chapter three and the knowledge I acquired about the implementation of RETs in England to develop a research strategy that allows me to address the research questions. Aligning the theoretical approaches behind my research questions was imperative in developing the direction of my data collection and analysis.

In the next chapters, I will present the empirical research collected in the last two years. In these chapters I explore the processes of implementing the photovoltaic technology in the two case studies discussed earlier. In my description, I intend to illustrate the multiplicity of actors involved in the projects, and the processes by which they build their associations with the technology and among themselves.

CHAPTER FIVE

Renewables in Action: Installing Photovoltaics in the UK

"To describe, to be attentive to the concrete states of affairs, to find the uniquely adequate account of a given situation, I myself have always found this incredibly demanding" (Latour, 2005: 144).

5.1 Introduction

The first part of this thesis presented the rationale, theory and methodology of my research. In this chapter, I present the empirical data collected during the course of my studies. I have thought carefully about the presentation of my thesis, aware of two issues. Firstly, my interest of portraying the two case studies in a thorough manner and secondly, to write with a style and method that would be in keeping with the agnostic and naturalistic principles adopted in my research. In other words, I intend from my writing to reflect and extend the theory and methodology of my research.

I have thus decided to only describe in this chapter the two case studies as well as some background information about the photovoltaic Domestic Field Trial (DFT). Along with Brand (2005: 35), I wanted to "avoid colonizing the readers' perceptions" at this stage of presenting the study. My own analysis and interpretation of the data is presented in the two following chapters.

5.2 Photovoltaics in England: the Photovoltaic Domestic Field Trial

5.2.1 A background note

The UK Photovoltaic Domestic Field Trial is a renewables development scheme funded by the Department of Trade and Industry's New and Renewable Energy Programme (NREM), with the Building Research Establishment responsible for co-ordinating the project teams involved (DTI, 2006b). According to the BRE (2006a), whilst photovoltaic energy technology has been available for many years, its deployment in the UK is limited. Therefore, the aims of the DFT are to provide more information to the UK's construction industry in the hope of stimulating the market. As such, the scheme involves coordination among the government (through NREM), the PV industry as well as other relevant parties in installing and trialling PV technology in the country and monitoring their performance. The trial is the first wide spread monitoring of PV systems in the domestic sector in the UK. In addition to monitoring the PV's performance, the scheme included collecting information on the design and commissioning of the projects, as well as feedback from the developers and occupants.

The trial has resulted in the installation of 470 PV systems on twenty eight different projects, covering different types of residential buildings. The projects represent a mixture of roof-mounted and roof-integrated PV systems, new-built and retrofit projects, and included a variety of PV module types. The data on the performance of the systems and the knowledge obtained from the projects has been collected and is being disseminated through improved guidelines for designing PV systems, as well as the publication of good practice guidelines.

5.2.2 Understanding PV installations

According to the DFT (DTI, 2006b), lessons learned from the PV installations were analysed and produced in the Good Practice Guides published by the BRE. These lessons centred on three main themes: communication, design/location and good practice. Communication involves the effective communication of the contractual agreements between the various actors involved in a PV installation project. This was seen as especially important for the construction industry, where poor communication resulted in extra costs being incurred on the installation budgets.

Knowledge and information on systems operation such as wiring, balance of system (BOS) components and siting was perceived as insufficient. Accordingly, it was concluded that training project personnel and informing tenants is necessary for the effective installation and operation of the systems. According to the *Good Practice Guide: Part I*, "residents will also need information on the operation of their system to ensure that they at least know the basics of the operating principles" (BRE, 2006a: 8). This was important to ensure the correct operation of the technology and make it acceptable to the householders. Good practice was another important theme which involves a thorough and orderly installation of roofing structures, wiring, and cabling. It is believed that a clean and presentable installation would improve users' perception of the technology. Furthermore, providing documentation was seen as essential for ensuring the correct use of the system in homes, especially regarding issues concerning safety (BRE, 2006a).

Results from the post occupation survey (BRE, 2005) conducted by the BRE found that acceptance among end users was high, however, an understanding of how the PV systems work was found to be lacking. This was especially highlighted with respect to daily routines involving energy consumption, the reduction of electricity costs and maximising the environmental credentials of the systems. It was therefore recommended that better user involvement and effective information provision is necessary in order to help householders understand the technology and its operation.

Among the projects funded through the scheme, my research has looked into two examples that took place in the north of England. As mentioned in chapter four, the two cases are exemplary as they involve different types of PV technology, different buildings, clients and construction characteristics. This makes the choice of cases useful in designing an effective sampling strategy, and also reflects the aspects that the scheme considered significant in identifying and addressing barriers to PV deployment in the UK (DTI, 2006b). In the subsequent sections, I will present in detail the two case studies. In particular, I will describe the actors involved in each case and the different actions taken that culminated in the installation and commissioning of the PV system.

5.3 The case of the social housing block

The photovoltaic project in the social housing block was managed mainly through the local authority. The local authority in the city prides itself in having been one of the first to adopt the Local Agenda 21 charter and in being one of the few local authorities that has a department with a specific energy remit. Central government has emphasised the local authorities' role as community leaders with respect to energy and the importance of local and regional approaches to climate change policy and sustainable development (DTI, 2003: 116). In this respect, local councils were perceived as key in ensuring local projects and development plans include elements to tackle climate change.

With energy consumption for the domestic sector on the increase, it has become increasingly necessary to achieve energy efficiency in homes, reducing the reliance on more electricity use and better heating insulation. One of the ways for local authorities to promote energy efficiency and renewable energy in the domestic sector is to include them as part of refurbishment projects on the council housing stock (BRE, 2006). As such, the local council in this case study embarked on a project for installing photovoltaic panels on a block of social housing that was already undergoing roof refurbishment and insulation. Funding was obtained through the PV DFT for installing twenty five photovoltaic panels to benefit twenty five flats in a three-storey block. The funding provided approximately £250,000 to cover the various costs associated with purchasing, designing and installing the photovoltaic system, whilst the local authority provided the services and personnel in kind. The project amounted to the installation of 38.25 kWp (Munzinger *et al.*, 2006), making it one of the largest PV installations in the North. The modules consisted of 25 roof-integrated PV systems mounted on three different sides of the roof structure, as shown in figure 5.1.

Figure 5.1 The social housing project during PV installation

Source: Housing Association (social housing project)

5.3.1 The actors

Several parties were involved in the project, typical of similar projects funded by the DTI as part of the trial. For this case, the main players included the client being the local authority through its energy and housing departments, as well as the installers and energy consultants. Moreover, the project involved the housing organisation that managed the refurbishment and the day to day running of the houses. In the sections below, I will describe the actors involved and their responsibility in the project. This description is brief and is intended to give a background to the actions taken, which I will detail in a later section, for installing the photovoltaics on the social housing block.

5.3.1.1 The local authority

As mentioned before, the local authority in the city is one example of many local authorities that have developed their own environmental initiatives and plans for addressing climate change. In fact, the Council has pledged to reduce its impact on the climate and extended the responsibilities of its energy department – which was established in the 1980s to control and reduce the city's energy bill – to improve on energy efficiency, reduce electricity consumption in commercial and domestic buildings, and increase the deployment of renewable energy. Through this action plan, the city's energy strategy aims to involve other local and non-governmental bodies to achieve the above goals as well as tackling fuel poverty and promoting energy awareness in the city. These goals were outlined clearly in the local Council's Energy Strategy and according to the Energy Officer at the department:

> "There are a lot of different things going on…and because energy and related matters are taking a higher profile; we have developed the new energy strategy which we are hoping to get approved by the cabinet" (Energy Officer; January 2006).

Among the many goals of the energy strategy was increasing the deployment of renewable energy sources in an effort to reduce carbon emissions and provide green energy solutions to various city developments. As such, the plan for installing the photovoltaic panels on the block of flats was overseen directly by the Energy Officer interviewed. However, other actors were involved in the PV project, since the terms of the references for the PV DFT requires the involvement of consultants, PV installers and other related parties such as the local distribution network.

Due to the nature of the projects within the DFT, proposals for applying for funding through the scheme were to be prepared by the client (in this case the local Council), an energy consulting company and a PV installer. According to the Energy Officer, the energy consultancy approached the local authority with the idea of obtaining a grant to carry out the PV installation. The consultant then prepared a general proposal for installing twenty five roof-integrated PV panels on council housing. Subsequently, both the local authority and the consultant chose a site for the project. After that was chosen, the initial proposal, which included the expected benefits of the project for that particular site, the technical work that is needed, and the amount of funding needed to carry out the work was finished.

The involvement of the energy consultant in the project was therefore central to the development and plan of the installation project. It can be said from interviews carried out, that it was the energy consultants who promoted the DFT scheme to local authorities in general; and for this local council, it was certainly the case. In the following section, I will describe the consultants and installers, who according to the Energy Officer were nominated by the funding scheme to manage the projects.

5.3.1.2 The energy consultants and the PV installers

The consultants' main responsibility was managing the contract that was signed by all parties with the DTI. In other words, they act as a liaison between the client and the government department. Thus, their involvement is to ensure that the requirements of the DTI be met by the consortium of companies undertaking the installation project. Their role was both managerial and technical, as they were also involved in the specifications regarding the panels, the capacity installed and the coordination work that this requires. As the Housing Association Officer described it, "the consultants did the technical work; they managed the technical side of things" (May, 2006).

More than being responsible for the technical side of things, the consultants were a very important link in the network of stakeholders for the PV field trial. Like many other consultancy companies for energy and sustainable development, their involvement with the DTI was crucial in terms of lending expertise that would benefit local authorities and private investors, especially given that the technology was new. Indeed, the design and building departments, as well as the housing association, at the local authority, found themselves in situations during this project that they have never encountered before. Hence, the work of the consultant in the process of managing the contract was in guiding the client and other interested parties towards best practice for the installation of solar photovoltaics.

The installers were assigned to the project from the start. In addition to providing the panels and the engineers to fit them onto the roof, they were also involved in the planning stages of the project, making sure that all the technical requirements for the roof and the electrical wiring were available. Because the work was to be contracted out to the installers, several delays were inevitable. These were mainly due to making sure that health and safety measures were implemented during the building work on the site and getting the installer company on the list of contractors approved by the City Council. According to the Principal Investment Officer at the Housing Association, these bureaucratic processes slowed down the project but they were also necessary as – in his opinion – the private sector needed to learn about the methods of work at local authorities. I will discuss this aspect of the private sector and local authority translation in the next chapter, as I restrict myself to only describing the associations of the relevant actors in this chapter.

5.3.1.3 The Housing Association

Social housing in the City Council is managed by an arms length management organisation. In fact, it was during the planning stages of the project that the management of the housing department was taken over by the Housing Association. However, that did not alter the nature of the relationship between the energy department and what was previously the housing department, now an independent entity. As such, a partnership developed between the energy department and the Housing Association in order to complete the work, with the ownership of the project being negotiated in the process. Whilst the Energy Officer described the Housing Association's role as "in the background" (Energy

Officer; January, 2006), the Housing Association perceived themselves as "managing the contract". In effect, the energy department had to work *with* the Housing Association in order to gain access to the building, encompassing the flats and the residents. Accordingly, the responsibilities and roles were defined from the start. Whilst the energy department managed the project as a whole, the Housing Association acted as a liaison between them and the residents of the twenty five flats. According to the Housing Association Officer, their role was:

> "Insuring that the contract goes well [but] not necessarily in a technical way because the way it works is that the tenants are [on one side] and then [we] are [in between] the tenants and the contractors" (May, 2006).

By separating themselves from the "technical" side of the project, which involved the PV installation and the required building works; the Housing Association took responsibility for the "management" side of things (Housing Association Officer; May, 2006). As such they felt that they were the guardians of the building. Any alteration to its form, which might be necessary for the installation to succeed, was to be sanctioned through them. In that sense, the Housing Association was monitoring the contract in its own right. I interviewed the Housing Officer who took part in managing the project, who liaised between the residents and the other actors involved in the installation. According to her, the association had a role to play with respect to monitoring the contract, and accordingly they were "the interface between the contractor and the tenants" on the one hand, and also the clients of the project given that they were responsible for the building on which the panels were installed. As the Principal Investment Officer at the Housing Association noted to me during the interview:

> "They (the other actors) weren't properly geared up to understand the technical problems involved in running a contract in somebody else's building. They no doubt in the end appreciated that it is not [their] building; [they] have to work through whatever [we] are doing" (Principal Investment Officer; June, 2006).

The nature of the project site meant that many actors had to coordinate their work in order to finish the installation and the related construction work on schedule and within budget. This set-up increased the complexity of the organisational nature of the project, resulting in delays and other bureaucratic measures that became necessary. The nature of the projects within the trial, where the purpose is that clients and local authorities 'learn' about the installation and operation of the technology, meant that a lot of time was spent on trying to accommodate new practices into the normal workings of housing refurbishment projects that the Housing Association normally undertakes. As a result, there were many meetings to coordinate decisions before any work could start, "just to try to get the thing working and trying to understand what it was because it was not all that clear" (Principal Investment Officer; June 2006).

In addition to trying to monitor the project, the Housing Association was "left with the practical things", as the Housing Manager put it (Housing Manager; May, 2006). As such, they were responsible for insuring the panels, providing the space for the construction materials and the use of the car parking site. However, it remains that the principal role of the Housing Association was acting as the interface between the project managers on the one hand and the residents on the other hand.

5.3.1.4 The residents

The proposal upon which the funding for the project was granted stated that the tenants of the twenty five flats concerned were "low-income adults [who would] benefit from solar power, raising their self-esteem and reducing their energy bills" (Project Proposal, 2001). The reality is that due to the nature of the flats and the area, the turnover of flat tenancy was fairly high, and whilst the flats were indeed occupied during the installation period of the project which started in April 2004 (see figure 4.1), most the tenants had moved out by the time the fieldwork for my research was conducted in the summer of 2007.

However, from the information that I gathered through the documents and the interviews, I was able to get some information about their role in the project. It appeared that the residents had a limited presence in the planning and implementation of the project. When I was analysing the meeting minutes, emails and memos of the project, the residents were only mentioned twice. In both cases it concerned having the residents informed through letters about the project and keeping them up-to-date with the installation date and building works. In fact, it was necessary to keep the tenants informed as this was one of the requirements of the DTI contract, and for obtaining funding from central government. The second concern was the expected disturbance due to building work, which was mainly on the roof, and security concerns regarding the scaffolding structure. It was, according to the Energy Officer, necessary to keep the disturbance under control so as to avoid complaints. His previous experience with residents complaining about site disturbances during construction, m eant that he took great care in avoiding any such occurrences as they can delay the work and lead to extra costs. Therefore, as far as the project managers were concerned, the tenants had to be informed, but nothing beyond that was thought of as necessary. The decisions taken by the managers with respect to the residents reflected a passive position on their part towards the residents' engagement with the project. In other words, they felt that if the residents wanted to know more and to be more involved, then they (the residents) would make contact. As the Principal Investment Officer commented when I asked him about the residents, "we did talk about them (the tenants) and felt that beyond telling them what's going on; we left it up to them. In a sense that if they were interested, we would have told them" However, he then contemplated his answer and added "I suppose that was a mistake, as they tend not to be interested" (Principal Investment Officer; June, 2006). This later sentiment was shared by the other actors involved in the installation. For them, the lack of interest on the part of the residents was apparent to the project managers. I will be discussing this in more detail in the next chapter; however, I will in here describe the project managers' communication with the residents.

The mechanisms through which the tenants were informed consisted of letters from the Housing Association sent to the tenants throughout the project, indicating to them the different stages of the work. The initial letters promised a full consultation with the residents if the project was to go ahead. That took place as an afternoon meeting at a community centre, and was attended by the Energy Officer, as well as officers and area managers from the Housing Association. The meeting consisted of a presentation by the Energy Officer and time for the residents to ask questions and voice any concerns. According to the Energy Officer:

> "The presentation was about keeping them informed, telling them about security, and obviously one of my big concerns was vandalism. I was keen to tell them that we're going to have security for 24 hours so it was more practical reasons as much as anything, but less technical reasons, and the principles and the ideas and climate change" (Energy officer, January, 2006).

As this quote illustrates, there were three main concerns regarding the residents. There was a pre-occupation with the practical concerns regarding the project, and as a result, most of the communication with the residents involved making sure safety and security measures were in place and that nuisance was minimal. The second concern related to vandalism, which reflected an experience the DFT had with an earlier project in a similar socioeconomic area. Information about climate change and RETs, however, was kept to a minimum and was presented briefly and in a simplified manner, because the project managers felt that it was too technical for the residents to understand. As the Energy Officer added:

> "We explained a little bit of the background to climate change, we didn't want to go too much into that and we didn't want to make it too technical, but we wanted to keep them informed because, it may sound trivial to you, but once you start getting complaints it can cause major headache with trying to get work done" (Energy officer, January, 2006).

According to the project managers, only two or three residents attended the consultation event. During my interviews with the residents, I asked those who were living in the block during the project installation whether they knew about and attended the consultation event. Most of them knew about it, however, they did not attend because they felt it to be a waste of time. According to some, as they had no objections to the installation taking place, they did not see any benefit in attending or taking part in the event. Others told me that they had evening jobs and child care matters, which prevented them from going. They did not, however, feel the need to contact anyone from the Housing Association as they too did not see a role for themselves in the project.

The project managers, on the other hand, assumed that the tenants would be naturally interested "and pleased" (Housing Association Officer; May, 2006) because the installation would benefit them financially through lower electricity bills. The reasoning used to explain their lack of involvement was that they are young and single. In the experience of the Housing Association, they weren't surprised with the lack of attendance at the consultation event, because (in her opinion) this demographic were generally passive about housing refurbishments or other housing-related projects that take place in the area.

5.3.2 Actions taken

In the sections above, I have attempted to describe the groups of actors involved in installing the PV panels in the social housing block. In doing so, I have sought to clarify the roles and responsibilities that were assigned to each of them as the installation project developed. As the description above shows, the project mangers defined a role for the residents through actions they took as they planned the installation project. I will be highlighting this point further in the next chapter, as it illustrates how the actions taken by actors in a network shape the technology and create a script (Akrich and Latour, 1992) that influences the interaction between the users (the residents) and the technology (the PV panels on their roof).

5.3.2.1 Locating PVs on the council estate

Choosing a site for the installation was not a straightforward decision. Originally, the project involved a different site which consisted of twenty five individual council houses described as "non-traditional Dutch bungalows" that had a significantly low energy efficiency performance and were seen as difficult to rent. It was also stated in the planning proposal that the homes had been inefficient regarding their heating and that residents had suffered from high utility bills. Later on, the flats were refurbished and loft-insulated. Regarding the location, the houses were ideal as they were south-facing. However, the new roofs rendered the buildings unsuitable for the panels to be installed on and it would have meant an extra cost of 35,000 GBP for the project. The plan, consequently, was rejected on those grounds by the housing department at the City Council[9]. It was decided that this location would not be feasible and that, in any case, the extra costs were not

[9] At the start of the project, the social housing at the City Council was still managed by the local authority.

available (letter to Energy Officer; 20/March/2002). As a result, the plan for the site was abandoned and another location – where the installation took place – was chosen.

Other factors also influenced the choice of building, which resulted in the final conception and design of the PV installation. The location of the site was to be in a neighbourhood on the west side of the city with low-income households. That decision was strategic in order to increase the chances of obtaining the grant from the DTI. As the Energy Officer argued, it was a "thing about all kinds of grants from the government. You have got a better chance of getting a grant if it is in a [low-income] area"[10].

Moreover, the ideal building for monitoring purposes was to be a block of flats, or houses that were laid out in close proximity to each other. Because the electricity generation from the PV panels had to be monitored for two years, the systems in each flat were linked together by means of a data cable and monitored via a computer linked by modem to the installer's offices, where the data was downloaded on a daily basis. Connecting houses that were scattered across the area, as such, was deemed too expensive. As the Energy Officer explained:

> "Cables would have to be put linking the buildings up, which meant digging roads or putting the cables over head. So we eventually came up with the idea to put the PV on one roof" (Energy Officer; January 2006).

Furthermore, the separate bungalows meant it was difficult for the Housing Association to manage the site. The Principal Investment Officer felt that it would be far easier to manage if the installation was in one structure. As he described it, the Council "came up with some bungalows and houses which they wanted to use, but which would have been incredibly inconvenient because they wanted to set up a system which had wires between houses and across roads and things like that so it was really difficult" (Principal Investment Officer; June, 2006).

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[10] The area was chosen based on the multiple deprivation index (MDI). Through out my interview with the Energy Officer, he referred to the area as "low MDI". He did not personally endorse the definition, but added that it was based on "people's income, their education and the type of work they do".

Eventually, a decision was made to install the twenty five PV panels on a block of flats, and these were linked to only twenty five flats within that block. Due to the lay out of the building, the majority of the panels were south facing, with some southeast and southwest facing. Letters were sent to all the residents as they were affected by the project, and it was pointed out to them that not all the flats will be benefiting from the scheme. Additional letters were sent to the flats that were connected, explaining possible savings they would observe in their energy bills once the PV system is commissioned.

5.3.2.2 The roof, the panels and expected vandalism

During the course of the planning stage of the project, the issue of the roofing structure brought about various challenges to the managers. The initial concern was the ability of the roof structure to carry the weight of the panels, and though that was not a problem *per se*, the initial inspection carried out by the engineers at the City Council found that the solar panels were lighter in weight than the roof tiles, and as the panels were to be roof-integrated thereby replacing some of the roof tiles, there was a concern with the risk of wind uplift. As the Energy Officer explained, the "structural engineers were not sure [about the roof]. There were originally clay tiles on the roof and the engineers were worried about wind lift and problems about the structure ... and decided to put two blackboards underneath the framework for the panels, so there were a lot of extra costs involved. It was expensive to start with, and that made it even more expensive at the end of the day".

Moreover, the installation prompted the strengthening of the roof timber structure, and installing a waterproofing membrane, as well as engineering vents to avoid the overheating of the PV panels. All this added to the costs of the project, which were not covered by the original grant obtained from the DTI. This led to the need for engineers from the local Council to inspect the roof, and design the required solutions to the problem. It meant more delays in the schedule and more challenges with respect to dealing with a new technology. Whilst the local authority accepted that it might have invested too much in strengthening the installation and modifying the roof, the general view was the need "to err on the safe side" (Energy Officer; January 2006). In fact, the inexperience of the local authority with solar panels meant that more risk assessments were made. and all possible measures to prevent them were taken.

The work on the roof – combined with the work of installing the panels – involved putting up scaffolding around the building block. That in turn meant the need to employ 24 hour security to ensure the safety of tenants and equipment. In fact, providing security was prioritised and every effort was made to avoid vandalism. That was also mentioned in the project proposal, which stated that "to reduce the risk of vandalism, given the social nature and the location of the housing, efforts will be made during the design phase to minimise risk". This aspect could not be further emphasised by the local authority. As the Energy Officer said, "the installation went well, the monitoring went well, and I was worried about vandalism, but we haven't got any vandalism" (Energy Officer; January 2006).

The concern with vandalism was the result of reported experiences in a similar project in Belfast (in a low-income area) that had been vandalised. As such, security issues took a lot of time and planning, as observed from the general management of the project (social housing project meeting minutes; 20/03/2003). The PV installer required the provision of safe storage on site for the panels during the installation phase, which brought in further costs. Whist these measures are typical of construction sites, the retrofit nature of the installation made it more expensive for the project as a whole, as well as making it more difficult to manage on the ground.

5.3.2.3 Installing the meters and display monitors

Another difficulty foreseen in the installation was the need to gain access to individual flats in order to install the required meters and the display monitors. According to the Good Practice Guide (BRE, 2006a), the location of the inverters, switches, and other components should be considered in such a way as to minimise the need to access individual homes in case of retrofit projects. As such, it was deemed a suitable solution to complete all the connections in the meter cupboard in the hallway on the ground floor of the building, as this presented a time and cost saving solution. The need to access the flats was avoided early on in designing the installation project under study. A decision was made to install the necessary components outside individual flats so as not to disturb the residents, and as a result, the inverters were fitted in the cupboard along with the electricity meters.

Furthermore, the display monitors were also mounted on the wall in the hallway, although these were individual display panels that are meant to show residents the amount of electricity the photovoltaic panel is generating. This meant that the residents have minimal interaction with the photovoltaics on their roof and are not provided with a tool that could actually help them in visualising the function of solar panels, as shown in figure 5.2. In fact, the display monitors were mounted on the wall, and enclosed in a glass box making it impossible to touch them. Even though the monitor was designed to be interactive – with a button to press that shows instantaneous power generated and total power generated from the panel – the location in the hallway and inside the protective box went against its purpose.

Figure 5.2 Display monitors encased in social housing project

Source: author

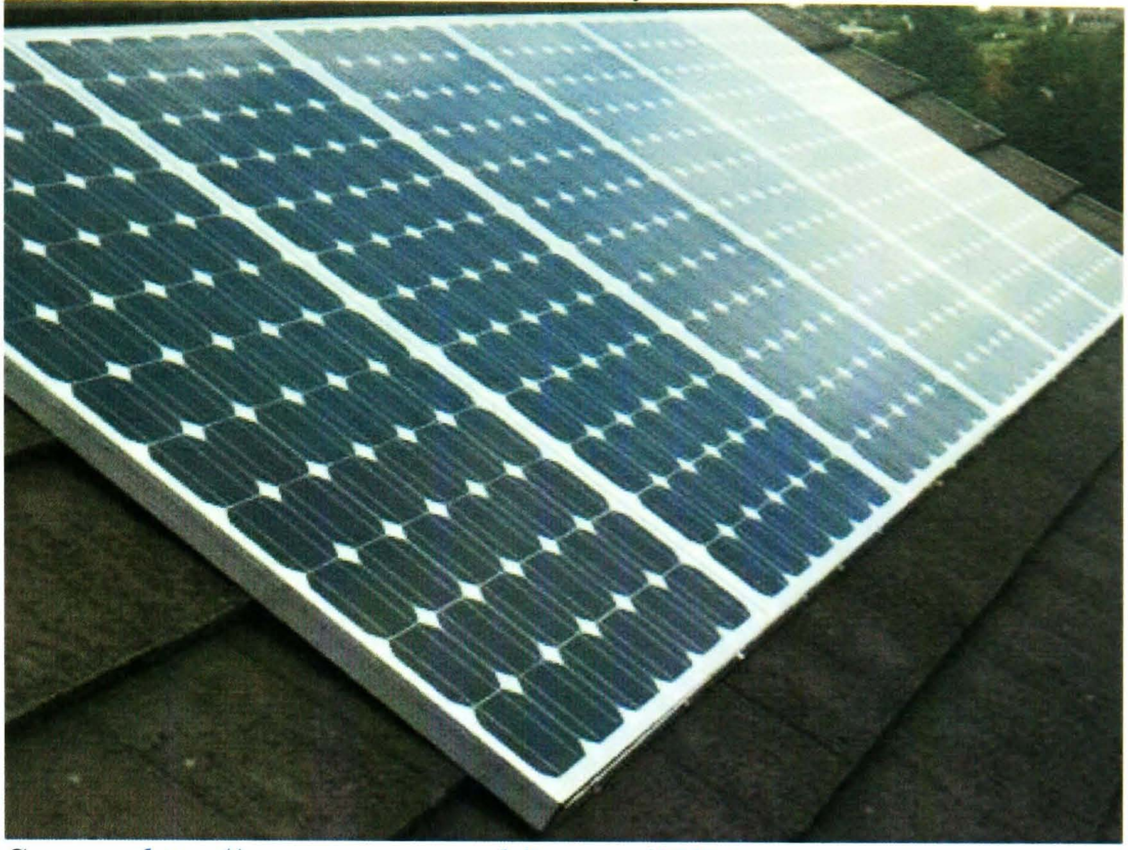
I should mention here that the location of the display monitor is treated in this thesis as a system design decision. Though initially it was not something I intended to study, the matter concerning its location arose whilst conducting the interviews for both cases studies. I will be discussing the issue of the display monitor (its design and location) in more detail in the following chapters, due to it being the interface between the photovoltaic technology and its end-users. the residents. In the next section, I will describe the roles of the actors involved in the private development case study. As I have presented earlier, I will also describe the various actions taken in planning, designing and installing twelve PV systems in a private housing development.

5.4 The case of the private development

The private development project was one of the few private sector developments to benefit from the DFT scheme. It is a large suburban mixed-use development in Northern England, which was led by two well known property developers and involved the construction of 2,500 houses on a green field site approximately four miles away from the city centre. The development is on green belt land and as such is a desirable location. The development is to be completed through several phases over a period of ten years to 2018. Alongside the homes, a town centre, leisure facilities, a school and buildings for commercial uses are included in the plans.

The private development project involved the installation of PV systems on twelve individual housing units. As mentioned in chapter four, the project included the trialling of two different types of PV panels, a 'sun-in-a-box' system on two roofs and a tile system on the other ten. The 'sun-in-a-box' system is a retrofit solar PV kit that can be mounted on a roof without the need to dismantle or restructure the roofing. The advantages of this system is that it only takes one day to mount and connect to a building, by fastening the PV modules using roof tile brackets. In appearance, the panels are slightly raised from the surface of the roof and the silver-white backing is visible. Figure 5.3 shows a typical 'sun-in-a-box' PV array mounted on a conventional roof.

Figure 5.3 Example of 'sun-in-a-box' system on roof



Source: http://www.segen.co.uk/images/PV8.jpg

In contrast the PV tile systems are thoroughly integrated into the roof structure. According to the PV installer, the tiles "allow the production of clean and renewable power, without compromising either the appearance or integrity of the roof" (PV installer brochure). It is fixed to the usual tile battening and does not have any visible brackets, as shown in figure 5.4. accordingly, the properties which had a south facing roof exposed to the road had the tile system due to its aesthetic advantages. In total, the installation amounted to 17KWp of installed generation capacity and principally involved the property developers, the energy consultants, the energy engineers, and the installers. In the next section, I will summarize briefly the background and roles of the actors involved in this installation project.

Figure 5.4 Roof-integrated PV tiles in private development

Source: Private development PV installer

5.4.1 The actors

In this section, I will introduce the actors and explain their roles and describe how they became involved with the project. Mainly, these include the housing developers as well as the consultants that were contracted to manage the sustainable energy requirements for the development. However, other actors were also crucial for the design, management and installation of the photovoltaics on the new-build housing. These included the energy engineering consultants who were responsible for designing the systems, the PV installers, the regional development agency that provided some of the funding, as well as the local authority. Moreover, the project managers had to liaise with the utility company that would buy the unused electricity generated by the system, the distribution network operator and the photovoltaic manufacturer. In the following description, I will focus on the main actors that influenced the management and design of the photovoltaic installation under study. These comprise the energy consultants, the designer (the engineering consultants contracted to design the PV system), the PV installers as well as the residents of the twelve housing units onto which the PV systems were installed.

5.4.1.1 The developers

The developers were a partnership between two large building companies in the UK. The first company has over three decades of experience in home building, whilst the other company – which had traditionally been involved in large construction projects and office buildings – had since 2004 been involved in the housing development industry and mixed-use developments. According to the first company's promotional leaflets, it has "the largest land bank in the UK house building industry, at over 80,000 plots owned and under control, placing the company in a strong position to deal effectively with the current planning environment" (private development's website, no date).

The planning environment in the city in the late 1990s made it difficult for the developers to have their large-scale and lucrative housing development accepted through the planning process. The intention of the planning regulations in the city was to encourage brown field development close to the city centre, which would regenerate areas and avoid the creation of further traffic that suburban developments might exacerbate. However, the proposed development was not only large, with substantial environmental impacts, but was also located on land allocated as green belt. As a result, a consortium was created involving the local Council and the Commission for Architecture and the Built Environment (CABE) to push forward the development project. This was necessary to ensure that an attractive plan for the site was developed that had the required environmental credentials. As mentioned earlier, the plan for the site was an attractive business proposition and was argued to be a good contribution to the economic growth of the city. This aspect meant the interest of the local authority and, therefore, a joint effort made to ensure the successful application of the project plan. As a result, every effort was made to comply with the requirements for environmental protection adopted by the local authority.

Eventually, permission to start the project was granted on the basis of the inclusion of various types of sustainability measures, including the use of sustainable building materials in construction, contributions to sustainable transport facilities, open space and energy efficiency. In addition, an agreement to build two housing units in a brown field site for every housing unit in the development also attempted to address criticisms that developers are neglecting needed inner-city brown field regeneration. The planning agreement included various requirements for the inclusion of green building measures, one of which was the installation of energy projects. It was this planning requirement that provided the opportunity to install photovoltaic technology and benefit from the government scheme. I will discuss this in more detail in section 5.4.3.

5.4.1.2 The installers and consultants

As mentioned earlier, the idea for taking part in the DFT scheme to fulfil the sustainability requirements came from the Energy Consultant who was contracted to comply with the sustainability requirements included in the development's planning permission. The Consultant was involved in piloting and installing solar water heating systems on two houses in one of the earlier phases of the construction. During the installation of that project, talk began on a different energy project that was needed for the next construction phase of the development plan. At the time, the Department for Trade and Industry had invited proposals for its second phase of the DFT scheme. According to the Energy Consultant, the North region was one of the areas that had benefitted the least from the funding allocations during the first phase of the trial. Moreover, she stated that most of the projects in the scheme involved social housing, and so there was a need to diversify the type of housing that could install this type of energy technology. This situation created an opportunity for developing the proposal on some of the homes in the construction phase that was due. The Consultant was to manage the project, procure the photovoltaic systems and sub-contract the installation work to a local PV installer.

The design of the system was subcontracted by the energy consultants to an international engineering consultancy with extensive experience in photovoltaic system installations, including the domestic sector. The designers were involved in the project from the proposal stage, as their task was to design a system that would maximise private development's chance of obtaining funding from the scheme. Because the design included two different types of photovoltaic systems, the project included two different installers. The priority of the Energy Consultant was to involve local businesses, and hence the two installers were based in the North.

5.4.1.3 The residents

Although the residents did not take part during the planning or installation of the project, they played an important role in many of the decisions that the project managers had to consider regarding the system design and the homes. As the project was new-build, none of the house plans were sold when they were chosen as sites of the PV installation. Moreover, the homeowners did not intentionally choose to be part of the project. In fact, they were not told which houses had photovoltaics on their roofs and were only informed after they had chosen the plot to buy from the site plan. According to the developer, potential buyers did not object to PV panels as they were not paying for the technology and there was no mention of potential buyers rejecting a house because of the PV installation.

The project managers prepared a home information pack for the future homeowners of the properties that included information about the system, how it worked, and a section of frequently asked questions. It also contained the user manuals for the system's components and contact numbers of the engineers and consultants to contact in case anything required maintenance. The energy consultants made home visits when the properties were completed and handed over. The Energy Consultant explained:

> "We went into each house with the handover pack. We spent at least two hours with each homeowner going through the pack and telling them what it consisted of and what the system was all about" (Energy Consultant; March, 2007).

Of the nine residents interviewed, five had purchased their property from the plan before their construction was complete. They chose their property based on its size, layout and the size of the garden and only knew of the photovoltaics on the roofs after they had made their choice. Two other homeowners had bought their property from a previous owner but – whilst the properties were advertised as having the technology – they did not pay more than the usual price for that property, nor were they interested in the property for it having the photovoltaics as such. The other two were renting their homes.

The attitudes of the residents varied from those who were really excited about the system to others who wanted the least level of involvement with it. However, none of them had a say in the design of the system, or the type of photovoltaics that were to be installed on their roofs. They were all aware that they were to take part in a research trial funded by the government, and thus the choice of technology would depend on the research needs that according to them shaped the design of the installation. However, some of the homeowners were asked where they preferred the location of the display monitor to be, and whilst most of them opted for the utility room, three of the nine residents interviewed had the display monitor located in a cupboard (either in the hallway or under the stairs). Table 5.1 lists the location of the display monitor in the nine households interviewed for this research, indicating ownership status and whether they had a choice in the display monitor's location. As I mentioned earlier in my description of the social housing project, the display monitor will be discussed in more detail in later chapters, and in a further section I will discuss briefly the decisions made in the private development regarding the location of the display monitors.

Table 5.1 Display monitor Location and resident choice (private development)

Resident no.	Own/Rent	Location of display monitor (DM)	Choice of DM location
Resident 1	Own	Cupboard in hallway	No
Resident 2	Own	Utility room	Yes
Resident 3	Own	Utility room	Yes
Resident 4	Rent	Utility room	Not applicable*
Resident 5	Own	Staircase cupboard in hallway	Yes
Resident 6	Rent	Utility room	Not applicable*
Resident 7	Own	Cupboard in hallway	Not applicable†
Resident 8	Own	Utility room	Not applicable†
Resident 9	Own	Utility room	No

** Choice of display monitor location does not apply to renters, and the relevant homeowners could not be interviewed. † These two homeowners had bought their property from previous owners, and therefore did not have a choice.*

In general, the residents had positive views about the PV technology. Although they felt that they wouldn't invest in this particular renewable source due to its long payback period, they were quite happy to be part of a trial project, and could see the benefits from the technology in their reduced electricity bills. Most believed that the technology is a good choice for the long term, with increased interest in the environment and stricter regulations for buildings and energy efficiency, but the majority stated in the interviews that they would not voluntarily seek to install photovoltaics because of their price. This aspect, as well as the residents' views and interactions with the photovoltaics, will be discussed in more detail in chapter seven. In the next section, I will describe the various stages of the installation project at the private development.

5.4.2 Actions taken

5.4.2.1 Planning requirements and windows of opportunity

Since the planning agreement required the inclusion of energy efficiency measures on some homes, the energy consultancy was involved and their task was to allocate which sections of the development would include different energy technologies. Dividing the development into several cells, the developers proposed an energy project for each housing development cell. According to the master plan, each cell had to include at least one unit where an energy project is to be implemented. The project had to be exemplary and should showcase possible energy efficiency and RETs that can be incorporated into housing in the UK. According to the master plan, the energy project should be functioning and available for public viewing, and the developers should publicise them. This was the reason developers involved a local energy consultancy, since sustainable measures through energy efficiency and RETs were required from the start. As mentioned earlier, the Energy Consultant's role was ensuring that the buildings on the development site complied with the energy efficiency standards, as well as planning and commissioning the required energy projects, which the developers had to implement as a result of these requirements.

5.4.2.2 Installing photovoltaics: roofs, panels and tiles

As mentioned earlier, the idea of installing photovoltaic systems on some of the houses was prompted by the Energy Consultant. At the time, the DTI had initiated the second stage of their DFT scheme and were accepting project proposals for installation of solar photovoltaics in the housing sector. This led the Consultant to look into solar photovoltaics as a technology choice that would enable the developers to comply with the energy efficiency section of the planning agreement and finance part of the cost involved in the installation through government funding. As a result, the energy engineers were contracted to design a plan for the installation of the twelve photovoltaic systems that were to be installed on the roofs of twelve properties, as part of the second construction phase of the development.

Designing the photovoltaic installation to obtain government funding meant optimising the research aspects of the project whilst maximising the amount of PV generation deployed. As such, the funding proposal highlighted the demonstration of different types of PV panels and their installation on various locations around the development, in order to trial different roof angles and to compare their performance. According to the Engineer Consultant involved in the project, with the budget available it was decided that twelve housing units would be included and their location was chosen based on the roofs' sun exposure aspect (Energy Engineer; March, 2007).

The proposal included two different types of PV technologies and both systems were to be mounted on two clusters of houses of various sizes, ranging from three to five bedroom homes. The purpose was to compare the performance of both systems, which would be situated at different south facing aspects. As such, the roofs selected were mostly south facing, with a few that were slightly southwest facing and others that were slightly southeast facing.

5.4.2.3 Installing the PV systems

The deployment of the photovoltaic system on this development was planned as part of the building programme intended for the site. In other words, the installation of the systems, and the wiring and connections required, was to take place within the normal timetable of the building works. According to the Energy Consultant:

> "There was a very definite work programme that we had to slot into which was because [of] the way they sold the properties. [One] sold the land and the plan of the house to somebody whereas the other developer actually part-built the house and then it was sold so they were built very differently" (Energy Consultant; March 2007).

Therefore, the need to include the installation programme within the building meant that a lot of coordination work was to be agreed on before the installation of the photovoltaics took place. However, that was not the only problem facing the project managers. To complete the installation as part of the trial scheme, a monitoring system had to be installed that connected the photovoltaic panels and the inverter to a modem that would collect the necessary data needed to monitor the system's performance.

According to the Energy Engineer, the problem was with connecting the telephone lines that would link the photovoltaic system to the data collection point at one of the housing units on the site. In fact, it was difficult to schedule the engineering works for the lines with the installation of the systems on the roofs. The Energy Engineer added:

> "The whole thing took a lot longer; it all had to do with communication, in getting the telephone lines in, which was time consuming and had to be coordinated with people outside the project" (Energy Engineer; March, 2007).

Moreover, a further problem with completing the installation of the photovoltaic system was the purchase and installation of the export meters, as well as the energy exporting agreement that the project managers had to agree with energy suppliers. Unlike other European countries, energy suppliers in the UK are not obliged to buy unused electricity generated by photovoltaic systems in buildings and households. As such, the project managers had to negotiate an agreement whereby an energy utility company would buy exported electricity from the twelve houses. A rate was negotiated, and as the Energy Consultant believed, "it was actually quite a good deal but it did require that they stay with [the utility company] as their supplier as well" (Energy Consultant; March, 2007). The problem of access to flats will be discussed in relation to the project managers' decision-making in more detail in chapter six.

The issue of exporting electricity was hindered further by the unavailability of the needed export meters in the UK, which then had to be ordered as a result. Problems with having the right meters and the need to wait until suitable meters were available meant a delay in the commissioning of the photovoltaic systems. Moreover, the problem aggravated the need for the installers and the engineers to access the properties after the building work was completed and the houses were occupied. As a result, there were "problems with access to buildings because the residents have just got fed up with the amount of people who wanted access to their properties" (Energy Consultant; March, 2007).

Whilst this was not the only reason for the various delays, it did add to the project 'obstructions' that the managers had to deal with, as the Energy Engineer commented. The main reasons for the delay in commissioning the PV panels were "more technical requirements" (Energy Consultant; March, 2007). These, as mentioned above, involved exporting electricity to the national grid through export meters connected to the PV system in each household and the monitoring infrastructure that had to be put in place to comply with the DTI's requirement of monitoring and data collection for the next two years.

5.4.2.4 Monitoring photovoltaics, maintaining the systems

Unlike the designers and the installers who were responsible for only the installation phase of the project, the energy consultancy had to maintain and monitor the system for the next two years after the project had been commissioned. Accordingly, the data was collected and sent to the DTI for analyses and research, which would enable more accurate feasibility estimations in the future based on more examples of PV deployment in the UK. In total, the data monitoring process went smoothly, except for one case where the householder had turned off the electricity mains due to a fault in the electrical system. As a result, the inverter was turned off and, for six months, potential energy generated from that PV on this roof was lost.

However, the monitoring process for two years meant that the householders were not allowed to turn their systems off or remove them from their roofs, until the monitoring was decommissioned, after which they would be the sole owners of the photovoltaic panels. Accordingly, the systems were monitored until December 2006 and the last month for which the data was reported to the DTI was July 2006. This information was collected and reported back to the energy consultancy for feedback. It consisted of information regarding the amount of energy generated by the photovoltaic systems at different times during the day and at different climatic conditions. Whilst the Energy Consultant believed that the information was valuable for practice and research, she felt a lack of interest from the developers' side. The developers were no longer involved with the energy project when the houses were sold and when the monitoring was completed. As the Consultant conceded at the end of the interview:

> "The private sector would only do it because it is a requirement. They weren't necessarily interested in the technology itself but they had to do it because it was required" (Energy Consultant; March, 2007)

However, the lack of interest after the completion of the project did not mean a 'hands- off' attitude from the developers during the design and installation of the systems. As developers, their main concern was in selling the properties at a good price and they wanted to ensure that the installation did not lower the value of the property or make it unattractive for their target market. As such, the aesthetic aspects of the houses from both the outside and the inside meant constant negotiation with the project managers on the design of the photovoltaic system. This was certainly the case with the display monitors.

5.4.2.5 Locating the display monitor

As mentioned earlier, the issue of the display monitor emerged through interviews with the project managers of both installation projects, especially in the case of the private development. Accordingly, the Energy Consultant's original plans included locating the display monitor in the kitchen as it is one of the most used rooms in a house. The idea behind this choice was that the display monitor should be in a position that is easy to view during the normal, day-to-day routines of householders. Moreover, it was felt that the display monitor had educational benefits and to maximise that, it had to be mounted in a visible fashion, and in an often used area of the home. However, the developers objected to the idea, fearing that such a decision would lower the value of the property and make it difficult to sell. That was their view, even though the Energy Consultant felt that it would not cause an aesthetic problem since the kitchens were modern and the display monitor – mounted on a wall – would not look particularly odd given its modern design (Energy Consultant; March, 2007).

Nonetheless, the developers opted for the display monitors to be located in a cupboard, along with the electricity and export meters. Eventually, the location had to be negotiated between the two parties and a compromise was reached, which was locating the monitor in the utility room – a back area connected to the kitchen that houses appliances such as the washing machine and the tumble dryer. That option also faced resistance from developers who were worried about the financial impacts this would have and wanted the monitor out of sight. Ultimately, an agreement was reached that would leave it to the homeowners to decide on the location of the monitor in their homes.

In field visits to the twelve households, I found that only four households had the display monitor inside a cupboard in the hallway. Most of the homeowners who bought the property from the developers could not easily recall the details over the location of the display monitor, with only one resident stating that they chose the utility room rather than the hallway because she did not know what the monitor looked like and feared "a large box with buttons, wires and switches" (resident 2, private development). During my interviews with the residents, I noticed that they would refer to the display monitor when asked about the photovoltaic system. In a way, the monitor represented the PV panels inside the house.

5.5 A summary and some remarks

My intention from this description was to highlight the negotiated nature of the PV system design, which not only involved the installation of panels on roofs and the necessary electrical connections. In fact, in this research I argue that designing PV systems continues through to their implementation phases. As the above examples have shown, there are many contingencies that are the result of the coming together of different actors with varying objectives, understandings and views regarding the photovoltaic technology. This is apparent in the case of the display monitor in the private development project, and also in the decision to mount the display monitors in the building hallway in the case of the social housing block.

Another example is the decision regarding the choice of the buildings. As such, priorities, budgets and regulations amongst a myriad of factors, influenced the choice of the building and – as the case in the private development shows – the type of the PV panel used. The experience of the Housing Association personnel in the social housing project, the priorities of the private developers, and the budget provided through the DFT scheme meant different designs for the PV system installed on the two different types of buildings. As I argued in chapter three, the design of the technology is both shaped by and can shape the society in which it is implemented. Moreover, a lot can be said about the users of a technology and the way a technology is used by looking at how it is designed and adopted. I will be discussing these issues in the next two chapters. In chapter six, I will be presenting the 'design logic' that shaped the installation of the PV panels in the two case studies. I will follow that by describing the ensuing 'use logic' and what it means to the implementation of microgeneration technologies in chapter seven.

CHAPTER SIX

Installing Photovoltaics: the Managers' Perspectives

> *"It is not just the identity of the user which is constructed. For along with the negotiations over who the user might be, comes a set of design activities which attempt to define and delimit the user's possible actions"* (Woolgar, 1991a: 61).

6.1 Introduction

Having described the two case studies that constitute the empirical work in my research, in this chapter my aim is to illustrate how the various mechanisms shaped the design and installation of the solar photovoltaic systems in the two projects. In this chapter, I discuss how the actor-networks were shaped around both implementation projects. With my focus on users, I argue that the project managers, being the designers of the PV installations, configured the users and the technology. This configuration work (Woolgar, 1991a), or the script as Akrich (1992) describes it, is based on the project managers' expectations regarding their users (Summerton, 2004). Hence, my analysis also focuses on how the project managers constructed the users of the PVs. I argue that the constructed images of the users (Akrich, 1995) contributed to the shaping of the PV installations, and as a result configured the users' relationship with the technology.

Following Grint and Woolgar's (1997) call to explore the metaphor of the machine as text, my chapter attempts an understanding of whether photovoltaics during their deployment were being 'written', and if so, how. In other words, I intend to explore the actor-networks surrounding the installation of PVs in the two projects to show how they led to the implementation designs in these cases. As Jelsma (2006a: 66) states, "things are not what they are but what they become by fixing them in a network with other actants". Accordingly, in this chapter I explain what became of the installed PV system as the actors began the building of associations. In the next section of the chapter, I focus on the users and on the creation of scripts. I therefore discuss the main user constructions that emerged from my empirical material and show how the user was configured as a result.

6.2 Institutions and the building of associations

For most of the projects funded by the DTI's Photovoltaic (PV) Domestic Field Trial (DFT), different institutions had to collaborate to ensure the su ccessful installation of the photovoltaic technology. The literature produced from the DFT scheme reinforces the 'technical' and highly specialised nature of the technology at hand, and consequently stresses the importance of communication between the PV industry who are perceived as the experts, and the clients. Accordingly, the early involvement of the engineers, environmental or energy consultants as well as suppliers and installers was encouraged due to the complexity of the technology. I argue in this section that whilst the experts' interest was in the successful installation and commissioning of the technology itself, the need to coordinate with local authorities, private developers, planners, installers, utility companies and network operators resulted in a negotiated design of the photovoltaic system. Moreover, the different nature of the physical structures onto which the photovoltaic system was installed and the need to monitor its performance as part of the trial, was also significant in influencing the final form of the photovoltaic system and the shape in which the installation took place.

The two examples of PV installation that I present in this thesis reflect the complexity of the network within which the technology and its installation is shaped and negotiated. Project managers are faced with various priorities and practical matters, which limit their capacities to implement the technology as it is ideally required. This raises an important point regarding the way a technology is adopted or implemented. As Callon (1995) argues, whilst conception networks depend on the interplay of different actors during the early phases of a technology's development, they are also crucial for the development of adoption networks in the future. In other words, how the PV technology is implemented today is important because it can affect the design and diffusion of technology in other housing projects in the future. Moreover, adoption networks are more complex than conception networks due to the considerable increase in the number of actors involved (Rohracher, 2003: 182). The complexity of analysing implementation projects makes it necessary to indicate the structural level at which to study this process. For this research, the focus is on the micro-level dynamics that take place during the implementation of PVs and how they shape the technology, and are equally shaped by it.

6.2.1 Enrolling buildings, roofs and other actors

In the two empirical cases presented earlier, several actors were enrolled into the network for the purpose of ensuring the effective translation of this renewable energy choice. As mentioned in chapter five, the installation at the social housing block began with the environment consultant and the supplier approaching local authorities with potential bids for photovoltaic installation projects that could be funded by the government. Therefore, the consultants and supplier firms had to 'translate' the photovoltaic technology into a viable building refurbishment project with green credentials, complete with a design plan, a PV supplier and funding. The benefits of implementing such a project for the City Council were in strengthening its environmental performance and gaining publicity as they deploy RETs in the city. According to the Housing Association Officer, the installation was an opportunity to create a positive exposure for the local authority, especially the housing management organisation.

> "You could say that it brought [us] a lot of positive publicity, and it still does. So whenever anyone [visits], whether they're new starters or students or part of our board, we *always* take them to the project and say "look what we've made". That's not what it is really, but for that reason alone it is beneficial. I also think that as an organisation, we are trying to portray ourselves as interested in renewables and interested in energy efficiency. I think that because it is so expensive, it is much sexier than putting in cavity insulation" (Housing Association Officer; May, 2006).

The publicity element was always present in the case of the social housing installation. In fact, some of the managers involved in the project felt that political agendas had strongly contributed to developments which led the City Council to adopt the proposal. One of the respondents was eager to point out the "new liberal politics which are very keen to do new projects" (Energy Officer; January 2006), in reference to the control of a political party on the City Council and the impact this had on its environmental policy. Moreover, the interest in media attention took precedence over other matters such as budget requirements and the ability of the local authority (which was the sole client at the time of the proposal) to commit personnel time. This, as one of my respondents put it, led to the local Council's quick decision regarding the project. As he stated during our interview;

> "Unfortunately somebody from the Council put out a press statement and put out a picture of some properties that would be done, which was not true because they couldn't be done, and promised some people that it would be happening and it ended up in our city news" (Housing Manager; May, 2006).

In his reply, the Housing Manager referred to the group of houses that were chosen earlier at the planning stage of the project. It thus indicates the immediate interest in gaining publicity, which took place as soon as the project was granted funding from the DFT scheme. In that sense, the project was no longer a trial directed at learning lessons about installations, but a high-profile, "sexier" technology that would make local news and symbolise the City Council's commitment to green issues.

Whilst public relations were an important factor in the enrolment of the City Council, for the private developers in the second case study, it was not as significant. As the project's managers acknowledge, the only reason for the developers' decision was the planning requirement of deploying energy technologies. In that context, the media and promotional aspect was less useful. According to the Energy Engineer who designed the system for the private development, the main objective of housing developers is to build and sell houses as efficiently as possible, with very little room for interest in renewable energy technologies such as photovoltaics. Although the publicity factor of installing photovoltaics remains a strong reason behind many of the large installation projects in the UK (for example, the CIS building in Manchester), it was perceived that a private housing developer will only install such technologies if it was a requirement;

> "A housing developer is not going to be interested in PR because he is just flogging [the houses] on, whereas for large companies it works because they want to demonstrate to the world that they care about the environment so they put PV on their building, whereas the developer is building to sell" (Energy Engineer; March, 2007).

The Engineering Consulant argued that the technology, at the current levels of deployment and in the regulatory context in which it is installed, is not yet economically feasible for mainstream property developers like the clients in the private development project. As such, large scale projects on tall buildings by large insurance companies and international corporations are mainly due to the publicity and the good visible message that photovoltaics can provide for these types of clients.

Indeed, and as I explained in chapter five, the private developer was encouraged to apply for funding through the DFT scheme in order to satisfy planning requirements concerning energy in buildings. The installation was presented to the private developers by the Energy Consultant as an opportunity to include the required energy efficiency and sustainability measures and to satisfy the planning regulations and the local authorities. Therefore, whilst both projects were funded by the same scheme, each consultant consigned a different meaning for the technology in order for it to be accepted by the main actors: the local authority in the case of the social housing and the private developers in the second case. Accordingly, for the social housing, the technology was a modern solution to improved energy performance in council houses and also an opportunity to gain publicity and for the local authority to appear to be implementing their environmental agenda. For the private development project, on the other hand, the installation was a good way to fulfil the environmental requirements that were set out in the project's planning permission. The energy consultants were successful in defining the 'problem' for each client and presenting them with a solution, which was to take part in the DFT scheme.

Having successfully enrolled the main clients of both projects into the DFT scheme, the project managers had to undertake various steps to ensure their application for the grant would be successful. For example, as mentioned earlier, the proposal for the private development included the deployment of two types of photovoltaic technology: a roof mounted 'sun-in-a-box' system designed by BP Solar and roof-integrated Redland PV700 tiles that were installed on the other ten roofs. Moreover, the choice of the buildings was made such that different variations of the south facing aspect would be achieved. By ensuring the testing and trialling of different PV system designs, the project managers successfully enrolled the government in their application for project funding. According to the Energy Engineer;

> "To actually put in a proposal by the government to get a grant and you were showing that you were doing something whereby you compare between two systems [then] you get a better chance at getting the grant. Whereas, if you had all the houses on the same system; maybe you would be less likely to get the grant" (Energy Engineer; March, 2007).

Similarly, the social housing project team chose to install the photovoltaic technology on refurbished residential buildings on a council estate. By choosing an area with a high Multiple Deprivation Index, the local authority was more likely to obtain the needed financial support for the installation. In doing so, the project managers were able to argue the case for increased social development in such areas and the potential contribution that photovoltaic technology could make with respect to reduced energy bills and fuel poverty reduction. As my respondent stressed:

> "Now, that's another thing about all kinds of grants from the government. You've got a better chance of getting a grant if it is in an area like that. Now, I don't want to get into people's personal situations and educational backgrounds, but that's what they class it as. You know, and within the MDI, there are all sorts of things to take into consideration such as social, economic and educational backgrounds" (Energy Officer; March, 2007)

The above examples show how the funding mechanism shaped the design of the projects in terms of the choice of PV technology as well as the homes on which they are to be installed, as the case of the private development project indicates. As for the social housing project, the local authority's interest in the area was shaped by what is favoured in proposals on the part of central government.

The impact of the DFT regulations was not only limited to the original project design, but extended to the general management of the installations. By accepting the terms for undertaking a photovoltaic installation funded through the trial scheme, the managers at the social housing had to comply with the DTI's procedures of reporting regularly about the different stages of the installation and progress of the project. Additionally, the project managers from the PV industry had to observe local building regulations, planning restrictions and health and safety laws in both installation projects.

This issue was especially pronounced in the case of the social housing. Due to the nature of project management in the local Council, the PV installer had to comply with the local authority's health and safety requirements in order to become an approved contractor. As a result, there were considerable delays due to the time it took to approve the PV installer as a contractor with the local Council. Moreover, the project managers at the social housing project were expected to involve the district network operator (DNO) to insure the connection of the system to the national grid (BRE, 2006a: 9). As one of the respondents astutely put it:

> "One of the things is that [the PV installers and consultants] were trying to do things in a short space of time and they weren't properly geared up to understand the technical problems involved in running a contract in somebody else's building. They no doubt in the end appreciated that it is not [their] building [and they] have to work through whatever [we] are doing. That caused a lot of the delay" (Principal Investment Officer; June, 2006)

The above situation suggests that the complexity of the project was not only the result of the different stakeholders involved in the installations, but also the different way they functioned. The mode of work and the manner of doing things was negotiated between different actors – the local authority had to accommodate a new type of contractor and the managers from the PV industry had to learn the way the City Council managed contracts. Therefore, as the sections above show, the different actors involved in both developments had to make a series of decisions to secure the success of the installation. Meanwhile, they had to adhere to various administrative and regulatory requirements to attain a workable programme within which they could successfully complete their project in the available time frame. Therefore, they had to achieve an effective translation of the installation project (Callon, 1986: 206) and successfully enrol other actants necessary for the successful completion of the PV deployment; be they health and safety regulations, government grant approval systems, reluctant developers or politically driven local authorities.

Consequently, the enrolment of the different actors took place in what can be understood as a successful actor-network whereby the project goals were achieved according to the DFT scheme's standards. This process involved identifying the role that each actor had to play, and defining their responsibilities accordingly. As mentioned earlier in chapter 5, the social housing project involved several departments within the local authority (energy centre, housing, and construction), and as a result a clear framework for action was needed and was followed through the various stages of the installation, where roles and responsibilities were clearly defined at the start of the project. As such, the role of the Housing Association was defined by the main actor (the Energy Centre) as "non-technical" and "mediating", between the project leaders and the tenants as the Housing Association Officer stated. The Energy Centre enjoyed a more comprehensive role by managing the process as a whole, from concept to completion. Similarly, the private development project succeeded in defining the various responsibilities among the designers, PV installers and developers. The role of the energy engineering firm was in designing the installation and their role was supplementary to the energy consultants in helping them prepare a successful proposal. The energy consultants had the more managerial role and they coordinated with the private developers through the construction phase. The Energy Consultant commented that the installation went smoothly because the project was new-build and so it was relatively easy to include the installation of the technology on the twelve houses with minor delays.

Having described the actor-networks enrolled during the planning of the project, I will in this section describe the processes that occurred during the installation of the photovoltaic panels on the roofs of the chosen properties. In doing so, I wish to highlight the different elements that influenced the final design of the installation and the rather contingent nature of adapting the technology into the domestic sphere.

6.3 Representing users of RETs: imagining the PV users

Social constructions of who the users are, or "visions of users", as Summerton (2004: 486) labels them, were often utilised by the actors to explain the end-user's reaction to the installation project and the technology. Moreover, these representations were necessary for the project managers in both case studies to aid them in understanding the users' expectations and consequently, taking the necessary actions that would ensure the smooth running of the projects. From interviews with the project managers and the documentation available, several constructions of the identity of the users were revealed as the respondents described their experience during the installation of PV panels on the two sites. These 'visions', I argue, influenced the project managers during project implementation as they tried to rationalise the users' behaviour with respect to the reasoning they employed, as well as the assumptions and decisions that they have made regarding the introduction of PV panels into the building.

The co-construction of artefacts and user identities in techno-scientific practice has been described in numerous STS studies of specific technologies, including telephony and electrification (Kline, 2003), reproductive technologies (Oudshoorn *et al.*, 2004), vaccines (Rose and Blume, 2003), computers (Woolgar, 1991a), and photoelectric lighting (Akrich, 1992) among others. As Akrich (1992) describes in her study on the 'scripting' of users during technology design, designers and engineers define "actors with specific tastes, competences, motives, aspirations, political prejudices and the rest" (Akrich, 1992: 208). These 'scripts' or scenarios result from the visions of both the projected user, and the context of interactions between the user and the technologies. In this way, the technological artefact defines the framework of action in which the relationship between the user and the artefact is negotiated.

The managers in the above example of PV installation constructed the users based on their socio-economic status, their age and the managers' own knowledge and experience regarding RETs and climate change issues. Hence, users were perceived as rational consumers, in line with the general 'common sense' view of economically rational individual behaviour evident in much of the conventional literature. Other constructions characterized the users as ignorant and passive, and therefore unlikely to be interested in the project or the technology involved. These constructions emerged from my interviews with the project managers and the documentation relating to the projects and the DFT scheme.

Various modes of interactions with the technology were assumed on the part of the project mangers, who – as they took on the installation projects – were effectively the designers of the installations. To help them in imagining the roles and aspirations of the residents, the project managers relied on socioeconomic and demographic characteristics which they believed represented the backgrounds of the residents. The social housing residents, as mentioned before, were low-income individuals whilst the householders in the private development were expectedly medium to high-earning professionals. In the sections below, I describe the different user constructions which emerged from the managers' description of the project phases, as well as their responses when I specifically asked them about the residents. I have categorised these into three different constructions of the user: the 'economically rational' user, the 'ignorant' user and the 'passive' or 'indifferent' user. I argue that these constructions were predominantly formed by the project managers prior to any contact with the residents, and in some cases they were verified by the managers through the residents' reactions or apparent behaviour during or after the completion of the installation.

6.3.1 The 'economically rational' user

Visions of the economically rational user were implicit in the assumptions that the project managers of both projects made regarding the acceptability of installing PVs on the roof. The actors who believed in the effective performance of the system expected the tenants and householders to be pleased with a technology that could save them money. Other managers, who doubted the economic benefit of the PV technology in the UK climate, associated the lack of interest on the part of the tenants to be the result of minimal savings on their electricity bills. This vision was in line with the general view of society members being consumers who are chiefly interested in their economic benefit (Batley *et al.*, 2001; Dias *et al.*, 2004; Mitchell, 2003). In the social housing project proposal, the economic benefit was greatly emphasised, promoting the technology as an ideal solution for low-income families who would certainly be interested in lowering their energy bills. In an effort to translate the technology into the context of the council estate, the image of a rational user was constructed and maintained. Furthermore, the project managers expected the tenants and householders to react positively to a money-saving technology, which was argued to be a good and beneficial addition to their homes.

> "We didn't really show much concern about how residents would feel about it, I mean, there is the assumption that people would be happy about it - you know, its going to save [them] money at the end so we don't need to ask [them]" (Housing Association Officer; May, 2006).

As the quote above suggests, the expected economic concern and calculation of the residents by the Housing Association Officer meant that the technology's diffusion should be unproblematic. As long as the technology performed according to expectations, in addition to the fact that the tenants do not have to pay for it – the reaction of the users was expected to be positive. The assumption regarding economic rationality has been noted earlier, but the Housing Association Officer used a method similar to the 'I-methodology' discussed earlier in chapter 3 (Akrich, 1995). In a later part of the interview, my respondent reiterated her view by stating if she were living there, she would definitely be happy with PVs being installed, even if the difference they would make to the energy bill is not more than fifty GBP per year (Housing Association Officer; May, 2006).

The economic view of users' interests is also represented in the managers' view that the diffusion of PVs has been slow because it is expensive and not as financially feasible as other RETs suitable for the domestic sector. Such a view prompted project managers, especially in the case of the private development, to market the homes that had photovoltaics installed without a premium. The cost of the panels was seen as too high for the potential buyers to be interested in such an investment (private developer, electronic communication on 31/January/2007). Moreover, in both projects the marketing of the installation focused mainly on the expected financial savings in electricity bills.

> "The benefits are perceived as being a lower cost of your energy supply, in a nutshell. There is no aesthetic for it. People don't buy it because it looks nicer, you might buy a house for this reason and that reason, but you don't buy a house because there are nice looking PVs on it. You can't sell it on that ground, you can only sell it on a basis that you can make a gain later on with your electricity bills, because they can be lower" (Energy Engineer; March, 2007).

Thus the argument of the Engineer Consultant reflects to a great extent the assumptions about individual's views regarding RETs in general, and PVs in particular. Accordingly, the majority of people might be interested in the technology if its economic value is strong and consequently highlighted to them. To the project managers in the private development, their view was that those who would be interested in RETs like PVs because of their environmental credentials are a minority, and would actively seek the installation of this technology on their homes, unlike the residents in the project. The aesthetic aspect was viewed particularly negatively. The private developers felt that the panels on the roof might lower the value of the property and the consultants expected buyers to be discouraged as a result. This view echoes literature on the environmental and economic qualities of photovoltaics (Jager, 2006), as well as findings regarding the aesthetic impacts of the technology on buildings in a survey of solar technologies on buildings in Greece (Sidiras *et al.*, 2004). The rational user was also manifest in the reasoning that the managers of the social housing project used, as I will illustrate below.

As I mentioned in chapter five, most of the residents in the social housing block did not attend the tenant consultation or the media launching event. This was explained by the project managers as a lack of interest in home improvement projects in general, and particularly projects of this kind. This was also related to the assumed economic rationality of the users. As such, the Housing Manager attributed this lack of interest to the minimal difference (in his opinion) that the PV technology will make to their energy bills. Accordingly, my respondent expressed his view that the tenants' indifference and their absence in both events was because of the "small saving of around fifty GBP in a year [that] nobody would bother about" (Housing Manager; May, 2006).

As I mentioned before in chapter two, the vision of the user as a profit maximising rational individual is not new, however, the examples above show that using such an image of an end-user (whether a homeowner or tenant) had an effect on the way the technology was translated into the project and consequently the home. For example, the communication with the tenants in the social housing project concentrated on only that aspect. In a letter in the early stages of the project, the Housing Association stated:

> "The panels can convert energy from the sun into electricity, which will result in reduced domestic fuel bills" (letter to residents; 5/September/2002).

Similarly, in the final correspondence that was sent after the completion of the installation and construction work, the letter states:

> "Thank you in advance for your co-operation with this scheme and I hope the financial benefit you receive from lower power bills due to the photovoltaic panels meets your approval" (letter to residents; 6/April/2004).

Alongside this was a neglect of any other possible benefits from the technology, such as environmental advantages. In contrast, the residents in the private development received more information about the technology. The home information pack included a question and answer section which stated that "PV provides an infinitely renewable form of **'free-green'** electricity production without emitting any harmful gases or substances into the atmosphere, unlike fossil fuel produced electricity" (bold typing and single quotes in original). The aesthetic aspects of the technology were mentioned; that "PV technology has no moving parts and is therefore silent during the production of electrical energy" and that the "main difference between a property with a PV roof system and a property with a traditional roof will be aesthetics. The PV [tiles] will most probably be a slightly different colour to the roof tiles or slates and create a reflection as the PV modules have a glass front. The 'Sun in a Box' system will be installed on properties with a south facing roof at the rear of the property to reduce perceived visual impact" (Home Information Pack, private development [no date]).

Despite noting those aspects of the technology in the private development project, the overriding emphasis was on the economic credentials of the technology. This was also reflected in the expectations of the private developers and the engineers, which was that potential buyers will not be interested in the technology as its economic feasibility is debatable due to its long pay-back period. However, the economically rational resident was not the only user construction created in the course of the installations. The perceived and expected ignorance of the end-user made by the project managers contributed to the further shaping of the technology during its adoption in these two examples.

6.3.2 The 'ignorant' user

Reviewing the literature on the diffusion of RETs in general, and photovoltaics in particular, there are several studies that stress the importance of education, awareness and information about the technology, and that this is necessary for its successful implementation (Bahaj and James, 2007; Boardman, 2004; Ekins, 2004; Jager, 2006). The point these studies make is that educating users about the benefits of RETs for tackling climate change could alter their attitudes about these technologies in general, and induce them towards energy saving behaviours in particular.

In the case of the social housing project, the project managers had to organise consultation sessions with the tenants prior to any construction work taking place. As explained in chapter five, the event which they defined as a 'consultation' workshop became an information session, involving the Energy Officer who was eager to explain to the tenants about the practical matters associated with the project. Accordingly, simplified "information about climate change" was included at the end of the presentation by the Energy Officer. Despite that, he felt that the low-income group represented by the tenants in the council housing block would not understand "technical things like climate change and how photovoltaics work". As a result, the information on the environmental role or value of the technology was minimised, and was presented to the tenants only briefly. The perceived socio-economic status of the tenants and their educational background was seen as a barrier for promoting the environmental value of the technology. As the Energy Officer stated:

> "I don't want to get into people's personal situations and educational backgrounds, and within the MDI, there are all sorts of things to take into consideration such as social, economic and educational backgrounds" (Energy Officer; January, 2006).

As a result, the focus was on the practical matters. As he pointed out, the preoccupation was with not moving satellite dishes to avoid complaints. He explained further, stating that:

> "This is the real world. They are more interested in the satellite TV than they are in getting PV on their roof. When we had the scaffolding, we had to delicately move their satellite dishes so that TV wouldn't be disturbed and we had to fit them on the scaffold. That's one of the major things you've got to do when you do a job like that. You get people from all walks of life" (Energy Officer; January, 2006).

Moreover, the project managers felt the need to educate tenants about the benefits of having a PV system in their homes and the dangers of global warming. As a result, leaflets were distributed that briefly explained climate change and presented photovoltaic technology as an alternative to reduce carbon emissions, in addition to a few sentences that described how the technology works.

In contrast, the level of education of householders in the private development was expected to be higher, as the Energy Consultant of the project stated. Again, this was based on their socioeconomic status, as the homes sold on the private development had a price range that was generally accessible to medium and high-income professionals with families. However, included in the project plan was a two-hour private consultation visit to each householder's home where the Energy Consultant and a colleague "explained everything they need to know about the panels". When I asked her the reason for these visits, the Consultant involved stressed that this was part of the DFT scheme's regulations to provide sufficient hand-over information and documentation, however, she also added that it was an opportunity to raise the homeowners' awareness of climate change and the need for reducing carbon emissions. Additionally, it was felt important that as much information on the technology was provided since PVs were seen as a relatively new technology.

> "The argument is more that the technology is fairly new and it was completely new to people buying houses. As far as [the developers] are concerned, people who buy houses are interested in nice kitchens and nice bathrooms, and they do not look at anything else to do with the property" (Energy Consultant; March, 2007).

This indicates clearly the difference between the expectation of the Energy Consultant and her image of the users compared to the expectations of the property developers. This was experienced in her argument to market the property as having PVs and for putting a premium on it, because she felt that the potential buyers will be responsive towards the technology, given their economic and educational background. This was also the reason behind attempting to locate the display monitor in the entrance hall or the kitchen, as the developers felt that householders will appreciate the energy generation data displayed, and additionally would be an effective educational tool for householders who do not understand how the technology works.

This image of the user as a well educated buyer who would be interested in climate change issues was not shared by the property developers. They relied on their previous experiences with potential buyers in the region. According to the director from the private development company, the "people in the North are not interested in green issues". This therefore made them reluctant to market the homes as having photovoltaics, and instead would inform the buyers only after they had made their decision to purchase the property. They believed that the people had generally lower educational attainment in the North compared to the South, and comparatively lower incomes, which meant that their appreciation of climate change issues and interest in RETs in their home is less. This is in line with the general view that concern for the environment is a luxury affordable only to the well-off.

In addition to knowledge about climate change, the expected knowledge of the users with respect to practical issues related to living with the technology was also high. In other words, the Energy Consultant thought that the householders knew the basic information involved in the functioning of the technology. As she added when we discussed householders knowledge in the interview, "you would expect them to know a thing or two but actually that was not so. I mean, one of the householders asked if he always needed to have his socks on when at home (to avoid an electric shock)". Nonetheless, the higher income of that group of residents meant an expectation of slight interest in the technology and its environmental benefits. However, the Consultant was surprised as to the general lack of interest in the PV system or its functioning, where "only three out of the twelve residents showed any interest when we talked to them" (Energy Consultant; March, 2007).

The project managers in both case studies felt that it was necessary to explain the practical matters surrounding the construction and installation (such as noise, dust, parking space, etc.). This was particularly the case for the social housing project, where complaints could delay or jeopardise the progress of the project. The expectations of the City Council and the Housing Association was that the social housing tenants were likely to be concerned with disturbance and the construction work, and an emphasis was put on informing them ahead of time and practicing good customer services measures. For the private development, the interest was in ensuring access to the property to install the panels or other 'Balance of System' components. As a result, the emphasis was on the practical matters about the installation, but also implicit was the users' ignorance regarding the threat of climate change as well as their ignorance regarding the technology and how it functions.

6.3.3 The 'passive/indifferent' user

A further way of envisioning the user which was common among the respondents was that of a passive recipient of the technology. This was as a result of a perceived lack of interest in the technology (on the part of the user) and the nature of photovoltaic technology which does not require any form of engagement for it to generate energy. A significant construction of the users in the above projects was that of a passive user, which was mainly constructed through what the managers perceived to be the correct functioning and use of PV systems. In other words, because the technology produces electricity on its own, and the householders do not need to contribute in any way towards its performance, meant the absence of any potential role oruser involvement in the functioning and usage of the PV technology. I therefore argue that the photovoltaic system was interpreted as independent of the user at home, promoting it as an electricity generator on the roof. As I discussed earlier, the project managers are the designers in the case of the technology application, and as Woolgar (1991a) argues, the designers configure and constrain the users into particular roles based on the attributes of the technology and the way the designers felt it should be used. This was evident, for example, in the engineer's perception of the resident's role.

> "In terms of roles, the householders would have very little to do. The panels don't need maintenance or cleaning. I can't see any particular role for the householder at all. I think that's an advantage, in a sense that once it is there you don't have to do anything with it. So, it is a very self-contained, so self-reliant and could be a very stable and robust system (Energy Engineer; March, 2007).

This conceptualisation of the technology was noted by Rohracher and Ornetzeder (2002) in their study of green buildings, where technical solutions can improve the environmental performance of buildings "without needing the co-operation of users after the technology has been implemented" (2002:73). This line of thought is common in the technoeconomic approach, where technological fixes can perform necessary environmental action on behalf of the user. Latour (1992) explains this in the concept of delegation, and gives an example of the mechanical door closing device, where the action is delegated or translated to the door. Hence, the duty to close the door after the person has walked through is transferred to the device, relieving the individual of reasonability whilst maintaining the warmth indoors. Delegation is a character of a technology which "is deliberately designed to make up for presumed moral deficiencies in its users" (Pfaffenberger, 1992: 293). I argue, therefore, that the approach of the project managers in the above case reinforced a definition of photovoltaic technology as a solution that will not need the cooperation of users, since it generates green electricity regardless. In this sense, the technology is defined or constructed as "a tacit technology" (Brand, 2005: 8), which is reflected in my case studies through the project managers' decision to simply inform the residents about practical issues regarding the technology, and neglect any need to involve them with the PV system's design and implementation.

Additionally, in the case of the social housing project, the tenants were perceived as passive, mainly because they were young and single. The previous experience of the Housing Association in other projects involving housing improvements suggested that young, single persons are the least interested in work taking place in their homes or in the neighbourhood.

> "I think because the type of properties that we put the panels on, they were all three-storey flats that were largely housing single people and younger people and it's really really difficult to engage young single people in anything. Generally, it's the most difficult group of people to be involved in anything or to consult to about anything are young and single" (Housing Association Officer; May, 2006).

As such, the expectation of the Housing Association was of minimal involvement from the tenants and as a result, the process of enrolling them into the project was limited to letters informing them of the various stages of the work. Moreover, most of the tenants were absent during the consultation event, as well as the media event which was organised after the completion of the project. Their indifference was understood to be in relation to the environmental aspects of the installation, prompting the Energy Officer to indicate that "nobody [the tenants] cares about climate change" (Energy Officer; January, 2006). Their indifference was perceived to be a result of their socio-economic status, their education and the general apathy of this group to matters of sustainability and the environment.

On the day of the consultation event, few of the tenants attended and those who did were reportedly mainly concerned with practical matters, such as the availability of parking space. As the energy officer explained:

> "What I did is that I developed a PowerPoint presentation ... and basically only one or two turned up. There were 25 flats, they were all informed by letter through [the housing association] that there will be a meeting to explain what we were going to do so we went through that process but they weren't really interested" (Energy Officer; January, 2006).

The perceived and consequently reported lack of interest in the environmental or economic benefits of PVs on the part of the tenants was analogous to the focus the project managers placed on these practical matters. This focus was driven by previous experiences with projects within the DFT in similar areas, where there were major problems related to vandalism, security and disturbance, which caused delays. In an effort by the managers to complete the project with minimal interruption and complaints, due to the bureaucratic nature of dealing with such matters, they overemphasised these issues in the presentation. Consequently the users were confined to a passive role with the project that minimised their interaction outside the boundaries of what the managers deemed appropriate, namely the practical issues. As indicated from speaking to the Housing Association officer:

> "None of the tenants were in the least bit interested. There was no interest at all at any level in the project. We tried to engage them and the project officer visited them all to talk about that obviously there will be people on the roof and there is going to be noise and disruption but nobody showed any interest" (Housing Association Officer; May, 2006).

Constructing a passive user, therefore, was rooted in the project managers' conceptualisation of photovoltaic technology on the one hand, and their assumptions regarding the residents' attitudes and lifestyle. The result was configuring users into a passive recipient role. As views from the private development case show, the users are uninterested individuals, who are presumably fortunate to be able to benefit from electricity savings in their bills and who "do not need to do anything at all" (Energy Engineer; March, 2007).

Having summarised the main user constructions that were employed by the project managers, the next section explores how these user constructions influenced the design of the PV system and the management of the installation project. Hence, I argue that during the installation of the PV technology, the project managers represented (Akrich, 1995) users as passive consumers who needed to be educated. This resulted in a particular configuration of the technology's design and functioning, which I describe in the next section.

6.4 Configuring PV users in the home

In configuring the user, Woolgar (1991) shows how the preconceptions made of the "nature and capacity of different" users affects the actions and decisions of designers and results in a particular configuration of the user and the technology. When the characteristics of the end-users are presumed, a process of constraining and defining their actions takes place. In the case of the PVs in the north of England, this process can be described as an attempt to explain how the activities and decisions made by the project managers defined the role of the user during the implementation and operation of the PV system. In this chapter I argue that the various actions of the key stakeholders resulted in configuring the end-user into various roles within which they were expected to perform. Through their decisions, the project managers wanted to ensure the successful completion of the projects within the available budget and timescale.

Guided by their image of the users and the users' capacities and the characteristics on the one hand, and the affordances of the technology on the other hand, the project managers configured the technology and its user into prescribed roles. Thus, the technology (as a text) was written differently in the two cases discussed above. The resulting design of the PV system in the social housing project configured the user as absent and separated from the technology, whilst the design in the private development project assumed a slightly more interactive relationship, despite it consisting of the display monitor as a source of information for, and consequently the education of, the householders. Although the 'writing' of the PV systems can be 'read' in several ways, the resulting text can nonetheless limit possible 'readings' and interpretations.

In the following section, I will explain how the configuration of the user's relationship to the technology occurred by looking at two aspects. The first is the design of the system in the buildings, in particular the location of the display monitor. As I mentioned earlier, the issue of the display monitor emerged during my fieldwork. In my analysis, the focus on this component of the system stems from two main points: the fact that it is the user interface of the technology as the literature from the DFT indicates (BRE, 2006a), and the reference to the display monitor when I asked the project mangers (during the interviews) about the residents.

The second aspect of configuration is in the documentation aimed at the users, which was provided during the installation of the technology in the case of the social housing and at the handing over of the twelve houses in the case of the private development. The good practice promoted by the DFT scheme stresses the importance of handing over informative documents about the technology; showing how it works, as well as the technical user manuals related to it. Dobbyn and Thomas (2005) argue that when information about the technology was made available, residents were more likely to act positively about the technology. In the next section, I will therefore discuss how the configuration of the users occurred by highlighting these two aspects of the PV installation.

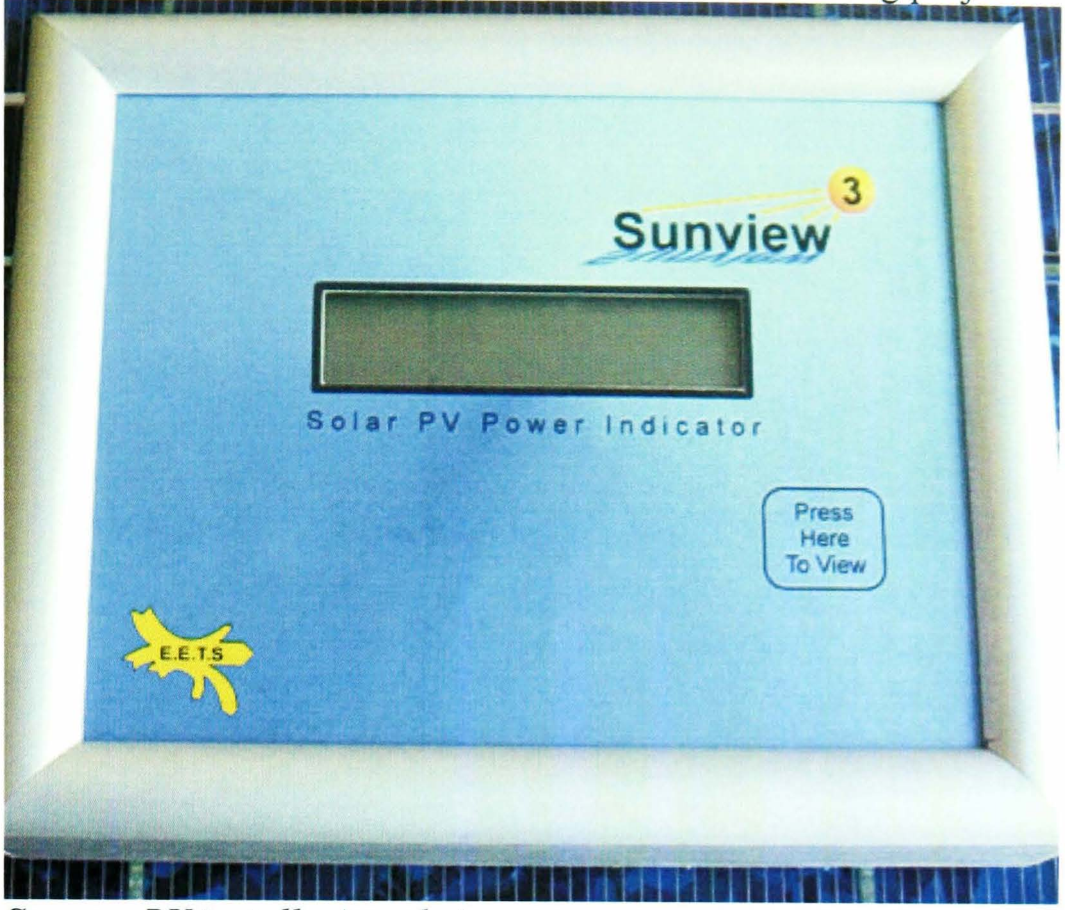
6.4.1 Designing PV system installations: locating the display monitor

The photovoltaic system consists of various components in addition to the panels; including an inverter that converts the direct current (DC) produced by the panel into an alternating current that can then be channelled into the electricity supply of the home, power conditioning units that control the flow of electricity from the PV panels, export meters to measure the electricity that goes back into the grid, and a consumer unit which is a small monitor displaying the amount of energy produced by the PV system and the system's contribution to the overall electricity consumption of the household.

Installing the display monitor was a DFT requirement, along with other best practice recommendations highlighted at the start of the installation project. The purpose of the display monitor was to visually demonstrate to the user the effectiveness of the PV technology. In addition, the display monitor was deemed a useful component in the system as an indicator for any malfunction of the technology and hence maintenance needs. In technical reports and good practice guides on the trial, it was recommended that the display monitor and other BOS components be appropriately installed to "avoid any follow-on problems when it comes to maintaining the system" (Munzinger *et al.*, 2006: 49). It also added that an "effective layout combined with precise and easy to understand handout documentation will make monitoring of the system operation and subsequent maintenance easier" (Munzinger *et al.*, 2006: 49). This was the context for installing the display monitor, where this component performs this dual function.

Moreover, it was recommended by the DFT scheme that the panels be located inside the home and preferably in a location that is highly visible. However, in the social housing project they were mounted on the wall in the communal hallway facing the entrance to the building. The monitors were encased with break resistant glass to avoid vandalism. Mounted next to each other, each display monitor corresponded to a flat and had a sticker label to indicate the flat number. As figure 6.1 shows, the display presents a summary of the cumulative electricity generated by the PV in three modes, total generated electricity, hourly and the daily generation. This can be scrolled through using the panel button indicated with "Press Here To View".

Figure 6.1: Individual display monitor in social housing project



Source: PV installer's website

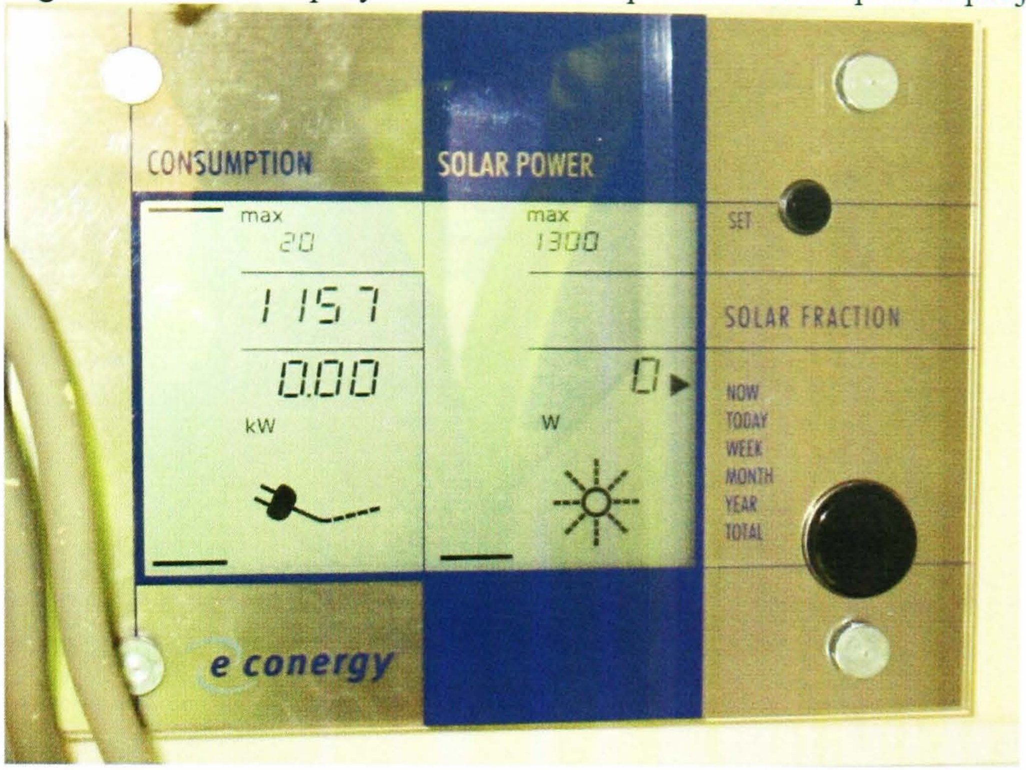
However, the action was impossible because of the glass encasing covering the display monitors, as figure 5.1 shows. To save time and effort accessing the flats to install the displays, the project managers decided to mount them in the hallway. The priority of the project managers in reducing disturbance to tenants and the amount of time it requires to arrange to access all twenty five flats resulted in this decision being made. The glass encasing was added to prevent vandalism, which as mentioned earlier, was another priority of the social housing project managers. According to the Energy Officer, these were practical decisions that he took in ensure the completion of the project on time. This further reflects the project managers' interest in avoiding contact with residents, or any situation that would require their cooperation with the installation of the technology. Whilst their intention was to limit the complexity of an already rather complex project, this unfortunately resulted in reinforcing the boundary between the tenants and the technology. This view was also supported by the project managers' belief in the complexity of the PV system and its independence as a functioning energy source. This physical boundary – materialised, in this case, as a break-proof encasing of the display monitors – symbolises the expected relationship between the tenant and the technology. I argue, in this thesis, that the design of the installation configured a passive, indifferent user to a technology installed onto their roofs and not in their homes.

In contrast to the decision in the social housing case, the location of the display monitor within homes at the private development project was negotiated between the various actors involved in the project. The Consultant wanted to install the monitor in the kitchen or entrance hall, a location that would make the monitor more visible, optimising its potential as an educational tool. As figure 6.2 shows, the display monitor shows the amount of electricity generated (the blue panel in the middle) and the proportion that it contributes to the home's total electricity consumption (the silver-metal panel on the right). The button on the left of the display allows the user to scroll through the PV generation data for immediate or cumulative generation.

As I mentioned earlier, the developer did not want to risk lowering the value of the house, and consequently insisted on the display monitors to be mounted inside the cupboard which housed the utility meters. The result was a compromised solution, where the display monitor was either in the cupboard or in the utility room near the kitchen.

> "We tried to convince the developer to put them in the kitchen with the argument that if they are in a living area, people are more likely to look at them, use them and act on what they are looking at on the display monitor. The developers didn't like it and said that people would not buy the house if the display was in the kitchen although it was a modern new kitchen" (Energy Consultant; March, 2007).

Figure 6.2: The display monitor in the private development project



Source: BRE (2006b: 15)

In line with views on the need to educate the users explained before, the literature from the DFT encouraged designers and installers to locate the display monitor in a visible place to maximise its educational value and to promote energy awareness among residents (BRE, 2006b). However, the Energy Engineer was less concerned with the location of the monitor, preferring it to be inside the garage. Whilst the emphasis was on the effectiveness of the visual depiction to clarify how the technology functioned, it was suggested that the imagined user would have to be particularly interested in the functioning of the technology, that they would make time to look at the energy production indicated on the screen.

> "The advantage of having [the display monitor] is that you can write down however many times in simple language the savings and the money that you are making. When you can actually show that, in a visual form, I think it is a more powerful message. They can go to their garage and see the lines and think their electricity bill must be lower. It is very powerful, brings out a very powerful message" (Energy Engineer; March, 2007).

The impact of the user constructions on the design decisions was apparent in the location of the display monitor. In the case of the social housing, the image of an uninterested and passive resident was configured into the design of the PV system. The location of the display monitor indicated the project managers' preference in keeping the user outside the PV system, and consequently keeping the technology and its interface (the display monitor) outside the residents' flats. The presumed ignorance of the residents was materialised in the design of the PV system, as it was felt that they would not appreciate the technology, and how much electricity it generates since they are not concerned about climate change and do not understand RETs.

In the private development, the educational element of the display monitor was similarly stressed, which reflected the Energy Consultant's need to educate the householder about the energy generated from PVs and about their general energy consumption. This was contrasted with the lesser importance the engineer gave to the display monitor, framing it as mere visualisation that should interest the peculiar technophile. This was mainly because the technology was perceived as functioning without the need for any action on the part of the user, a view that does away with the need to locate the monitor in a highly visible place. It is also worth noting the private developer's insistence on minimizing the visibility of the display monitor. The priority for them is the value of the property, as well as the preferences of future homeowners with respect to the home's and the kitchen's appearance. In this study, my intention is not to suggest a right or wrong way for installing the PV system and locating the display monitor, but to elicit how the design and expected use of the technology and its components was not always implemented as the DFT consortium have intended (Munzinger *et al.*, 2006). This agrees with the view in STS on the diffusion of technologies and their appropriations in ways that are opposed to the designers' intentions (Akrich, 1992).

6.4.2 Information packs and leaflets

As the DFT *Good Practice Guide* (BRE, 2006a) suggests, its authors believe it is important to provide simple and accessible information about PV technology as this will encourage users to become involved during the installation and operation of the technology. This is encouraged in particular, as it allows the residents to tackle the minor issues related to the general maintenance and operation of the technology. Viewed this way, information becomes necessary in order to ensure the "proper" use of photovoltaics. This is also mentioned in the *Final Technical Report* prepared by Munzinger *et al.* (2006) for the DFT scheme. The purpose of information provision, supplemented by the display monitor, is necessary to ensure that users are aware of the system's maintenance needs. The guide therefore recommends that the PV industry develop clear documentation "specifically describing issues such as how to carry out simple visual checks and appropriate instructions on how to interpret readings" (Munzinger *et al.*, 2006: 110). Furthermore, the DFT literature stressed the need to avoid "user mis-operation", pertaining to users turning off the system when they should not, and only turning it off for the right reasons (such as decorating or doing other electrical work) but not restarting the system later on. It added that "it is important that users understand when they need to turn off the PV systems but that it is equally important to remember to switch them on again" (BRE, 2006a: 22).

Indeed, both case studies that I explored in this research have produced documentation, albeit of different natures and focusing on different aspects of the installation. In the case of the social housing project, the document was a double-sided A5 leaflet that was posted to the tenants. It featured pictures of the building block and explained the project which involves "using photovoltaic technology to help generate electricity for residents". The focus, therefore, was on the benefits of the technology and the "estimated savings depending on the weather". Furthermore, the leaflet stressed how the project will "benefit residents, improve the local environment, and increase employment opportunities now and for the future". The maintenance and operation of the technology was not mentioned. Instead, the focus was on the benefits of the community, highlighting the main issues believed to be the most important for residents of these areas: employment, savings and the local environment.

The language of the leaflet, I argue, separated the tenants from the technology even further. Whilst the benefits were made closer to home, as opposed to a focus on the global climate change problem, the technology itself was hidden. Instead, the focus was on the project and its community development credentials. It could perhaps be argued that the project managers were trying to promote the project to the tenants. In doing so, they minimized the interaction with the technology as such, in favour of translating the project into neighbourhood improvement and community development action.

The private development, on the other hand, included more information, in the form of a ring-binder including a description of the system, general information in a question and answer format, as well as instructions on maintenance and operation procedures. This involved checking the panels on the roof and the performance of the system by looking at the inverter in the loft, as well as the output of the system as shown on the display monitor. Furthermore, the information pack noted the issue of shading and it was advised that householders avoid building structures or extensions that might limit the amount of sun exposure the panels receive, and hence lower their performance. Accordingly, it was suggested that regular pruning of trees or shrubs is needed to maintain the systems efficiency. As the DFT literature pointed out, "shading can also increase during operation if care is not taken...This should be explained to the system users, so that action can be taken to keep any trees at an appropriate height... Again, this can usually be prevented by education of the user" (BRE, 2006a: 25).

Therefore, as the above examples show, there are many steps that need to be taken to ensure that the PV system operates in the intended way, and certainly, there are forms of incorrect use that are pointed out and discouraged after the PV system is left to operate in the realm of the user. Indeed, users interact in different ways to the technology, an aspect which I discuss in the next chapter in more detail. However, I argue that from the designer perspective – the writing of the technology, the script – the users' role with respect to the PV system is constantly defined and constrained. This has occurred during the installation and the operation of the technology, and was reinforced in the documentation intended for the PV industry. This indicates that the practice of configuring the user was taking place during the implementation of PVs, thus shaping the relationship between the technology and its users. Because as the projects were part of the trial scheme, these configuration processes were continued and were formalised in the knowledge produced from the trial experiences. These efforts indicate how the project managers in the two case studies and the DFT have sought to define and control the users' behaviour, and to educate them about best performance conditions, and more importantly the maintenance needs of the system. Seen this way, the designers of the PV implementation projects configured their users into a photovoltaic-friendly role.

6.5 Conclusions

In this chapter, my intention was to describe and analyse how the designers – the project managers and other actors within the DFT scheme – wrote photovoltaics during their implementation. At the start of the chapter, I described the different negotiations that took place and the mechanisms employed by the different actors as they built associations as they sought to implement the PV installation projects. The purpose of that section was to highlight the socially shaped nature of the technology and the influence of the implementation process, i.e. the adoption networks, in shaping the design and role of the technology.

I then moved onto the notion of users. Following the work of Woolgar (1991a) and Akrich (1992) on user scripts and configuring the user, I wanted to explore how the project managers defined the role of the residents in relation to the PV system. My analysis, therefore, starts with how the project managers constructed the users. I argue that the installation decisions, which the project managers made reflect the images that they had of the users: their expectations, preferences, behaviour, and knowledge.

As such, these images were materialised into the design of the PV system (as it is installed on the buildings), thus creating a script. I discussed how this configuration took place in relation to two PV implementation aspects: the location of the display monitor and the documentation provided for the users in each project. I showed how in both cases, the intention of the designers focused on separating the users from the technology, especially in the case of the social housing project. The example of the private development indicates the negotiated nature of the PV system and how different actors shaped its design, and consequently its relationship to the user.

Having explored the managers' perspectives, in the next chapter I will discuss the perspectives of the users as they live and interact with the technology in their homes or on their roof. In doing so, I describe how the technology is 'read' by its real users, explicating how the design of the installation had influenced their interaction with the technology, and how in some cases they have challenge the intended use of photovoltaics.

CHAPTER SEVEN

Living with Photovoltaics: the Users' Perspectives

"[W]e have to go back and forth continually between the designer and the user, between the designer's projected user and the real user, between the world inscribed by the object and the world described by its displacement" (Akrich, 1992: 209).

7.1 Introduction

Having described the various processes that took place during the design and implementation of PV systems in both case studies, in this chapter I describe the experiences of the residents who are living with the photovoltaic systems on their houses or flats. As Akrich (1992: 209) suggests, investigating the experiences of technology use from the user's perspective is crucial for avoiding the somewhat deterministic view, with its focus on how technology can constrain and configure its users. In other words, it is important when analysing technology in society to explore not just how it is being 'written', but also how it is also 'read'. Therefore the question would be: how do the residents use photovoltaics? Can we think of users of photovoltaic systems as such, and if so, would using photovoltaics be distinct from the general use and consumption of electricity in the household?

In this section, I describe the different spaces within which residents use the photovoltaic technology. In doing so, I attempt to draw a picture of the various day-to-day activities of the residents' in relation to the photovoltaic system. As explained in the previous chapter, the display monitor represents the photovoltaic system to the consumer, and as a result is the user interface through which most of the interaction with the PV technology takes place. Therefore, in analysing the consumption and use of the photovoltaic system in these two cases, more often the process is described as the interaction of the residents with the display monitors.

7.2 *Using photovoltaics: spaces of consumption and domestication*

According to Shove and Chappells (2001), the consumption of a utility such as electricity is distinctive because it is not consumed directly, rather it is the services that the availability of electricity makes possible that are important. As a result, "the extent of electricity consumption is mediated by all sorts of domestic technologies; patterns of use are typically inconspicuous and householders are only dimly aware of the social and technical infrastructures of electricity" (Shove and Chappells, 2001: 55). Moreover, the authors argue that the practice of daily routines around the household shape and are shaped by the existence of different domestic technologies, such as washing machines and fridge-freezers (Shove and Chappells, 2001; Shove, 2003; Shove and Warde, 2003), and more importantly "we might reach for similar narratives of co-evolution were we to consider the introduction and diffusion of other products and services" (Shove and Chappells, 2001: 55). Therefore, in considering the effect of introducing a photovoltaic system into a building (be it a block of flats or individual homes), it is important to think of the processes of electricity consumption as a whole, paying attention to the daily habits and routines that individuals establish in their homes, and the various sociotechnical relations constituted in the network of electricity consumption. In the sections below, I attempt to sketch out the different use contexts of photovoltaic technology in the domestic environment.

7.2.1 The house, the roof and the technology

Based on their replies when asked their opinion on the photovoltaic technology, the residents of the private housing development can be divided into two groups: those who like the appearance of the panels and those who do not mind having them. This view was found in contrast to the assumption of the developers regarding the social acceptance of the PV technology. Of the virtues of the technology, the integrated and "out of the way" design (as one of the residents put it) make it convenient and easy to live with. According to one resident in the private development:

> "[The technology] is not obtrusive or anything in any way. I mean, have a look for yourself, if nothing, we've got a glass panel for a roof" (resident 5, private development).

As such, the panels are "nice, when you look from the outside" (resident 2, private development). In the social housing, most of the residents interviewed appreciated that "unobtrusive" aspect of the technology (resident 1, social housing), pointing out that it was acceptable and "does not bother us" (resident 3, social housing).

The aesthetic qualities of the panels in particular differed in the case of the private development. As a result, my discussions with the residents included the design of the panels (tiles or 'sun-in-a-box'), in addition to the notion of having them on the roof. Accordingly, the response to the two different designs varied. Whilst some preferred the "nice flash, but smooth finish [of the tiles] because they are integrated into the roof tiling" (resident 1, private development), others preferred the ease of dealing with the bracketed, 'sun-in-a-box' system because it is easier and cheaper to uninstall in case of maintenance or repairs, or if they decide to remove it altogether.

For all those interviewed in the private development, the installation of the photovoltaic technology in their house was not a factor in their decision to purchase the property. The majority stressed that the decision was based on the size of the house, its location and the size of the garden. However, one resident chose the house for having the panels on over an identical property:

> "I was given a choice between this and another house that is exactly the same, but I chose this one because it had the system on" (resident 3, private development).

This resident was positive about the addition of the PV technology in her home, as she believed that it would benefit her property in terms of its value, and the fact that she would be generating her own electricity. In general, the existence of the technology was either viewed as a bonus or was regarded with indifference. Nevertheless, most of them gradually took greater interest as they noticed lower electricity bills after they moved into their homes. Other residents were more sceptical, maintaining an objective or detached assessment of the technology when they were first told about it. According to one homeowner who lives with her partner:

> "It didn't make us choose it over other properties, but it certainly didn't put us off. If anything, we would have gone for the house anyway because of the location and garden and all other things, but it was certainly an added bonus (resident 2, private development).

In both projects, the view of the residents was generally positive; with some residents in the social housing stating that they thought it looked nice and modern, whilst residents in the private development felt that it was good because it generates electricity and makes the property more attractive as an investment. Most comments concerned the unobtrusive and tidy appearance of the technology, and accordingly appreciated the building integrated aspect of the PV installation. A few respondents in the private development project commented on the modern addition that the technology brought to their home's appearance. Thus, the unobtrusive nature of the photovoltaic panels, with its location on the roof and outside the house, meant more readiness for adopting the technology or choosing to live with it. This resonates with the positive appeal of the technology that the private developers reported after they sold the houses. According to one of the developers, none of the potential buyers who were told about photovoltaic panels changed their mind about the property because of it. Whilst the private developers were concerned that the installation could lower the appeal of the property and discourage buyers, their experience with the homeowners was otherwise. However, the view from the developers was that this was due to the fact that the residents did not have to pay for the PV system, and maintained that the high cost of the technology – if it is to be sold – would put off the home buyers.

In the description above, my intention was to explore people's perception of the PV panels on the roof *per se*. What appears from the above is that residents find the technology aesthetically acceptable, and in some cases pleasing. The view from the literature suggests that the visibility of the photovoltaic installation was not sufficient as a reminder for the link between energy generation and consumption, and hence a continuous re-enforcement of the energy message is necessary to achieve sustainable and long-term demand reduction of energy (Bahaj and James, 2007: 2136; EST, 2005b). From the results that emerge in this research, the respondents in some cases did link the panels on the roof with their energy consumption, and felt that the panels remind them of how much electricity they use. This was also reflected through their interaction in relation to the display monitor, which I will discuss later in this chapter. However, what appears from this study is the acceptance of the technology, where residents felt positive about the panels or were at least not opposed to them. This is in line with a study on public attitudes to solar energy, which found an acceptance towards the aesthetics of the technology among the early adopters (Faiers and Neame, 2006).

In the following sections, I describe the experiences of the residents regarding the technology. In my interviews with the homeowners in the private development and the tenants in the social housing block of flats, I asked them to tell me what it feels like living with the technology, what they like and dislike about it and how they use electricity in the house.

7.2.2 Household electricity consumption and photovoltaics

As mentioned earlier in chapter five, the experience of users with respect to the installation of photovoltaic technology varied considerably between the social housing block of flats and the private individual homes. In summary, the majority of those living in the private housing development still recall the dissemination activity and the handing over of the information pack by the Consultant, whereas the tenants in the social housing remember only vaguely the letters and leaflets "that came in through the door" (resident 1, social housing). Whilst there is the problem of recall because it has been two years since both PV systems were commissioned (to the time of conducting those interviews), what could to said is that comparing the responses of the two case studies to each other shows that the residents in the private development felt more engaged in the project.

Some of the current residents in the social housing flats were living there during the installation of the PV system. From the interviews I conducted with them, the tenants unanimously stated that they do not perceive any benefits from the photovoltaics on the roof of their building. Whilst two of them conceded that the reason might be the increase in the number of electric appliances used compared to previous years, the majority felt that the technology "probably does not work" (resident 2, social housing) and that "maybe it does not make much difference in electricity bills" (resident 4, social housing). With the exception of one tenant, none of the residents were aware of the number of household appliances that they own and their consequent electricity consumption. According to one of the tenants:

> "I suppose the benefits should be with my electricity bill, right? But I cannot see any difference with my bills. Maybe because I am now using more appliances [compared] to when I was back then, before they put them on. I had only been in the flat for a couple of years before the project began. I only had a fridge, a television and a video recorder. But now I have three televisions, two video recorders, a DVD player and a computer. So now I guess I use more electricity (resident 1, social housing).

Whilst the increase in household appliances is not the direct result of the installation, the above example shows that tenants did not relate their electricity usage to the functioning of the photovoltaic technology. Studies on the deployment of photovoltaic systems in households argue that residents are more likely to respond to the functioning of photovoltaics if they are provided with relevant feedback from the system, in terms of output generated or electricity consumption in the household (Darby, 2006; Keirstead, 2007b). As mentioned earlier, the display monitor was located in the communal hall near the staircase, making it only visible for the tenants as they entered and left the building. They were, therefore, unable to interact with the technology and use the display monitor compared to the users in the private development.

Thus, the design of the monitor and the way it was installed in the building resulted in lack of interaction with the technology. This is reflected in the responses of the tenants who, when interviewed, did not feel that they have anything to say about the panels. The majority stated that their energy bills did not show any decrease after the installation of the technology in the building, in contrast to what was promised in the leaflets and letters from the local authority. Previous studies on PV use in the home suggests a rebound effect, expressed in the householders increased use of energy efficient technologies due to perceived savings (Keirstead, 2007b), the responses from the tenants suggest that they did not relate their consumption to the technology and few showed an interest in changing their energy use since the PV system had been installed.

When it came to the display monitor itself, none of the tenants interviewed reported using it. Two of those interviewed who lived in the property during the installation looked at the monitor when it was first installed. However, both could not make sense of it and consequently decided not to look into it anymore. Moreover, some of the tenants who moved into the flats after the installation was completed did not understand what the monitors were for. In fact, the more recent tenants were reluctant to be interviewed for this research because they "did not know anything about it" (resident 7, social housing) and hence felt that they did not have anything to say about the technology.

It could be said from the interviews that there is a general understanding that the display monitors are part of the PV system; however, none of the residents could translate what the digits on the LCD corresponded to, or what they meant in terms of their electricity usage. One resident, for example, thought that the monitors were for the technicians when checking system maintenance. As one of the tenants explains:

> "On the bottom landing, there is a glass panel and each flat has just a small ten square inch [monitor] which would tell you how much you are using. I guess. I never look at it, you know. I never understood it anyway. They did not tell us how it works or anything, none at all" (resident 1, social housing).

The lack of any information on the display monitors corresponded with a lack of any information made available for the tenants when the technology was installed or when they moved in. As a result, recent residents who moved in after the completion of the project did not have any information at all about the PV panels on the roof, or the display monitors in the hallway. The responses from the interviews with the tenants suggest minimal interaction, if at all, with the PV system, which is reified with the installation of the display monitor outside the flats and the absence of information on how to use it.

By dissociating domestic spaces from the system components of the PV system, the tenants were unable to use the PV technology, as such. Moreover, the tenants were not able to relate their electricity consumption to the electricity generated by the PV panels. As a result, the perceived benefits of the technology, defined by the project managers as lower electricity bills, were never apparent. In table 7.1, I summarise some of the responses from the interviews conducted with the tenants in the social housing project regarding their electricity bills, the presence of the panels on the roof, their interactions with the display monitor and their electricity consumption.

Table 7.1: Responses from tenants in the social housing project

Theme	Responses
PV technology	"I think in general it is a great idea but I am not sure if they actually work, it is not much sunny around here" (resident 2). "I don't think they really do much" (resident 3)
Perceived savings in utility bills	"In the letter it said that it will benefit us by cheaper electricity bills, I didn't see any difference" (resident 1). "In the last two years since the panels were installed, my bills are actually higher" (resident 2) "I moved from a three bedroom house to this [two bedroom house]. My bills are still the same" (resident 5).
Electricity consumption	"I have more electrical appliances now, so I use more electricity" (resident 1) "I live on my own; I don't use a lot of electricity. Maybe more gas for heating because it can get cold" (resident 6)
Display monitor	"I think I looked at it once, when they put it there and that was it" (resident 1). "I never really look at it but I know it is supposed to tell me how much the panels are generating and such" (resident 2). "I don't look at it, I don't think people understand what it is for" (resident 3) "I know it shows the electricity but where do you go from there" (resident 5) "I don't know what that is" (resident 8)

To summarise, the responses from the residents in the social housing reflect a generally negative view regarding the benefits of the technology. Apart from its appearance, the performance of the panels was questioned, and this was brought to bear on the perceived lack of savings in their utility bills. In terms of their consumption, most of those interviewed felt that they do not use a lot of electricity either because they live in a relatively small, two-bedroom flat or because they live on their own. Also, they did not feel any difference reflected in the utility bills. As for the display monitor, which was mounted in the hallway, most of the residents stated that they did not look at it, whilst others did check it once when the system was first installed. All except one of them, however, did not understand how it worked or what relevant information it displayed

In contrast to the experiences of the social housing tenants, the residents in the private development showed more interest in the PV technology on their roofs. With the monitoring of the system for the DFT scheme being complete by the time this research was carried out, the residents now 'owned' the system. The ownership of the property was a significant factor in their interest in the technology. As one resident puts it:

> "It makes a very good talking point. When friends come round, they go like 'what's that on your roof?' and I go like 'Oh, that's my solar panel' [boasting]" (resident 2, private development).

As such, their enthusiasm and satisfaction with the technology was related to three main aspects: its investment value and their belief that it would add more value to the property if they were to sell their house; the direct savings in their electricity bills that all of those interviewed had reported, and the possible high energy rating the house would have (given that the properties are insulated and double-glazed as well) when it comes to new legislation on sales and the requirements for the Home Information Packs. One of the residents noticed significant decreases in her family's electricity bill:

> "I think it is great because for the electricity we get, they pay us back for it. In the end, the bill is almost nothing, so it is very useful. We don't pay a lot and I think that is great" (resident 4, private development).

Most of those interviewed reported receiving payment for the electricity generated from the utility company. As one homeowner commented:

> "For a family of four, I don't think the bills have been up, and when I compare with some of the lads at work, they would expect to pay each a quarter what I pay for a year. They would expect to pay hundreds of pounds. And also, once a year they send me back a rebate, because it actually generates electricity and puts it back in the system, which is lovely. So once it was more then 50 pounds but last time it was only 30 pounds, but maybe the sun hasn't been shining" (resident 5, private development).

In addition to the above characteristics perceived of the technology, some of the residents valued the technology for its environmental qualities. This was mainly expressed in the context of increased awareness of the climate change problem in the media and in schools. In this respect, they acknowledged that PVs could be considered as 'doing something for the environment', similar to turning off the lights when not needed or buying energy saving light bulbs. Nevertheless, they felt that the high cost of purchasing a PV system for the home compared to the financial returns, would not make it an attractive renewable energy source. If given the choice, seven out of the nine households interviewed said that they would opt for a cheaper renewable technology or one that would give them higher returns in a shorter time, such as solar water heating. In general, the view was that despite the savings, the cost of the technology makes it prohibitive. In fact, all those interviewed admitted that they are quite happy to benefit from a technology which they did not have to pay for, as one resident stated:

> "For what they cost, I think it takes a while to recoup the money. If I was doing it myself, I wouldn't go for it. I mean, it is good for the environment, but I don't think if it were up to you that you would go out and pay that kind of money" (resident 1, private development).

Owing to the fairly comprehensive information pack and the handover practice, there was not any difference between residents who had bought their property when it was first built – primary owners – and those who bought the property recently. Both types of homeowners had some knowledge about the workings of the technology and had used the display monitor. Residents who rented the property (two out of the nine) had less information about why it was installed and the expected savings it could have. Nonetheless, they did report cheaper bills compared to other homes that they lived in previously. According to a resident who was renting:

> "We use the same amount of electricity that we use before; I turn on lights and also the things in the kitchen, but it is a bit cheaper and we get money in the end" (resident 4, private development).

Despite the information made available to the homeowners after the installation, only one resident knew about the availability of government grants if she were to install photovoltaics on a new property. The new interest in the technology was mainly due to the savings and the benefit that it entails, which prompted her to seek more information about it. Accordingly to her:

> "I was viewing the house [before buying it] and was told that it would have photovoltaics on it. I wouldn't have considered them because of the money, but now I would as I do benefit from them. You can get government grants now. I looked on the internet and you can get money to install them in your home" (resident 3, private development).

Several points are worth making in relation to the residents' statements above. Whist little or no savings were experienced by the tenants in the social housing, the residents in the private development were able to benefit directly from the technology, and perceive these benefits in lower electricity bills and financial gain. As I argued earlier in chapter six, the different approaches to the design of the photovoltaic systems in the social housing and the private development, and the underlying constructions of the users as imagined by the project managers, have influenced how residents conceptualised and used the technology. In this thesis, I highlight that the absence of the user in the planning of the PV installation for the social housing project has led to a situation where the existence and functioning of the technology on the block of flats is hardly felt by the residents, despite the relative visibility of the panels on the roof and the installation of the display monitors in the hallway. However, the residents of the private development project were given more information about the technology, had a more visible display monitor and were given individual consultations when they moved into their new homes.

In saying that, I do not exclude other factors that might have contributed to the performance of the technology. The monitoring of the installations should shed light on the performance of the panels in each case, comparing different types of panels, their location and building site characteristics. However, at this stage the analysis of the system performances is aggregated (BRE, 2005), and hence it was not possible to compare the two cases in that respect. The availability of this detailed information in the future could make further analysis of the case studies (including the functioning of the technology) possible.

In a study about photovoltaic systems on social housing in the south of England. Bahaj and James (2007) conclude that the effect of photovoltaics in terms of savings in household electricity consumption was considerable for only the first few months of the installation, when the information provided and the novelty of the installation wore off after a few months. The residents would revert back to their old ways and abandon the energy saving behaviours that were encouraged by the fresh presence of the PV system. In this research, the residents of the social housing did not perceive any savings on their utility bills and none of them reported a change in their consumption. Seen this way, the results agree with the above literature, with a lack of correlation between the existence of the energy system on the technology on the roof and the residents' energy consumption. Therefore, the presence of the technology by itself did not necessarily lead to sustainable changes in user behaviour.

Furthermore, studies on the deployment of photovoltaic energy systems argue the need for feedback on energy consumption (Darby, 2006) and on-going education (Bahaj and James, 2007; Sauter and Watson, 2007; Watson, 2004) to achieve the anticipated benefits in terms of reducing energy demand and lowering carbon emissions. A study conducted by Dobbyn and Thomas (2005) compares the behaviour of three groups of householders, these are: householders who have actively purchased microgeneration technologies, those who moved into homes where such technologies were already installed, and mainstream households with no microgeneration device. Whilst the active purchasers reported changes in their energy consumption, the study found that households with microgeneration installed through the City Council or Housing Association showed greater understanding in environmental issues and were more likely to adopt energy efficiency measures compared to households with no microgeneration installed. Moreover, these behavioural changes varied between those users; the change was more likely in situations were the housing association or council provided information, and clear and simple instructions on how to maximise the technology's efficiency.

The results from my research have shown that information about the photovoltaic technology was effective in familiarising residents with the panels and ensuring that they report failures and maintenance needs if necessary. The knowledge about the system apparent in the interviews with the private development residents was reportedly due to the personal visit paid by the Consultant to their homes early in the project. The householders were given a tour of the photovoltaic system in their home, from the convertors and switches in the loft to the meters in the cupboards. As such, the information pack was never referred to directly as a source of knowledge about the technology. In the conversation from one of my interviews below I probed about the information pack, with the interest of locating its use in relation to the technology:

> "They came and gave us information about the panels; I've still got [the file] somewhere. They also gave us a whole manual on it. I've got a full manual somewhere upstairs as well.
>
> D: What did it contain in terms of information?
>
> "I don't really know as I've never been through it" (resident 3, private development).

In fact, most of the residents interviewed in the private development did not read the information in the pack, have never referred to it and had it stored away from the normal living spaces. As such, the "big black ring-binder" (resident 6, private development) was "somewhere in the loft" (resident 2, private development), or "upstairs, gathering dust" (resident 5, private development). This aspect of the use of information resonates with the residents in the Housing Association. The tenants who lived in the flats during the installation project remember that leaflets were sent by post, however, they "didn't remember what was in it" (resident 1, social housing) or "never got around to reading it, to be quite honest with you" (resident 7, social housing), as one of the residents stated. Whilst I have discussed in the previous chapter the different content of the social housing leaflets and the private development home information pack, in this section I wanted to highlight the user perspective with respect to the documentation provided. In both case studies, the residents had rarely referred to the material and had only consulted it when they had come across a maintenance problem.

In this section I have shown how users in the social housing felt little or not benefits at all from the photovoltaic panels, whereas those at the private development expressed their satisfaction with the technology. Residents cited energy savings, financial rewards and the investment value of the technology; however, they also appreciated its environmental credentials and took pleasure in its aesthetics. As such, these two case studies show the possible uses of this renewable technology in the domestic sector, and also demonstrate what could be understood as a form of non-use of photovoltaics, where residents did not interact with the technology. In doing so, the examples above have shed light on the influence of the residential context (rented social housing or owned individual homes) and the design of the system (export meters, the types of display monitors and their location) in how users interact with photovoltaic technology.

Having explained how the system was perceived in the built environment, in the next section I will illustrate the various instances where the users were able to make use of the PV system in their domestic spaces in the context of housework and the existing sociotechnical landscape of their home.

7.2.3 Housework, household appliances and energy saving

According to Shove (1998), the debate on energy matters concerning conservation and carbon reduction has failed to grasp the logic of energy use. The dominant discourse focuses on energy conservation and financial savings, whilst ignoring the perspectives' of households where the use logic of energy centres on comfort and convenience. It is important, therefore, when studying energy use in the home to consider notions of everyday 'normal' conveniences and consumption practices (Shove, 2003; Wilk, 2002). With an interest in how people might use photovoltaic technology, I attempted to explore their everyday habits around the house, and their subsequent interaction with the technology.

The relationship of the users with the photovoltaic technology can be explored in their use of typical household electrical appliances. During interviews with the residents of the private development, talking about the photovoltaic panel involved talking about how they used the electrical appliances, on what occasions and for how long. Many of those interviewed stated that when they were performing housework activities, they would look at the monitor to assess how much electricity the household appliance was using and then compare it to other electrical devices around the house. As on resident explains:

> "It is useful sometimes when you put certain electrical appliances to see which ones use the most. For example, when you put the kettle on you can see the difference it makes in terms of the energy it uses" (resident 8, private development).

Shove's (2003) ideas about comfort and convenience figured strongly in exploring the use context of photovoltaic technology for this research. It was interesting to examine how the addition of the photovoltaic system to the modern homes influenced their use, and how the photovoltaic technology was 'domesticated' as a result. As literature in the field of STS suggests, it is indeed more useful to study the use of renewable energy technologies as part of a host of everyday practices, preferences, attitudes, existing technologies and material infrastructures (Aune, 2007; Chappells and Shove, 2003; Guy, 2004; Shove, 2003).

Indeed, the residents living under the photovoltaic system had certain expectations from the services supplied to their home. Residents in both case studies sought services like entertainment with large television sets, information through computers and the internet, as well as countless other activities related to housework, cleanliness and convenience. As one resident interviewed commented:

> "It is nice having it you see. Once we had the washing machine on, I was watching TV in the living room and the kids were upstairs with their computers and TV and all that. And [my partner] was checking the system and apparently 30% of the energy consumed was generated by the PV system, and that is nice" (resident 5, private development).

Whilst some residents were quite happy to benefit from cheaper energy bills despite maintaining the same level of energy usage, others felt more conscious of their energy consumption and had taken various actions to reduce it. One resident talked about the evening meal:

> "We've got a double oven in the kitchen, one is small and the other a bigger one. So, because of the panels on the property, we consciously use the smaller oven. Also, you are very aware of how much electricity the oven uses, for example" (resident 3, private development).

Hence the use of the photovoltaic system, including all its components, depended largely at the context and time of use, and the activity taking place around the house. Some of the cases explored above resonate with the 'double dividend' of implementing photovoltaics, which is the reduction of energy consumption in the home and the use of energy from a renewable source resulting in twice the benefit from PVs (Keirstead, 2007b). In others, however, there is a sense of satisfaction with the financial benefits derived from the technology. However, like Shove (2003), I argue that in all the cases, the use of the technology was viewed and expressed through the utilisation of various technological appliances present in the home, and the services expected from them.

What was also evident in the residents' use of the display monitor was their interest in knowing how much energy certain appliances consumed. In a sense, some residents were able to gauge their energy use and subsequently alter their expectations regarding the volume of energy they would be able to sell back to the grid. One resident in the private development whom I interviewed expected lower bills because he spends a significant time in another part of the country, and because his children live with their mother and only visit on weekends and holidays. As such, his expectation regarding the volume of energy sold back to the grid is significant in his perception and use of the technology:

> "I like to have a look [at the display monitor] to see what level of energy [the panels] are generating and how much we are using. Nine times out of ten, unless we're doing something like ironing or hovering [vacuum cleaning] or using large amounts of electricity like the dishwasher, I always seem to be generating more then what I'm using" (resident 1, private development).

As I discussed earlier in chapter six, the concepts of 'scripting' and configuring users – as developed by Akrich (1992) and Woolgar (1991a) – were helpful in analysing the way project managers imagined, designed and installed the photovoltaics system. In this chapter, I have focused on the de-scription, or the reading of the technology by the users. My intention was to show how the scripting has shaped the context of use and the relationship between the system and its users, but I also wanted to explore how the residents used the technology and the different readings that they made from it in the context of their everyday lives. Through developments in household consumption studies on the use of energy and its services, I was able to highlight the importance of examining the use of photovoltaic energy through household appliances, technical structures and everyday practices. In this research, I argue that the residents used the PV system in relation to three aspects in their homes: the perception of the panels on the house, the consumption of energy and day-to-day household activities. Hence, the interaction with the PV system was situated in the everyday activities of the home. In the next section I look into the domestication of the technology in these use contexts.

7.2.4 Locating the display monitor/influencing electricity use

As I discuss above, whilst some residents felt more conscious about how much electricity the house consumed, the majority did not refrain from using household appliances with high energy consumption like dishwashers, tumble dryers, large flat-screen televisions and hi-fi systems. Such lifestyles are in line with what Shove (2003) would describe as the general pattern of increasing energy consumption. The combination of these various technologies in the household's sociotechnical landscape can "construct and script collective notions like those of domestic propriety, not to mention conventions and practices of well-being and everyday life" (Shove, 2003: 196).

Silverstone *et al.* (1992) look into how technological artefacts are positioned with respect to other technologies and conventional practices. They argue that how this artefact is positioned affects its meaning with respect to its user. As such, the consumption of the technology is a "transformative and transcendent process of the appropriation and conversion of meaning" (Silverstone *et al.*, 1992: 4), where the artefact is thus remade depending on the way it is deployed and the socio-cultural context in which it are used. Seen this way, technological artefacts are 'incorporated', whereby they become part of the users' routines and everyday life.

In the earlier sections, I argued for the necessity of thinking about the use of photovoltaics in the context of everyday energy consumption. Specifically, I maintain that in analysing the sociotechnical spaces in the home, one should keep in mind how the design of the photovoltaic system configures its use, and the users into particular roles based on the project managers' visions of these users.

Earlier, I mentioned how residents in the private development project used the display monitor to check the performance of the system or see how much energy they are consuming. In this section, I will explore how the location of the display monitor is significant in relation to the residents' use of, or interaction with, the technology. As mentioned in chapter five and chapter six, deciding on the location was based on the project managers' expectations of what users want (sleek and tidy modern homes) and do not want (visible display monitors in the hall) that a decision for locating the monitor was reached, in the case of the private development project. In the case of the social housing, the decision was made based on the priorities of the project managers, which were influenced by their budget constraints and time schedule. In addition to showing the negotiated nature of technological diffusion, the results from this study suggest an influence of the location of the monitor on the manner by which the users interact with the photovoltaic system.

In the private development, seven out of the twelve homes had the display monitor in the utility room whilst the rest had it installed in the cupboard in the hallway. Results from my interviews and discussion with the residents suggests that those who had the monitor in the utility room had more access to it and were more likely to look at the status of the photovoltaic system whilst doing housework or working in the kitchen. One resident, who had the display monitor in the cupboard, admitted to rarely looking at it:

> "Yeah, it is in the cupboard. I look at it very rarely. It is over there. It shows you how much it is making today, how much per week, and how much in the month and the year. And that's the total. I very rarely look at it" (resident 7, private development).

Moreover, when interviewed, the respondents associated the technology with activities in the home which are more likely to take place in the kitchen and utility area (using the oven or the kettle, doing the washing, etc.). The general consumption of the household was more likely to be mentioned by residents who had their display monitor hidden in the cupboard.

Whilst these distinctions can suggest a dominant use pattern depending on the location of the user interface, they should in no way be regarded as fixed. The use pattern will also depend on how residents utilise the various spaces within their built environment. One example is that resident 3 had her display monitor on the wall in her utility room. However, due to her (and her partner's) habit of leaving the house from the back door – which has easier access to the garage – the effect of the display monitor on their daily perception of energy use was greater.

To summarise, I have attempted in section 7.1 to draw a picture of the use of the photovoltaic system in the household context. In doing so, I considered the various aspects of the system's use in relation to the existence of the photovoltaics on the roof and their use inside the house. I then described how using the photovoltaic system cannot be analysed in isolation, and that attention should focus on everyday activities in the home. In the following sections, I describe in more detail the technology's different modes of use and suggest a more helpful way of thinking about its users.

7.3 Challenging user constructions: the users and uses of photovoltaic systems

Different users emerge from analysing the interaction of the user with the PV technology. The research shows that users can engage in different ways with the technology through their energy consumption and their use of the display monitor. Four different 'types' of users appear: the 'conscious' user, which is a grounded notion from the residents' reported engagement with the technology; the 'opportunistic' user; the 'interested' user who shows interest in the technology itself, and the non-user. These distinctions are not meant to divide users into different groups, and I certainly do not claim to represent the users in a more 'truthful' light. Rather, the four types of users highlighted below are presented as analytical categories or constructions that can suggest the various (and sometimes unexpected) ways that users can engage with photovoltaic energy technology. Like Aune (2007), these analytical categories "convey an understanding of a complexity that is far from the 'rational consumer'. Economy matters, but economical considerations are integrated into an everyday life setting" (Aune, 2007: 5464). As such, these categories of users are set against the 'user constructions' assumed by the project managers, echoing Akrich's (1992) call for analysing the "projected user" and the "real user" (Akrich, 1992: 209).

7.3.1 The 'conscious' user

> "I think it makes you more conscious of how much electricity you use, and as a result you take steps to reduce it" (resident 1, private development)

The notion expressed by this resident represents several respondents in the private development project. In some cases, the presence of the panels on the roof was sufficient in making them think about the energy they consume in their home. As one resident put it:

> "It made me a bit more conscious of the energy I use during different times of the day. It probably made me a little bit more careful for heating and lights on timers not to come on unless it is absolutely necessary. It just makes me think of it because you've got the physical presence of the display monitor in the utility room and the panels on the roof" (resident 8, private development).

As mentioned earlier, several authors have looked into the behaviour of householders living with photovoltaics (Keirstead, 2007b) and other renewable energy technologies (Bahaj and James, 2007; Dobbyn and Thomas, 2005; Haas *et al.*, 2004) and suggested that such microgeneration technologies can create "opportunities for consumers to become more aware of their energy use and its impacts, thereby encouraging demand management" (Keirstead, 2007b: 4129). Whilst these studies point to an interesting use of renewable technologies and perhaps a new meaning for microgeneration, their analysis remains based on a behavioural model, which assumes energy consumption as a rational activity that can be facilitated or hindered through the introduction of suitable technologies (Aune, 2007; Guy, 2004; Shove, 1998). In this study I argue that the influence of the PV systems on the residents' behaviour cannot be analysed in isolation.

Hence, the impact of the technology on behaviour is the result of the PV system's design, which is manifest in the location of the display monitor on the one hand, and the sociotechnical networks that shape the users' everyday social practices in their home.

Accordingly, the conscious users reported their acquired knowledge of consumption levels in their homes after looking at their display monitor. I argue that the visibility of the display monitor played a major role in the formation of such knowledge, bearing in mind the contingent nature of such knowledge. In most cases, the residents had "by chance" looked at the monitor or "because it was there" have had a look, and as a result were able to conceptualise how much energy they consume at different times of the day. As one resident recalls:

> "By not having the panel in the previous properties that we've lived at, you have no concept of how much electricity you use. Because of the [display monitor] in the utility room – we tend to go in and out of the back door a lot – we look at it and think 'Wow! Look how much electricity we have used'. And you're also very conscious and it makes you much more aware of which electrical appliances are on in the property" (resident 2, private development).

The awareness of the residents regarding their electricity consumption is acted upon once an unnecessary use of electrical appliance is detected. According to those respondents, in the absence of the display monitor such detection would not have been possible. In several cases, unnecessary use was through appliances that could be 'hidden', such as phone chargers left switched on in the plug socket, electric heaters on timers in rooms that are not occupied, or game consoles and computers that children forget to turn off. One resident reported an incident involving her friend's daughter who brought with her a portable games console. The child charged the console before they left the house, and as they were leaving the respondent spotted the registered consumption on the display monitor. As she explains:

> "Because we got out of the back door a lot, it catches your eye. So when the [games console] was on, [the display monitor] here

clocked around 10 kilo watts, so we thought that something was wrong. We quickly went inside and took the charger out of the socket" (resident 2, private development).

Therefore, the consciousness of the residents regarding the photovoltaic technology depends on the visibility and location of the display monitor, such as being looked at during day-to-day activities. Whilst the presence of the photovoltaic panels on the roof had in some cases reminded householders of their energy, in most cases the reference to the PV system and their energy consumption related to the display monitor. The conscious user, hence, was likely to take steps to eliminate unnecessary or unwanted energy consumption. As such, their action depended on what they perceived as wastage when it came to household energy consumption. Their interest was not only economic, but also related to their attitudes towards wastage and their preferences regarding what constitutes a comfortable and welcoming home. However, their energy saving action was influenced by the design of the photovoltaic system and its presence within the household environment (Silverstone and Hirsch, 1992). In line with STS research on energy (Guy, 2004; Shove, 1998), the consumption of energy in the home should be treated as a complex activity. As such, it is important to "identify how specific social, spatial, and temporal configurations of energy consumption encourage, or mitigate against, effective energy-saving action" (Guy, 2004: 695).

Similarly, this research has shown how the residents' view of what is comfortable and convenient is sometimes related to their use of energy services, such as heating and lighting. In the context of being conscious of energy consumption, the residents' views on what is considered necessary for the normal functioning of their homes and families determined their behaviour. In other words, whilst the users in this case were more aware of how much energy they were consuming, that was in the context of what they believed a normal household's heating and lighting level should be. As one interviewee added:

> "[The photovoltaic technology] makes you think about being economic without the house being cold and without necessarily sitting in the dark. It makes you stop and think whether we need all

the lights on at a certain hour so I turn them off. It gives you a mindset which you never had before" (resident 8, private development).

As the resident above stated, such 'consciousness' was not experienced prior to living with the photovoltaic technology, especially regarding 'hidden' types of energy consumption, as the example of the games console charger discussed earlier. This type of experience with regards to the photovoltaic system can be described as a mode of use, and we can thus conceive of a 'conscious' user in relation to the technology in focus. The quotation below best summarises this view, contextualising it, as such, within everyday practice.

> "[The photovoltaic technology] makes you very aware of things like charging your mobile phone, because quite often you plug the mobile charger in and you might leave it 'switched on' on the wall, but your phone is now charged and you go off to work. However, it is still drawing electricity out. It makes you more aware of things like that. And I didn't know that until we moved in and started using the panels" (resident 2, private development).

7.3.2 The 'opportunistic' user

The other mode of use evident from this research involves the operation of specific household appliances in relation to the functioning of the photovoltaic panel. With an understanding that on sunny days the generation of the photovoltaic panel is greater, which is backed up by the reading on the display monitor, these residents reported using additional electrical appliances to aid them in their housework. For example, one resident admitted using her tumble dryer when the generation of the PV panels was high, justifying it with the fact that she has recently had a baby and needs to do more laundry. Responding to my question about what she thinks about the technology:

> "I think it is excellent. I think it is generating about a third of my electricity so now I can use appliances like the tumble dryer and the dishwasher when I am generating electricity" (resident 3, private development).

This 'opportunistic' mode of use has occurred in many cases with the necessity of maximising convenience whilst benefiting from the technology. As such, the resident has taken the opportunity of increasing their energy consumption at the time when the photovoltaic panel generation is at a maximum. Another resident had shifted the time for performing housework in the interest of maximising economic gain. As she explains:

> "When I have to do the washing and it is raining cats and dogs outside, and if I have enough clothes in my wardrobe, I wait until it was sunny before I would do my washing because that way it is for free" (resident 9, private development).

Therefore, the 'opportunistic' user can sometimes reduce their energy consumption if they use their household appliances during the day whilst the panels are generating more energy, without increasing their normal consumption levels. However, as is shown above, that is not always the case. In some cases, the presence of the photovoltaic panels helped maintain a high consumption of household electricity. For families with children, such as resident 5 (private development), it was "nice" to have two or more computers on, as well as a television and other kitchen appliances, which were on at the same time whilst the system is generating energy. The expectation that such behaviours are now possible without an increase in the energy bill was reported as a positive aspect of having photovoltaics on the roof.

Load shifting, whereby users change their behaviour by using appliances they need during the day, is encouraged in the literature on photovoltaics in order to maximise the benefit from the technology and, as a result, increase returns. Keirstead (2007b) discusses load shifting as a behavioural change related to peoples' rational economic interest, whilst Denholm and Margolis (2007: 4432) talk about "a number of 'enabling technologies' that could potentially utilise excess PV production", such as timers on appliances and smart metering technologies thereby ensuring the correct use of photovoltaic technology. The interest in this literature is in obtaining a "double dividend", the result of lower energy consumption (Keirstead, 2007b: 4129).

In this study, I point out that such behaviour was reported from the residents but has not always been in the interest of reducing electricity bills. In fact sometimes the same 'opportunistic' users reported load shifting for different reasons depending on the situation that they found themselves in, and the needs they had to satisfy in terms of running a home with children or a large family.

7.3.3 The 'interested' user

The category of the interested user pertains to the respondents' reported fascination with the technology itself, without necessarily associating it in the context of electricity generation or utility bills. It is in contrast to the assumed indifference of residents as reported by the project managers. Such interest is expressed in the residents' gaze at the display monitor as it showed the amount of electricity generated by the system. The 'interested' user was more likely to be interested in electronics, the functioning of a technology such as photovoltaics or the novelty of having a modern electric device in the home. One resident commented on the "sleek, modern reader" as a positive aspect of having a photovoltaic technology, making it favourable compared to other microgeneration technologies. When asked what she liked about the technology, another resident mentioned the display monitor before anything else:

> "It was quite interesting to see because it would have a picture of the sun when the system was generating. The monitor clocked up the number of units that had been created by the panels so you know exactly what units had been created that week and that month" (resident 9, private development).

For those users, the display monitor was useful in demystifying the workings of the technology, allowing them to feel part of the system as they utilise different appliances around the house to see how much energy they generated. These users reported satisfaction in knowing about photovoltaic systems and how they function, how much energy different devices consume and which settings would use more or less electricity because it is "nice to know" (resident 5-private development). As another resident explains:

> "My husband looks at it to see how much energy we get from the sun. I don't know why, he is always looking at electrics and things like that" (resident 4, private development).

> "I turn on different [appliances] around the house and come and have a look [at the display monitor, you see. It is interesting" (resident 1, private development).

Whilst such modes of use are less prevalent than the two former categories, it is nonetheless important to conceive of such as user. As mentioned earlier, this aspect of the user-technology relationship challenges the configured use of the technology by the project managers as in this case, and the dominant literature concerning the correct and effective use of the technology. As was shown in chapter six, the project managers constructed users purely in terms of their interest in environmental causes and their pursuit of economic benefits. By conceiving of a user interested in the technology *per se*, we can – therefore – further the argument that calls for more focus on system design when it comes to implementing photovoltaics in domestic built environments.

Moreover, such users can be said to have 'de-scripted' the technology (Akrich, 1992), by challenging the boundaries built around the technology with respect to how it should be used and how it configured the user (Woolgar, 1991a). The dominant discourse on the use of photovoltaics limits the user's space to that of consuming energy and relating such use to the technology. The design of the PV systems in the two case studies is in keeping with this idea, where the actions and interests of the users where limited to energy consumption, and the performance of the technology is presumed to be uninteresting to the everyday practices of the residents. In fact, one of the perceived advantages, as echoed by the project managers in this study, is that the users of the photovoltaics do not have to do anything with the system and do not have to change their behaviour. However, when thinking about the 'interested' user, one can start to imagine different modes of use outside the expectations of designers and mediators (Kline, 2003; Lindsay, 2003).

7.3.4 The 'non-user'

Having discussed so far three different types of users that emerge fr om this research, in this section I present a fourth category, that of non-users. Historically, users have been neglected in technology studies (Mackay and Gillespie, 1992), and including them is important to avoid the focus on the powerful actors in the development and diffusion of technology. However, as Wyatt (2003: 69) argues, focusing on use and users alone introduces another problem, as "we implicitly accept the promises of technology and the capitalised relations of its production", and thus urges her readers to study users in relation to non-users. In her earlier work on the non-users of the internet, Wyatt (2003) constructs different categories of use and non-use and argues that there are different types of non-users (Wyatt, 2003: 76). In a previous study conducted by Wyatt *et al.* (2002), the authors list four different types of non-users: resisters, rejecters, excluded and expelled. The four categories of non-use varied according to the individuals' preferences, capabilities and the institutional infrastructures that determine their status with respect to the internet.

The category of the non-user emerges in my analysis. All the residents in the social housing project were non-users because they were hindered from interacting with the photovoltaic technology or its interface. As such, they could not associate their electricity consumption to the functioning of the technology. However, in applying a more nuanced understanding of non-use, it is important to indicate that their non-use was configured in the design of the technology. By imagining the users as ignorant and passive about the environment, the project managers at the social housing installation effectively designed-out their potential users, resulting in what I refer to as a passive non-user. In this case, the construction of the 'passive user' resonates with the category of non-users as it highlights the process of 'scripting', which took place in the design of the PV system.

Another category, or sub-category, of non-use is that of an active non-user. These residents were living in the private development project, where householders were more likely to engage with the technology and where residents were given sufficient information about the PV system. However, these non-users chose not to engage with the technology. In one case, their decision was related to their general disinterest in technologies such as photovoltaics. As this resident pointed out:

> "It doesn't really bother us to be honest. It is only that we get so much money at the end of the year. We don't mind having it but we don't have anything to do with it" (resident 7, private development).

Another resident renting a house in the private development did not believe that photovoltaic technology is suitable for the UK climate. By not perceiving any benefits from the technology, the householder in this case did not interact with the technology nor mind its existence on the roof. Whilst expressing interest in energy efficient technologies in the home, this resident described his use of the photovoltaic system as such:

> "We would like to have more energy reducing things in the house, but the UK needs different things like insulating your roof. I think solar panels are not very cost effective" (resident 6, private development).

When asked later on in the interview what he thought about the display monitor, the respondent acknowledged looking at the monitor sometimes; however, he could not see the benefit of the display monitor in the house:

> "I mean, when the panel is working normally, there is nothing you can do. You can not influence the energy generation. So, no, I don't really use the monitor" (resident 6, private development).

This resident's preferences resulted in a form of non-use stemming from his own beliefs regarding the technology, its performance and role in energy consumption. Table 7.2 summarises the different types of users that emerge from these two case studies.

Table 7.2 Analytical categories of the different PV users

Type of User category	Description
the 'conscious' user	These users are more aware of their energy consumption and seek (by employing the display monitor) to change or modify their energy use habits
the 'opportunistic' user	These users consume more electricity during the times when the PV system is generating the most energy (such as midday or on sunny days in summer). Their excess consumption is related to their requirements for convenience and comfort.
the 'interested' user	This user is fascinated by the technology itself, its workings and general performance.
Non-users	
Passive non-users	Non-users who were designed-out of the PV system implementation. This research argues that this mode of user is 'scripted' in the design of the installation, especially in the case of the social housing project.
Active non-users	Non-users who chose not to engage with the technology due to disinterest or the belief that it is not suitable or effective for tackling climate change in the UK.

Therefore, in thinking about the use and non-use of photovoltaics, one can notice slight variations in what can be considered use and non-use of the photovoltaic system. The residents varied with respect to their interaction with the technology, from householders becoming increasingly conscious of their energy consumption, to opportunistic users who wanted to benefit from 'free electricity'; and from interested users who are satisfied with owning a PV system in their homes, to others who do not relate to its presence or performance. Wyatt suggests further studies to incorporate non-use in STS and argues that the user "should be conceptualised along a continuum, with degrees and forms of participation that can change" (Wyatt, 2003: 77). Changes on the continuum can occur due to alternations or modifications in the sociotechnical contexts within which non-use categories are defined. The examples in this research show that different sociotechnical landscapes resulted in different categories of users, including the non-users of PV systems. I argue that differences in use were 'scripted' in the design of the PV installation and the varying contexts of use. By pointing out the importance of installation design and use contexts, I argue that studies on the diffusion of energy technologies can benefit from further research into non-use. In doing so, we can examine in a more informed manner why some energy technologies fail in their diffusion instead of choosing to interpret it as user ignorance and indifference.

7.4 Conclusions

The purpose of this chapter was to describe the users' perspective regarding the implementation of solar photovoltaic technology in their homes. This chapter discusses the way the users interacted with the technology, and effectively used it in their homes. My analysis focuses firstly on the different contexts within which the residents incorporated the technology into their everyday activities in line with the work of Shove (2003), and secondly on the emerging modes of use that can be observed in these contexts.

My intention, thus, was to explore the metaphor of 'technology as text' (Grint and Woolgar, 1997), but to focus in particular on the way the users 'read' the technology. My analysis is also influenced by the concepts of actor-network theory and in particular the work of Akrich (1992) which explains how designers congeal in technological designs the scripts which shape how the users can interact with the technology. This script, accordingly, can be 'de-scripted' by the users. As a result, they can develop different ways of using the technology, some of which are contrary to the designers' intentions. Thus, in this chapter, I showed how the users' interaction with the technology, performed through its interface – the display monitor, was in some cases occurring in accordance with the script, most evidently in the non-users of the social housing project.

In other cases, the 'conscious' users' awareness of energy generation and consumption, though desired, was not the initial intention of the project managers in the case of the private development. The Energy Consultant's intention to educate users about their energy consumption was dominated by the priorities of the private developer, and the implicit notion that the technology functions independent of users. Another interesting category of use is the 'opportunistic' user', where the interest was in maximising comfort and convenience and hence consuming more electricity because the PV system provided it freely. I also highlighted the 'interested' user, where the interest was in the functioning of the technology in itself regardless of the savings it leads to. The different types of users, thus, suggest the various ways that users can de-script technology, challenging the designers' intentions and 'reading' the text in different ways (Woolgar, 1991a). Applying the work of Akrich (1992), this research has shown that the intentions of the project managers – and the way they imagined its use –

were not always acted out according to the script. Similarly, exploring the metaphor of 'technology as text', one can argue that the residents developed varying readings that differed from the text configured into the technology's design.

As Woolgar (1991a) notes, configuring the user "never guarantees that some users will not find unexpected and uninvited uses for the machine. But such behaviour will be categorised as bizarre, foreign, perhaps typical of mere users" (Woolgar, 1991a: 89). In presenting these user categories, or modes of use, I wanted to highlight the different mechanisms that shaped the residents' use of the technology and hopefully dispel such judgements of users in relation to RETs. As these two case studies have shown, the residents' beliefs, priorities, circumstances, knowledge, and the one hand, and the design of the technology in their homes/building on the other hand, have effectively shaped their interaction and use of the technology.

CHAPTER EIGHT

Conclusions: Analysing Renewable Energy Technologies and their Users: from a Technoeconomic to a Sociotechnical Perspective

"Close inspection of technological development reveals that technology leads a double life, one which conforms to the intentions of designers and interests of power and another which contradicts them – proceeding behind the backs of their architects to yield unintended consequences and unanticipated possibilities" (Noble, 1984: 325).

8.1 Introduction

The implementation of renewable energy technologies can be an effective policy measure towards achieving lower carbon emissions and securing energy sources. Moreover, these technologies could be helpful in tackling fuel poverty as well as being a source of green electricity. However, like most environmental technologies which are new to markets and society, RETs face the problem of slow uptake (Guy and Shove, 2000; Henning, 2005) "even if their technical design seems promising" (Rohracher, 2005a: 201). As I argue in chapter two, energy related research has consistently called for favourable market incentives to promote RETs, whilst stressing the need for supporting new and innovative technologies to leap the barriers created by market mechanisms and imperfect information.

Whilst the focus on environmental awareness and consumer knowledge has its value, when it comes to new technologies such as photovoltaics or other microgeneration technologies in the home, a more thorough analytical framework that does not separate technologies from their social and cultural context is required (Henning, 2000; Ornetzeder and Rohracher, 2006; Rohracher, 2006a). A theoretical perspective from STS, which focuses on the relationships between humans and technologies and on the socially shaped nature of technology, can thus provide an effective analytical perspective to the diffusion of renewable energy technologies.

This thesis overviewed current research within the social sciences on energy and RETs, adopting a sociotechnical perspective in their analysis. The research thus builds on theories from STS concerning users (Akrich, 1992; Oudshoorn and Pinch, 2003; Woolgar, 1991a) to reflect on the application of photovoltaic systems in the residential sector in the UK. I argue that the design and use of energy technolo gies such as photovoltaics was increasingly dependent on the specific social contexts into which it was introduced; the way the photovoltaic system was designed, installed and used; as well as the design features and technical characteristics that this technology has.

Moreover, this study finds that analysing the implementation of photovoltaics as a process that is constantly shaped and negotiated by the different social, technical, cultural and institutional circumstances within which it exists can be valuable in formulating an understanding of how RETs can be successfully adopted and used. The two case studies, which were part of the Photovoltaic Domestic Field trial, show how different combinations of actor-networks were formed around the technology, as the actors involved engaged in a process of 'translation' and the building of associations in order to secure the projects' completion. The two projects were hence an entry point in analysing the role that various actants play in shaping the technology's installation and use. In particular, the interest of my research was in how the users were constructed during this process; and the implications this had on the installation design on the one hand, and how the users used (or did not use) the technology, on the other hand.

In this chapter, I revisit my research questions and the arguments expressed earlier in chapters six and seven, namely the design and installation of the photovoltaic technology and its appropriation by the residents. In doing so, I wish to emphasise the processes that shape the technology's design and use, or what Jelsma (2006a: 69) refers to as the "design logic and use logic". I have adopted the notion of 'technology as text' (Woolgar, 1991a), suggesting the various ways photovoltaics can be both written (designed, implemented and configured or scripted in practice) by the project managers and read (adopted, appropriated and de-scripted) by the users. In the following sections, I will outline the main arguments inferred from my study on photovoltaic systems and their users in the home.

8.2 Designing photovoltaic systems: imagining users/shaping technology

In this section, I will revisit the research questions posited at the beginning of this thesis. The first two questions concern the actors involved in RET implementation and their role in shaping RET design and implementation. The empirical work in this research has shed light on the complexity of the implementation networks by highlighting the comparatively larger number of actors involved in the diffusion processes. By following ANT's approach of looking at the role of both humans and non-human actors, this research explores the influence of actants such as the PV technology and its requirements, as well as the effect of the display monitor and the restrictions of the built environment. In doing so, the analysis elicited the different dynamics that took place and that shaped the final design of the PV deployment, as well as the form it took as it was installed on houses and buildings.

I have attempted to answer the second research question on the role of the different actors in shaping RET implementation in chapter six, which analysed the building of actor-networks around the PV installation and discussed the different user constructions that the project managers employed to aid them in making their decisions regarding the role of the technology with respect to the residents. This analysis is my attempt at answering my third research question on the constructions of users during the PV implementation process. The final question on the interaction of users with the technology is hopefully answered in chapter seven, as I describe the relation of the technology to household activities and analyse the emerging types of users (or modes of use) in relation to solar photovoltaics in the home. In the following section, I summarise the main conclusions of this research regarding the social shaping of photovoltaics during their implementation and how sociotechnical factors influenced the photovoltaic system design and installation, and relate this to emerging insights on PV technology diffusion and use.

8.2.1 Configuring the user in RET implementation

Examining the various processes in the implementation of photovoltaic energy technologies in this research highlights two main points: the social construction of the technology as the involved stakeholders negotiated and understood its meaning; and the creation, as a result, of a 'script' that shapes the interaction between the technology and its users, effectively configuring the users' relationship with the technology. The installation of the technology was negotiated through complex sociotechnical systems encompassing regulatory frameworks, organisational practices, financial restrictions as well as knowledge and opinions about photovoltaics and energy use.

As the example of the social housing project shows, the design of the system involving the location of its components (such as meters and display monitors) and their integration into the building was the result of several managerial choices. The decision making process was never straightforward, involving negotiations between the different actors involved in the installation project and the financial and regulatory requirements within which they operated. As such, priorities were set and design decisions were made to ensure the completion of the project within the required schedule and budget. This resulted in a relative distancing of the residents from the installation project, which was reflected in the communication process between them and the project managers. This was also materialised in the design of the PV system, locating the display monitors in the entrance hallway instead of individual flats.

Whilst there were no significant financial constraints for the private development project, the interests of the private sector in the marketability of homes with photovoltaics on the roofs and the developers' reluctance in introducing new technologies, resulted in the varied design of the photovoltaic system across the twelve individual homes. The installation of the PV system in the built environment was – in this case – the result of a complex process involving developers' priorities, their beliefs regarding individuals' preferences and properties, as well as the consultants' and engineers' goals and aspirations regarding the technology, its use and its environmental benefits.

Photovoltaic technology is not a typical technological artefact that can be purchased and used in a household, such as energy efficient washing machines or light bulbs. Instead, the photovoltaic system has to be installed in such as way as to allow sufficient sunlight exposure on the roof panels, in addition to the various connections that are needed inside the home and outside into the grid. The result is a myriad of objects, artefacts and stakeholders: buildings including their design and location; roof structures; the built and natural environment around the house; the people who live in homes and flats, as well as installers, project consultants, developers and local authority bodies who take part in designing and installing the system into the built environment.

In this respect, actor-network theory can be useful in analysing the variety and complexity of the installation processes. By not making any distinctions between human and non-human actors, the interplay between individuals, institutions and technologies can be explored in an innovative way (Lovell, 2005). As such, it can draw our attention to the role played by buildings and roof structures in the design of the photovoltaic system and its consequent use. As the two case studies show, designing the installation depended not only on the intrinsic characteristics of the photovoltaic technology, but more on the design of the built environment onto which this system is installed and the knowledge and beliefs of the actors involved. It suggests therefore that the adoption of RETs such as photovoltaics should be considered and analysed through a more complex and holistic framework, going beyond the merely technical and economic issues that dominate RET research and practice today.

As Rohracher (2006a: 269) argues in his study of the adoption of smart homes and passive ventilation systems, the relationship between technological innovation and its diffusion is a "dynamic and open process where technological artefacts, practices of use and general sociotechnical configurations have to be created, changed and adapted to each other". This process can also be observed in the case of photovoltaics. Analysing the application of photovoltaics in the Netherlands, Spaargaren (2003) states that in addition to the impact that PV applications can have in terms of utility co-provision and consumer autonomy (Spaargaren, 2000), the ways in which the technology was installed and integrated into the built environment varied between different contexts, which consequently affected its use. He therefore calls for a more holistic approach to the study of energy technology implementation, by looking into the social practices that shape the use of energy and related technologies.

Along with this body of research, I argue for the importance of researching microgeneration technologies in their context of use. In my approach, I adopt the theoretical work within STS on the diffusion of technologies to elicit the multiplicity of actors involved in the implementation of photovoltaics on homes and buildings. I also highlighted how these actors, through a process of negotiation and restructuring of priorities and preferences, shaped the installation of the PV system. This resulted in an installation design that differed from that expected by the consortium managing the trial scheme (DTI, 2006b). As such, my research attempts to open the 'black box' of photovoltaics by exploring its construction and reconstruction as it emerges through networks of innovation and production to more complex networks of adoption and diffusion. As Callon argues (1995), the changing dynamics indicates the complexity of technological diffusion and the impact it can have on the designs and use of technology.

Therefore, this research emphasises the change in the design, application and role of photovoltaics as they were implemented in the built environment. Accordingly, the use of the technology was not only affected by the social context consisting of practices and routines, but was also shaped by the design of the PV system during the diffusion process. This study therefore highlights the dynamic nature of technological diffusion, reinforcing the interpretive flexibility of technologies, and the myriad ways of photovoltaics/user interaction.

Furthermore, an important part of diffusion dynamics is the process of constructing user identities (Akrich, 1992; 1995; Jelsma, 2006a; Summerton, 2004). In the next subsection, I will summarise the main findings with respect to the user representations that I brought forth through my analysis of the project managers' perspective. This is followed by section 8.3 which describes the use logic of photovoltaics, drawing attention to the different users and modes of use that could possibly occur through living with the technology.

8.2.2 Images and imaginations: constructing users' identities

Studies in the field of science and technology studies have demonstrated how designers, engineers, and other actors involved in the development and implementation of technological artefacts form specific expectations regarding the attitudes, needs and preferences of the projected users of these technologies (Akrich, 1995; Oudshoorn and Pinch, 2003; Woolgar, 1991a). As such, designers (and their organisations) develop user representations to aid them in anticipating and addressing, through their design, the needs and behaviour of their users. In this research, the project managers therefore developed user constructions that contributed to their decision making and consequently the design of the PV installations. I adopted in my research the notion of constructing the user and 'user representation' by Akrich (1995) to analyse and shed light on the different images of the residents that the project managers employed during the installation process. Three main constructions of who the users are or might be were evident in the project managers of both case studies: these were presented as the 'ignorant' user, the 'passive' user and the 'economically rational' user.

Mostly prevalent was that of the ignorant user. This notion is not far from what conventional or technoeconomic perspectives on renewable technologies present. The deficit model pertaining to the expected ignorance of users when it comes to environmental problems and solutions is common (Owens, 2000) and is reflected in the project managers' rhetoric and decisions about the technology. As such, the managers in the social housing project constructed a user who – coming from a low socioeconomic status – would be indifferent to climate change and ignorant of its threats to humans in the future. Likewise, the potential buyers of lucrative properties in the private development were thought of as indifferent to a new technology in their properties, regardless of their environmental interests. The dominant view was that the tenants should be educated about climate change and how the technology works, and the managers perceived this to be the main reason residents might not accept or be indifferent to the technology.

The indifference assumed by the project managers in both case studies sums up their views on the residents. As such, a construction of a 'passive user' was evident through their decisions, as well as their descriptions of the installation projects in the interviews that I conducted. The passive user was thus uninterested and unengaged in the project, and was limited, as a result of the installation design, to the practical concerns of disturbance and safety as the social housing project shows. Accordingly, the managers of the social housing project designed an installation that would make it possible to tacitly integrate the photovoltaics into the building without causing inconvenience to the residents and potentially risking complaints. That was influenced by their view of the residents' (users') indifference and ignorance, making it more convenient to bypass them and avoiding the need to involve them in any way or to establish firm processes of consultation. Moreover, according to the project managers in both case studies, the user is passive since the technology performs on its own, producing green electricity without any intervention or engagement on the part of the user. This 'delegation' (Latour, 1992) or the construction of the technology as 'tacit' (Brand, 2005) will be discussed in more detail in section 8.3.

Another construction of users relied on their expected economic rationality with respect to the way they would assess the benefits of photovoltaics. The unchallenged assumption from the project managers' perspective is that users must always be interested in maximising their wealth, and therefore a technology with the added value of free electricity – and which could provide an extra source of income – should definitely be welcome by the users. In that respect, the disinterest of the users in the social housing project, and the reluctance of some householders from the private development to sign buy back agreements with the utility company were perceived as irrational behaviour that was "certainly unexpected", as one of the project managers pointed out. These assumptions are quite common in energy research and policy.

Moreover, the 'economically rational' user was strong especially from the private developers' point of view, as they sought to minimise the presence of the photovoltaic technology inside the property. Accordingly, the notions of property buying and the design of home interiors were restricted to economic explanations of investment and profit. As a result, the housing developers insisted on not locating the display monitor in the kitchen as the Consultant had suggested, preferring a more hidden and less offensive place. In so doing, the resulting design facilitated the projected passive relationship between the residents and the photovoltaic system. As I mentioned in chapter two, economics constitutes a dominant paradigm concerning energy efficiency measures and RET uptake. As Henning (2000) finds in her study on the introduction of solar heating in Sweden, economic arguments in explaining individual preferences and behaviour were perceived as indisputable fact and used to explain purchasing decisions.

I have outlined above the different user constructions that were employed by the projects managers as they sought to complete the design and installation of the PV systems. I argue that the project managers used these images of users to aid them in making sense of the technology and its role as it is installed in the domestic sector. The next section will outline the different ways the residents interpreted the photovoltaic system, choosing to appropriate it in various ways and integrating it into their everyday practices. I argue that the way the PV installation was designed influenced the modes through which the users adopted and used the technology in their homes, within the existing sociotechnical landscape that constitutes their daily routines.

8.3 How users matter: co-constructing photovoltaic systems and their users

8.3.1 Domesticating PV systems: appropriating RETs in the home

According to Oudshoorn and Pinch (2003: 24), to understand the role of users in technological development, a methodology is needed that "takes into account the multiplicity and diversity of users, spokespersons for users, and locations where the co-construction of users and technologies takes place". Accordingly, it is vital to consider the "embedding of these technologies in wider sociotechnical configurations" (Rohracher, 2005c: 26). Realising the complexity of energy consumption in the home and how it is instilled in the daily practices of families and individuals (Shove, 2003); this study explored the way different users interacted with the photovoltaic technology in their home. Four different types of users emerged from the investigation.

The 'conscious user' was prominent among the householders in the private development. This category included users who were made increasingly aware of their energy consumption as a result of installing the photovoltaics in their homes. At first glance, this might seem like a favourable behaviour that is adopted by the householders due to increased awareness on energy matters. However, as the interviews with the residents show, the consciousness of these users was due to different aspects of the technology and its installation design. Hence, the information pack and the visit from the consultants, the design of the system and the consequent location of the display monitor, the type of the display monitor and the design of the built environment were all factors that contributed to this particular use of photovoltaics.

The implication of this type of user is twofold. Firstly, the conscious user challenges the representations of the users that were made by the managers. Far from being ignorant of the functioning and purpose of photovoltaics or passive to its workings on the roof, the conscious users appropriated the technology into their daily life, in a manner that was harmonious with their general lifestyle. Secondly, the resulting behaviour of the conscious user cannot be limited to what constitutes a rational user interested in maximising their financial gains. Whilst in some cases the conscious user opted to use less energy to save money or reduce unnecessary wastage, this behaviour took place in a context of perceived convenience and comfort for them and their families. In other words, the choice of appropriating the technology as such could not be isolated as an economically rationalistic thought process, but is instead inextricably linked to daily habits, values and beliefs, convenience, as well as financial savings.

A second user category featured in the case studies was that of an 'opportunistic user'. These residents were generally using more electricity through operating additional electrical appliances and increasing their convenience, because they perceived the technology as a source of "free electricity". What is generally described in the literature as load shifting has occurred with these users, however, the purpose behind such behaviour was not so much about reducing their energy bills and producing less carbon. The residents' convenience and level of comfort was a motivator as well. From a sociotechnical perspective, the 'opportunistic user' is a classic example of de-scripting technologies or what is described as the antiprogramme of the intended use (Akrich and Latour, 1992: 256-261). This aspect is common with technologies in buildings. A study on users of passive ventilation systems found users who were resisting the technology and behaving in ways that in some ways undermined the value of the technology – such as blocking vents or opening windows – and accordingly contradicted what the designers had imagined and intended (Rohracher, 2006a). As the quote by Noble (1984) at the start of the chapter suggests, technologies can be adopted in unexpected ways, and hence increasing electricity consumption during the day could be understood in this respect.

Thirdly, the case studies have shown the existence of the 'interested users', who are fascinated by the functioning of the technology and are engaged with how much the system is generating and how much electricity they are consuming. However, these users are not necessarily changing their behaviour as a result of this information. Their interest, I argue, is another mode of use that is not in line with what the project managers intended. As the two latter user categories show, users play an important role in shaping the use of the technological artefact and the meanings associated with it. They do so by giving the technology different purposes and uses, and could modify their behaviour in a way that counteracts the projected use and meaning of photovoltaics.

A fourth category of users revealed in this research is that of "non-use". This group have either chose not to interact with the technology, or were configured as such as a result of the design and implementation decisions taken by the project managers. By being able to define possible "non-users" beyond the concepts of passive users that the managers had, this research attempts to bring some insight into the possible ways of rejecting the photovoltaic system and resisting the actor-network constituting the technology in its attempts to enrol the residents through their electricity consumption. Can we, therefore, follow Callon (1986; 1987) here in declaring the installation as a failure in these cases? At this point, I revisit the idea of configuring the user during the implementation of the PV system to indicate that the failure or success of the photovoltaics depended on how the project managers intended the technology to be used. In the process of installing the technology, the project managers made several decisions that resulted in different PV installation designs in each case study. Therefore, the design of the PV system was negotiated during its diffusion phase, resulting in certain meanings as to the role of photovoltaics in society. In the next section, I discuss the shaping of photovoltaic technology and its configuration in relation to users and the built environment.

The findings from this study describe four different users, or modes of use, of photovoltaics. However, it is not my intention in this research to rectify the managers' 'projected users' against the types of users that appear in my analysis. Rather, this study seeks to highlight the influence that the user constructions can have on the project managers' decisions regarding the design and implementation of the PV system. Furthermore, the different types of users summarised above, and detailed in chapter seven, are users in relation to photovoltaic technology in the built environment, and therefore cannot be compared to the general characteristics projected onto the residents by the project managers.

By following the implementation of photovoltaics, this research sought to explore the various processes that shape technology as it is implemented and used in various actor-networks. In the next section, I describe the different meanings that developed around photovoltaics in these case studies.

8.3.2 Negotiating PV systems in the built environment

The research presented in this thesis elicits several perspectives on the role of photovoltaic technology in a context where reducing carbon emissions and producing green energy is increasing in urgency. One perceived barrier for the diffusion of photovoltaics was their high cost, which makes promoting it for the domestic sector a challenge. However, it was the purpose of the PV DFT to promote the technology among property developers and housing associations and to test its suitability for these environments, whilst giving professionals in the field more experience in the design and management of the installation (BRE, 2005). Thus, the main concern of the trial scheme (and consequently the project managers in the two cases studies) was the design of the PV system, which would ensure its effective installation and performance, as well as comply with the requirements of the PV DFT with its two year monitoring programme.

I argue that the focus of the various actors on the performance of the technology, and the decisions made by the project managers as they sought to complete the installations contributed to enforcing the tacit nature of photovoltaics. This argument is not new; indeed as Rohracher and Ornetzeder (2002: 73) point out, "architects, planners and energy experts often hold the opinion that this strategy is the most favourable one", and accordingly promote a technical-fix approach "without needing the cooperation of users after the technology has been implemented". This perspective is in accordance with the technoeconomic paradigm described by Guy and Shove (Guy and Shove, 2000).

According to this perspective, the right technologies will address perceived environmental problems in an "unobtrusive and tacit way" (Brand, 2005: 8). The environmental behaviour is therefore 'delegated' to the technology (Latour, 1992) and the technology is designed "to make up for presumed moral deficiencies in its users" (Pfaffenberger, 1992: 293). This notion is evident in my research as the project managers reinforced this characteristic of photovoltaics, which does not require user cooperation. Accordingly, the users could benefit from the technology through savings on their electricity bill, substituting fossil fuels with green electricity, without the need to reduce their energy consumption or change their behaviour. This was also materialised in the design of the PV system, where the display monitor is separated from homes in the social housing project, and located in the cupboard or the utility room of homes at the private development. These implementation practices, and the design of the PV system reify the vision of photovoltaics as a technology that performs regardless of the user, as a result, configuring the PV system as a tacit technology which can be integrated into the built environment and at a distance from the residents' energy consumption habits.

A technology script is "non-deterministic" (Jelsma, 2003: 114) and can be 'read' in various ways. Hence, this study has shown that some users were able to interact with the technology, becoming more conscious of their energy consumption or increasing their energy usage during daylight. However, the context within which the installations occurred was the field trial, which was designed as a learning experiment for the installers, developers, consultants, local authorities and housing associations. In that sense, examining the factors that have shaped the PV system as a tacit technology (where user involvement was perceived to be irrelevant and unnecessary) is important if one is to consider the learning that is acquired about the technology and its relationship to the users and the built environment. In other words, the knowledge produced from the trial and the configuring of photovoltaics and their users could influence the future application of the technology and other RETs.

It thus becomes necessary to examine how RETs, such as photovoltaics, are shaped during their adoption and how this impacts their use. Also, how RETs are used, in this case within the context of the home, is also affected and shaped by the sociotechnical landscape that constitutes daily household practices. In the next section, I will show how this research is relevant to studies concerning the diffusion of RETs, including the trialling of new environmental technologies. I will then discuss the contribution of my study to the body of literature within STS concerned with users and technology, highlighting possible areas of further research.

8.4 Relevance of the study and further research

In addition to contributing to the debate on the diffusion of energy technologies and the role of users in this process, the ideas developed in this thesis can be useful for the design and implementation of RETs. The central theme from this research is the different ways RET implementation can influence the technology's design and the different ways users can interact with the technology. Therefore, it would be useful for planners and managers involved in the implementation of technologies like RETs to direct their attention to the interactions between the technology, the residents' views and behaviour, and the social and technological environment that shape people use of energy and its services. This, I argue, can be more fruitful than to focus on these aspects separately. Attention on these rather micro-level dynamics is important given the policy targets for RET diffusion and carbon emissions reduction. From this perspective, findings from this research contribute to implementation processes, through which policy targets can be realised. In the next section, I elaborate the implication of this research on the diffusion of RETs and the role that could be played by planning and implementation strategies.

8.4.1 Informing the diffusion of RETs

The growth in energy consumption and the rising threat from climate change pose an increasing problem for society today. From an environmental point of view, steps are needed to reduce energy consumption and to replace carbon emitting technologies with greener alternatives. RETs are one way to tackle the problem, and the UK government has recently introduced policy measures directed at the domestic sector in an effort to reduce residential carbon emissions. These include energy efficiency measures, such as the Energy Performance Certificate which is required in the Home Information Pack (HIP)[11], grants for installing home insulation or more efficient heating systems, and a grant scheme for installing RETs in homes and residential buildings through the Low Carbon Buildings Programme (BERR, 2008) which is currently in its second phase.

This research contributes to the arguments pertaining to the diffusion and promotion of RETs by taking as an example the case of solar photovoltaic technology. My intention was to explore the various processes the shape the 'scripting' of PV systems in the residential sector, and in doing so, highlighting current practice on the implementation of government schemes designed for the promotion of RETs. This study, therefore, contributes to the knowledge base of RET policy and implementation strategies.

The importance of research in STS lies in highlighting the socially shaped nature of technology and the influence of different contexts or localities on its usage and impacts (MacKenzie and Wajcman, 1999; Pinch and Bijker, 1987). Accordingly, technology from its inception through to marketing, implementation and use should be perceived as a process rather than an artefact or a technological solution, and as a result technology policy should be extended to consider these influencing factors (Sorenson, 2002). When it comes to energy policy aimed at the domestic sector, the focus should be on the broader concepts of energy consumption and services related to energy usage and its relation to modern day concepts of comfort and convenience (Shove, 2003), cultural practices (Shove and Wilhite, 1999; Wilhite, 2001) and wider sociotechnical systems constituting developers, building methods and house design (Lovell, 2005). As Shove and Wilhite argue (1999), the dominant focus of energy policy is on individual consumers and their choices, but they argue that attention should be given to the longer term changes in societal expectations and demand of energy and the services that energy provision makes possible. In a nutshell, studies on energy within STS have consistently called for a broader role of energy policy that can

[11] The Ministry of Communities and Local Government provides information on HIPs http://www.homeinformationpacks.gov.uk, which are required since 14 December 2007 in all cases involving the buying and selling of properties. The HIPs should include all the relevant information about a home, including an assessment of its energy performance.

take into account various cultural, political, institutional and technical aspects of energy use, which shape our knowledge and use of energy technology. My research contributes to this argument by revealing the complexity of RET use in the home which is far from the concept of the rational consumer, an image of the user that is dominant in the technoeconomic paradigm (see chapter two).

Furthermore, the emphasis on users and the importance of the role of users in domesticating (Silverstone and Hirsch, 1992) or co-constructing technology (Oudshoorn and Pinch, 2003) is crucial for the development of energy policy. This is especially important, since the government's regulation is for all new homes to have zero carbon emissions by 2016 (DCLG, 2006). Accordingly, the diffusion of energy technology for the domestic sector, such as photovoltaics in this case, could benefit from policy and implementation strategies that take into consideration the role of users, their needs and lifestyle. In doing so, it can focus on technical choices that can be effectively assimilated into current social practices. This is particularly important in the context of increased calls for the diffusion of energy technologies in architecture and building design. This study is, then, an attempt to explore the use of these technologies at the level of the end user.

Having said that, this research concedes that energy technology implementation should not ignore the broader sociotechnical landscape which shapes energy use, as this study has shown with respect to householders' preferences and choices regarding energy technologies, as well as the existing sociotechnical landscape that constitutes their energy consumption. By examining the spaces of adoption and appropriation, such an agenda could lead to the "empowerment of users" (Sorenson, 2002: 33), where their role in appropriating technologies and articulating their energy consumption choices is given due importance.

The importance of the design of PV systems is brought out from the findings of this research. The concept of 'script' and knowledge of the different modes of use made possible from the interaction of the user with the photovoltaics can be useful for developments in product design for environmental technology (Jelsma, 2003). The design of the PV system, its components and its integration into the built environment is a case in point. Here, the parties involved in the implementation of

PVs (consultants, installers, planners, local authorities and housing associations) have to look into what role do photovoltaics have in the reduction of energy consumption and carbon emissions, and accordingly, develop photovoltaic products and other microgeneration options that can facilitate a more environmentally-friendly energy consumption. The findings from this research would, therefore, be relevant in informing stakeholders of not only the impact of implementation programmes and the choices the managerial teams make on the design and use of technologies like PVs, but also microgeneration technologies in general.

Another argument for focusing on users is their importance as a source of learning in the application and management of energy technology (Rohracher, 2006b). as such, "technologies and use practices often co-evolve during the innovation and adoption phase, a process that will be more satisfactory for the various product stakeholders if it is organized in close interaction between product designers and producers, and product users" (Rohracher, 2006b: 49). This is especially the case of environmental technology, where users can engage with it, often 're-inventing' (Rogers, 1995) and shaping its use. Whilst marketing techniques can learn about users, learning from users remains a challenge to the implementation of technology (Akrich, 1995). Hence, effective communication between producers and users is essential if learning from users is to take place, as well as approaches from public relations and green marketing can be beneficial as a learning process for users (Rohracher, 2006:b).

Additionally, niche markets are important as specialised learning fields for environmental technologies, in addition to markets formed as a result of users with a high awareness of environmental problems and a motivation to use (and demand) green technologies. Organisations can thus learn by focusing on those users and broadening the application of these technologies. Moreover, the introduction of new technologies in society could benefit from developments in constructive technology assessment (CTA) (Rip *et al.*, 1995). Through CTA, technology is assessed from various perspectives covering its design, diffusion and development, where the "interests of all parties can be incorporated from the beginning" (Schot, 2001: 40). From this perspective, learning from users could benefit the diffusion of RETs by examining existing user preferences and energy use contexts, whereby knowledge could be employed in the development of technological designs that take into account these processes.

The issue of learning is particularly important in this research, since the case studies on which it builds are part of the UK government's trial scheme. Seen from this point of view, the practices and findings of the trial programme can have significant implications on the practice of PV system design and installation in the future. A study on the role of technology demonstration projects found that they can be limited as they tend to be framed purely as technological rather than social experiments, and as a result remain grounded in economic analysis (Harborne *et al.*, 2007). The research on photovoltaic technology presented in this thesis finds similarities in the case of the PV DFT, where the consortium managing the trial scheme, and the other actors involved in the demonstration projects, were focused on the technical performance of the PV systems. This is evident in the resulting publications from the trial, which were mainly dedicated to the technical aspects of the installation and the results of the two-year monitoring programme. Whilst these aspects are indeed important in the development and promotion of photovoltaics in the UK, crucially this over-emphasis led to the neglect of the cultural, institutional and political dynamics that shaped the technology's design on the one hand, and the role of the users in appropriating the technology on the other hand.

8.4.2 Users, photovoltaics and STS: contributions to sociotechnical studies on energy

Social scientists such as Guy and Shove (2000) and Wilhite *et al.* (2003) argue that except for economics and psychology, "social sciences began to be marginalized within energy related studies in the early 1980s" (Henning, 2005: 8), when social scientists were called in to investigate the attitudes, preferences and behaviours of users (Henning, 2005; Rohracher, 2006a; Shove *et al.*, 1998). However, as these researchers have shown, studies such as those within STS (as well as cultural studies and anthropology) can provide an integrated view of the design and implementation of technology, contributing to a deeper understanding of technology adoption in society and a critical analysis of the sociocultural contexts that can influence a technology's design, implementation, and use.

The focus on users in STS contributes to the above understanding of technology in society by articulating the particular dynamics that shape their design and use. From this perspective, this study supports research on the 'sociotechnical approach' in energy studies in two ways. Firstly, this work highlights the different PV system designs resulting from the interaction of various actors during the implementation of the technology; it therefore suggests a contingent application and use of new energy technologies. Secondly, it sheds light on the different ways of appropriating and domesticating photovoltaics into the homes and the daily practices of householders, and thus contributing to the argument on the 'de-scripting' of technologies.

The results of this research agree with the general concepts which currently inform STS research. The study reveals the influence of a myriad of actors and their role in constructing different meanings of the technology, and consequently questioning the linear model of technological innovation and diffusion (Guy, 2004; Pinch and Bijker, 1987). As Guy (2004: 694) points out in his assessment of the dominant thinking on energy technologies, "the technoeconomic "irrational user" is translated in the sociotechnical literature into a 'guerrilla fighter' of those disenfranchised from the design process". In that sense, the perspective from STS surpasses the notion of developing the technical performance of innovations and their marketability, and explores instead the viability of technologies in changing social contexts. This research, therefore, attempts an understanding of the relationship between the photovoltaic energy technology and its users. In doing so, it presents different ways of thinking about RETs and their potential users and rejects the technoeconomic view that perceives technological innovation and diffusion as a path from ignorance to enlightenment.

The analytical categories presented in this thesis of the four different types of users suggest the various ways users can engage with photovoltaic systems, thereby providing a more nuanced view of the technology's adoption. It thus hopes, in this respect, to contribute to a better understanding of the processes that influence the uptake of energy technologies in the home and the diffusion of these technologies as part of society's quest towards lower carbon futures. Such an understanding also calls for further research which is focused on the use of RETs in the home and the spaces and channels through which users interact with energy technologies. The study challenges common assumptions on the passive role of users, and in doing so, highlights the need for further research into matters such as engaging users in technology design and other participatory approaches in environmental management.

As such, research should focus more thoroughly on the consumption of energy, its impact on the introduction of new RETs and the influence of these technologies on energy use. Such an agenda would have, as its primary focus, an emphasis on the social construction of RETs in general, and of microgeneration technologies in the home in particular. Additionally, further research is needed on the design of RETs and their integration into residential buildings and houses. As the case of photovoltaic systems shows, ideas from product design and architecture can bring an interesting perspective to research on RET uptake. Thus, a multi-disciplinary approach on RETs, which analyses them as a complex sociotechnical system can significantly contribute to energy research and further their development and deployment in society.

8.5 Final remarks

The research presented in this thesis is a product of three years of study, where I had the chance to combine my interest in environment and society with insights from STS, and hence attempt a holistic analysis of society as part of a complex environment constituting nature, technologies, infrastructures, institutions and organisations as well as cultures and practices. Adopting a theoretical perspective framed in science and technology studies, I started to gradually think about the environment, technology and society as elements forming the 'seamless web' which Hughes (1987) refers to. From STS, innovative theories and analytical methods have been developed with subtle and sometimes significant differences in their analysis, methodology and focus. However, the major arguments that emerge from STS is the non-linearity of technological evolution, the complexity of the technology diffusion process and the role of users in appropriating and articulating different meanings to technological innovations.

Theories in STS have been widely critiqued within the field. Criticism has focused on the tendency of research to exclude the structurally weaker groups from the analysis of technological innovation and diffusion, focusing instead on relevant social groups which were given the opportunity to influence these processes. As such, issues of power and wider structural forces are ignored in this analysis, especially in studies adopting an AN T approach (Star, 1991). Also, constructivism has been argued to be apolitical (Winner, 1993), with its emphasis on micro-level activity whilst neglecting social structures and their political implications. However, I argue that an advantage of this approach in STS is that it permits a focus on the micro-level 'everyday practices' of technological innovation and diffusion. As such, one benefit of a sociotechnical perspective for energy research is the attention to these micro-level dynamics shaping the design and use of RETs on the other hand. The intention of this research, therefore, was to do just that; revealing the interaction of various actors and how they shaped the design and implementation of photovoltaic technology and the 'day-to-day practices' that shaped its use.

Doing this research has taken me on a journey, where as a novice researcher with a background in environmental studies, I had to learn new concepts in the analysis of energy policy, technology management and research practices. At the same time, I had to unlearn the analytical separation between humans and non-humans whilst focusing on the co-construction of technologies and users. The journey has taken me through various theoretical approaches through which I attempted to understand the social shaping of technology, and the role of users in this process. This led to the formulation – and consequently – the realisation of the empirical work presented in this thesis, where I focused on the micro-level actions that constitute everyday practices shaping technologies at the users' end. At this point, my interest was in exploring how these contextual dynamics shape technologies and their relationship to the user. This research, therefore, does not tackle wider or macro-level political, economic and cultural processes that become embedded in technologies such as RETs, thereby shaping their role and meaning in society today. However, I hope that my micro-level analysis contributes to a growing body of literature concerned with how users matter in the co-construction of technologies.

To conclude, through this journey, I learned the different theoretical and methodological concepts that can be used in understanding the role of technology in society in general and for environmental concerns in particular. I hope, then, that I can apply my knowledge into further research exploring users, technologies. and the built environment. This is especially important in the field of energy, where the promotion of energy efficiency technologies and RETs has been gaining more prominence. The value of this research, and further research exploring other types of energy technologies in the home, is in highlighting the importance of the local and cultural contexts in the diffusion of these technologies through the vocabulary of science and technology studies.

APPENDIX A

I. Sample letter to residents in the private development project

To: Owner/Occupier

Dear Sir/Madam,

My name is Dana Abi Ghanem, and I'm carrying out PhD research at Newcastle University in the

School of Architecture, Planning and Landscape.

For my research, I'm looking into the solar panels project in your area. I'm particularly interested in what people who have panels think about them, how easy they are to use, and live with. I noticed that your property has photovoltaics installed and I was wondering if I could have the opportunity to briefly speak to you regarding this technology. I would be very interested to learn about your experiences living in a house with solar panels and your opinion on their installation, value and use. I am not carrying out this research on behalf of any developer or government body, and am only interested in your views and opinions.

I will be dropping by your area during the week commencing Monday 21st May 2007 for one week between 7:00 and 9:00 pm. I would like to ask you some questions at the door which will not take more 20 minutes of your time. I will have my University identification with me, and will not ask at any time to enter your home.

I would really appreciate your cooperation and I thank you for your time. I look forward to meeting you in due course.

Please note that no personal information would be collected – I will not be asking any information that is not related to what you think about the panels. Please be assured that any views and opinions obtained will remain anonymous and be treated with the strictest confidentiality.

Sincerely,

Dana Abi Ghanem
PhD Candidate
School of Architecture, Planning and Landscape
University of Newcastle upon Tyne

II. Sample letter to tenants in the social housing project

To: Resident

Dear Sir/Madam,

My name is Dana Abi Ghanem, and I'm carrying out PhD research at Newcastle University in the

School of Architecture, Planning and Landscape.

For my research, I'm looking into the solar panels project in your block of flats. I'm particularly interested in what people who have panels think about them, how easy they are to use, and live with. I noticed that your property has photovoltaics installed and I was wondering if I could have the opportunity to briefly speak to you regarding this technology. I would be very interested to learn about your experiences living in a house with solar panels and your opinion on their installation, value and use. I am not carrying out this research on behalf of any developer or government body, and am only interested in your views and opinions.

I will be dropping by your block during the week commencing Monday 28th May 2007 for one week between 6:00 and 8:00 pm. I would like to ask you some questions at the door which will not take more 20 minutes of your time. I will have my University identification with me, and will not ask at any time to enter your home.

As compensation for your time, each of you would receive a £20 shopping voucher for taking part in this research. I thank you for your time and look forward to meeting you in due course.

Please note that no personal information would be collected – I will not be asking any information that is not related to what you think about the panels. Please be assured that any views and opinions obtained will remain anonymous and be treated with the strictest confidentiality.

Sincerely,

Dana Abi Ghanem
PhD Candidate
School of Architecture, Planning and Landscape
University of Newcastle upon Tyne

APPENDIX B

I. Interview schedule

a) Questions for the project managers

General questions:

Tell me about your organisation and its role?
What is your role in this organisation and what were your main responsibilities when the PV installation project was taking place?
How do you see the future of photovoltaics in the domestic sector?

Project specific questions:

How would you evaluate the PV installation process as a whole?
What do you think is the importance of RETs like PVs in the home?
What were the difficulties and challenges faced during the project management?

Questions about users:

What procedures were taken regarding the residents?
What do you think was their role in the project?
What do you think is the role for the residents regarding PVs in general?

b) Questions for the residents

What do you think of the PVs on your roof?
What was the effect of the panels on your energy bills?
What do you think of the process of the installation project?
How did the project managers communicate with your during the project and after the installation?
How do you feel about your energy use?

II. Checklist

Aesthetics of panels
Meters
Display monitor
Energy bills
Energy use
Information/ Home information pack
Letters/leaflets
Consultation event/House visits
Disturbance/ complaints
Vandalism/security
Access to flats
Coordination with site managers
Project management/ coordination with different actors
New technology
Users

APPENDIX C

I. List of project managers interviewed in this research

a) Social ho using project

Title	Role	Date interviewed
Energy officer	Based in the local authority and responsible for the work in the City Council's energy office. He was in charge of the project as a whole, a role commended for in the Good Practice guides in the DFT	January, 2006
Housing association officer	She was responsible for liaising between the housing department and the energy office, and at a later date between the Housing Association and the City Council.	May, 2006
Principal investment officer	He was responsible for managing the funding and expenses for the project. He took part in deciding the location for the project and evaluating the project proposal.	June, 2006
Housing manager	His role was in the field and his main responsibilities included coordinating the work of the engineers and installers on the site.	May, 2006

b) Private development project

Title	Role	Date interviewed
Energy consultant	Her role was central in the project, as the planned and managed the installation of the PVs on the twelve homes.	March, 2007
Energy engineer	He works for the engineering firm and was responsible for designing the PV system, and helping in the preparation of the proposal to secure funding.	March, 2007
Private developer	He was the project manager from the private developer's company. He was the energy consultant's point of contact with the property firm.	April, 2007 (via email correspondence).

II. List of residents interviewed in this research

a) Social ho using project

Resident	Date interviewed
Resident 1	28/05/2007
Resident 2	28/05/2007
Resident 3	28/05/2007
Resident 4	28/05/2007
Resident 5	28/05/2007
Resident 6	29/05/2007
Resident 7	29/05/2007
Resident 8	29/05/2007
Resident 9	29/05/2007

b) Private development project

Resident	Date interviewed
Resident 1	21/05/2007
Resident 2	21/05/2007
Resident 3	21/05/2007
Resident 4	24/05/2007
Resident 5	24/05/2007
Resident 6	24/05/2007
Resident 7	22/05/2007
Resident 8	23/05/2007
Resident 9	23/05/2007

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