



**Understanding public attitudes towards
hydrogen energy:
Lessons from studies on public attitudes
and behaviour towards energy and the
environment**

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Abstract

This paper builds on previous studies concerning prospective public attitudes to new technologies (Flynn et al., 2006; Bellaby et al., 2004), which took risk perception of hydrogen energy as a focus. It broadens the scope of investigation to the wider context of energy and environmental issues in which the debate about alternative and more sustainable forms of energy takes place. In particular, this paper attempts to address the following questions:

- What are public values, beliefs, attitudes and behaviour towards energy and environmental issues, in the UK and at international level?
- What are the determinants of environmentally-friendly behaviours? Is there a correlation between values, knowledge, beliefs, concerns and attitudes, and actual behaviour?
- What are public attitudes and behaviour towards specific energy technologies, such as new and renewable energy, and other technologies associated with energy and the environment?

To answer these questions, the paper reviews a broad range of studies comprising academic studies published in specialised journals, market research studies, opinion polls and surveys carried out at UK and international level. The ultimate aim of this review is to gain an understanding of whether, and to what extent, public attitudes and behaviour towards energy and environmental issues and technologies are connected to and may influence public attitudes towards hydrogen as an energy carrier.

1. Introduction

Recently, important issues about the future of energy supplies have been increasingly covered by the media and have gradually become priority areas for public policy at local, national and international scale.

Incontrovertible evidence points not only to the fact that fossil fuels will eventually become scarcer and more difficult to extract, but also to the environmental deterioration and profound global changes they are causing, not to mention the geopolitical problems associated with the location of fuel reserves and their distribution routes. However, it is still quite uncertain how these inescapable facts will be dealt with.

As far as availability and security of energy supplies are concerned, countries across the globe are investing massive resources and efforts to find alternative energy sources capable of meeting the ever-growing demand of developed and developing economies. In contrast to conventional fossil fuels, these new sources must also meet environmental requirements, such as the preservation of eco-systems and the reduction of greenhouse gas (GHG) emissions, which are virtually unanimously recognised as the culprit of global warming.

Governments are focusing especially on renewable energy sources, such as solar, wind, wave, tidal and biomass, by developing research programmes, strategic plans and institutional mechanisms to encourage the diffusion of such alternative energy technologies. Nuclear power is also receiving increased attention as a way of producing emission-free electricity. At the same time, efforts are being put in the development of technologies capable of mitigating the threat of climate change, such as Carbon Capture and Storage (CCS), associated with electricity production from fossil fuels. New energy carriers, such as hydrogen, are also gaining prominence in the wider debate about the future of energy. Hydrogen could become a pivotal element in a future energy infrastructure linking renewable supplies with power demand in a broad range of stationary, transport and portable applications.

No single energy route is currently prevailing in the debate and many different scenarios and pathways are being proposed and discussed. Much of the uncertainty depends upon the difficulty of unlocking our societies from the so-called “carbon lock-in” (Unruh, 2000 and 2002) created by the pervasive presence of fossil fuels. Switching to new energy sources requires the unbundling and de-construction of a whole set of technological, economic, social, political and cultural arrangements which have become strongly embedded in the way we live. Although technological feasibility and economic cost-effectiveness may one day ease off the taking up of energy sources and carriers, prospective users, including industrial and institutional stakeholders and the general public, will undoubtedly play a fundamental role.

As a consequence, it is useful to interrogate ourselves about what public attitudes and behaviours are, in current times, towards this whole range of future energy options, related technologies and associated environmental issues. Attitudes towards a future hydrogen economy cannot in fact be considered in isolation. If hydrogen were to be introduced as an energy carrier, it would necessarily be a part of a wider energy system characterised by a multiplicity of primary energy sources, infrastructures and applications. Therefore, attitudes towards hydrogen have to be necessarily placed in

the broader context of energy provision, consumption and its environmental implications.

Along with individual preferences related to perceived costs and benefits, wider concerns of cultural, political or moral nature may motivate publics to support or reject new technologies. This is particularly significant when new, disruptive technologies characterised by uncertainty are concerned, and for which expert knowledge is pivotal and public awareness is low. In the case of hydrogen energy, public sensibilities towards problematic issues surrounding the provision of energy resources, the use of fossil fuels, and their social and environmental implications may be particularly relevant. Trust has also been pointed to in several studies as a major, though still under-recognised, determinant of public responses to new technologies. Trust encompasses issues of responsibility for the occurrence and direction of innovation and technological change, control over its deployment, and communication about new technologies.

By drawing upon recent research findings in this area, the paper seeks to understand whether environmental values and concerns, attitudes and behaviour towards energy, and issues related to trust and confidence in the public and private sector could shape public responses to the introduction of hydrogen as an energy carrier and fuel of the future.

2. Public attitudes and behaviour towards energy and the environment in the UK

In recent years there has been a visible increase of the number of studies addressing public opinions, views and perceptions of various issues surrounding energy and the environment. Numerous studies have been conducted on behalf of public bodies, such as Government Departments, and private companies, especially utility companies. The vast majority of these studies are based on large-scale questionnaires, via telephone, face-to-face or over the internet. Some studies consist also of qualitative research work, such as focus groups or discussion meetings with members of the public, usually conducted prior to the quantitative survey. Findings from qualitative research are generally used to add depth and details to the outcome of quantitative analysis. Cross-comparisons are not always possible due to the different focus and research questions characterising each study, as well as to the distinctive ways in which similar questions are asked (i.e. prompted or unprompted answers) and opinions elicited (i.e. use of different types of scales). This being said, it is still possible in certain cases to identify general tendencies and patterns in public opinion. This section is organised according to the themes emerging from the literature review.

2.1 General concerns

When people are asked to name the most important issues or concerns affecting them, usually energy and environmental issues do not appear to be top-of-mind preoccupations. In contrast, people appear to be mostly concerned about social issues, such as crime, terrorism, health and education.

In a survey addressing public attitudes to quality of life and the environment (DEFRA, 2001), only 10% of respondents put the environment in the top three factors that affect the quality of life, whereas health scored the highest position. Environmental problems that raised concerns are those linked to pollution and noise from traffic.

A survey-based study of public attitudes towards energy and the environment in the UK was carried out in September 2004 on a sample of 2,640 panellists (1,056 usable responses) selected by YouGov, a company specialising in internet polling (Curry et al., 2005). The study revealed that the environment is not considered among the three most important issues facing the UK in current times. Perceived global threats, such as immigration and terrorisms, and social issues (crime, health and education) received comparably more attention.

Similar findings emerge from the study conducted by MORI in October 2005 on behalf of EDF Energy, by interviewing face-to-face a sample population of 1,931 aged over 15 years and representative of the British population (MORI, 2005). When asked which are the most important issues facing the UK, the most cited was crime (44%) followed by terrorism, education, immigration, drug abuse and the NHS (all around 20%). Global warming and climate change received little attention (13%), as did pollution/environment (8%). Very few respondents cited energy (4%) and even less chose nuclear energy (2%). When asked about major challenges currently facing the British Government, energy issues were chosen by 37% of the sample, however health care, law and order, immigration, education and pensions achieved comparably more citations.

2.2 Public awareness, knowledge and attitudes towards environmental issues

When explicitly asked about the relevance of major environmental issues of our times, such as climate change and global warming, people seem to be aware of them and generally express interest and concern. It must be noted, however, that these issues have enjoyed wide coverage by the media in the last decades. It is therefore unclear whether such results reflect genuine public concerns or simply reproduce what the media have said. Most studies focus on public 'awareness' whereas less evidence is available as to levels of public knowledge and understanding about the environment. The few available findings, however, identify knowledge gaps and inconsistencies in crucial areas, such as the causes of climate change and the environmental impacts of energy use in the home and private transport.

Important insights in this respect can be found in a recent edition of the British Social Attitude Survey (Christie and Jarvis, 2002), which addresses a series of interrelated issues, starting with knowledge and views about environmental problems. Although conventional forms of economic growth and life styles are generally considered unsustainable in relation to the environment, knowledge gaps and inconsistencies emerge from the answers. Respondents felt they needed more information on the environment and clearly identified academic research centres and environmental campaign groups as their most trusted sources of information. In contrast, lack of trust affects government departments, business and industry at large.

The study by DEFRA (2001) shows that, although most people recognised the major causes of climate change (by correctly citing destruction of forests, CO₂ emissions,

and emissions from transport and industry), just over 25% thought that electricity and gas use in industry was a major contributor to climate change and only 20% thought that use of gas and electricity in homes was a major cause.

Similar findings are reported in DEFRA (2005) about a public consultation exercise on sustainable development. People seemed aware of general environmental problems, but did not have confident understandings of the causes, solutions and implications for the UK. The concept of sustainable development was neither clear nor associated with their everyday experience, as also pointed out in a previous survey by DEFRA (2001) in which it emerged that 70% of respondents knew that climate change is caused by human activities.

An indication that global warming raises special concerns among environmental problems emerges from the study by Curry et al. (2005), in which 70% of the sample agreed that action should be taken to tackle it, and from the study by MORI (2005), in which 71% of respondents claimed they were interested in climate change and global warming (22% said they were not interested).

Evidence in this direction seems to be confirmed by several opinion polls conducted across the UK on behalf of major newspapers (The Guardian/ICM and Observer/ICM polls in the summer 2005) and in a study conducted in Wales by the Welsh Consumer Council and Friends of the Earth (2004), addressing public attitudes to climate change and wind farms in Wales. Two-thirds of respondents (N=988) said they were either fairly or strongly concerned about climate change and believed that climate change would have serious consequences for their ways of life, whilst 28% said they were not concerned. Respondents' views were not affected by the presence of children in their household. A large majority (85%) believed that weather patterns are proof of a changing climate. Nearly 60% believed that climate change is caused by human activities. Among the causes, burning fossil fuels, cutting trees and driving the car were mentioned by over half the respondents, whereas less people (33%) mentioned air travel and failing to compost organic waste (10%).

2.3 Public awareness, knowledge and attitudes towards current energy supplies and methods of electricity production

People appear to be moderately interested in issues surrounding the supply of different forms of energy and methods of producing electricity. There are not many studies addressing awareness and knowledge of energy issues in depth. However existing findings seem to point to several crucial areas where the public is not confident about their knowledge and understanding, such as availability and security of conventional energy supplies, issues around cost and price instability, and the prospect of a not so distant energy crisis.

A study by MORI (2004) reported on an interview-based survey addressing public views on various energy sources (N=1980, age=15+), conducted in the UK in December 2003 on behalf of BNFL. Public attitudes towards nuclear energy were sharply divided, with a slightly greater proportion of people feeling unfavourable about the nuclear industry. Almost a third of the sample thought it should be a major contributor to energy supplies, whilst around half the sample felt nuclear would be an inevitable option in the future. Although respondents were more inclined to be

unsupportive of nuclear energy, compared with results obtained in 2002 the trend is towards greater acceptance of nuclear power. The same can be said of renewable energy forms, which reinforce their appeal to the public: over 80% of the sample thought renewables should be major contributors to energy supplies.

Another study conducted by MORI (2005) found that over 65% of the sample claimed to be interested in renewable energy and future electricity supplies. Nuclear energy split public opinion, with similar proportions expressing interest and disinterest. Respondents were asked about their opinions and impressions about current methods of producing electricity, namely coal, gas, nuclear and wind. Favourable opinion was expressed mostly for wind (66%), followed by gas (36%) and nuclear (30%). Unfavourable impressions were mainly associated with coal and nuclear (34% both). Again public opinion seems to be highly divided about nuclear energy. In terms of perceived disadvantages associated with each forms of energy, price instability was mostly associated with gas, as was insecure supply and high cost. It is worthwhile to note that about 25% of respondents chose to respond “don’t know” to these three disadvantages. This reveals that a significant proportion of the public feels unsure to express an opinion on relevant issues surrounding the costs and availability of current energy supplies. Problems of safety and disposing of waste products were mainly cited for nuclear energy. Wind energy raised most concerns for spoiling the landscape. Global warming and CO₂ emissions were attributed mostly to coal and gas, but nuclear energy is mentioned by almost a quarter of the sample. Intermittency problems are recognised almost entirely for wind power, while vulnerability to terrorism is associated to nuclear. Interestingly, dangerous pollution is attributed to nuclear energy more than to coal. The fact that a future energy crisis might be on the way does not appear on the public radar yet: over 50% of the sample admitted they did not know that an important energy gap would affect the UK when nuclear power stations approached the end of their operating lives. About half of the sample could not form an opinion as to whether nuclear energy produces very little CO₂.

Lack of understanding about nuclear power and its assumed contribution to CO₂ emissions is also reported in Curry et al. (2005). The study claims that the link between concern and knowledge about the environment, energy technologies and their impacts appears to be unclear. Among new energy technologies, respondents have mostly heard of wind and solar technologies, followed by efficient cars/appliances and hydrogen cars.

2.4 What should be done to tackle climate change and improve security of energy supply, and by whom

The large majority of studies address public views on possible ways to tackle global warming and improve security of energy supply, showing a great variety of public preferences and needs. Overall, the public supports a move towards increased use of renewable sources and improved energy efficiency, and express a preference for well-structured collective action, with a clear lead by the Government within international programmes. Measures that do not affect individuals are preferred. However, demands for increased public intervention are mixed with diffused feelings of distrust of public bodies’ capacity (and willingness) to actively manage the change towards a more sustainable society.

Important findings concerning issues of responsibility and the role of individual agency emerged from the British Social Attitude Survey (Christie and Jarvis, 2002). Most respondents agreed that environmental problems should be tackled at international level by governments and expressed doubts over the efficacy of personal actions. They showed significant mistrust about the level of commitment that the government and industry have taken towards pollution reduction and environmental protection, whilst expressing the belief that the public in general is more committed than governments and industries to protect the environment.

Lack of confidence in the Government's ability to commit to tackling global warming emerged in the internet poll (Curry et al., 2005), in which respondents were asked about their expectations as to how global warming will be dealt with. Similar proportions of people (over 25%) believed that technological development and lifestyle changes respectively will help solve the problem, whilst a considerable part of respondents (around 20%) thought that the UK won't do anything about it. A clear majority preferred international (but not EU) regulation as opposed to national-level regulation. When asked which technologies they would prefer to combat global warming, respondents strongly supported the use of bio-energy/biomass, carbon sequestration (defined as using trees to absorb CO₂), solar energy, wind energy and energy efficient appliances and cars. Nuclear energy, CCS and iron fertilisation received mixed responses, which for the latter two technologies was accompanied by a very low level of public awareness and understanding. Willingness to pay for the reduction of global warming was in range £5-20 per month. Half of the respondents received information about current electricity production patterns and the expected costs of different approaches, including renewables, nuclear, etc. All respondents were asked about their preferred ways of electricity production to address global warming. Among all the available options, expanding renewable energy receives most support with and without information. Support for expanding nuclear energy and using fossil fuels with CCS increased dramatically when information was provided.

A series of discussion meetings with sections of the public (DEFRA, 2005) revealed that most people tend to place responsibility for taking action on the government, business and industry, and clearly demand for coherent and well-designed solutions rather than piece-meal arrangements. When encouraged to devise possible solutions, participants came up with a broad variety of actions and types of policy, most of which addressed household energy and water use. Solutions about transport attracted comparably less attention. As to how encourage behavioural change, people placed greater importance on messages and advice received from relatives and friends.

When faced with the problem of securing energy supplies for the UK in the forthcoming decades, respondents of the MORI survey (2005) showed most support to the construction of wind farms (especially off-shore), followed by coal with CCS. Building new nuclear plants received mixed opinions. Overall, respondents strongly supported the idea of improving energy security in the UK and reducing global warming by producing less CO₂.

In an earlier survey by MORI (2004) respondents mentioned solar and wave energy more frequently in relation to ways of improving security of supply. Gas was more frequently mentioned than wind. Among a list of possible actions that the UK should take to achieve this objective, most respondents chose investment in renewable energy, followed by energy efficiency and saving. Security of supply is not yet a priority for respondents when asked about which factors should be accounted for in electricity

production: environmental effects and costs are mostly cited. Reliability of supply is cited by about one fifth of the sample. About half of the sample believed that ensuring reliable and secure energy supplies should be a joint responsibility of the Government and the energy industry. Over a third thought the Government bears full responsibility. This study highlights the fact that public opinion on energy policy is constantly evolving and responds in various ways to claims made by scientists, experts and the media, especially in complex issues where public awareness and understanding is low.

The findings of the Powergen Energy Monitor (2003) point to a general support for government actions to impose minimum standards over energy-efficient electrical appliances, raise taxes and subsidise green energy. Three-quarters of respondents felt that electricity from renewable sources should cost less because of its good environmental impact. Responsibility for action was preferentially placed on the government, and half of respondents agreed over the need for collaboration on energy efficiency among government, individuals and companies. Support for even stronger government interventions in energy-efficiency suggests that individual behaviour is perceived as useless and ineffective, unless it is part of an overall strategy clearly led by the government and fully endorsed by all the actors (the government, regulators, energy companies, etc.). The qualitative research provided insights on people's need for more reliable and impartial information on energy use and its environmental implications.

2.5 Public awareness of energy use and evidence of environmentally-sensible behaviour

The public seems to strongly demand more actions from the public and private sector to tackle energy and environmental problems. Individual commitment and behaviour to the environment, however, appear to still lag behind pro-environmental attitudes and concerns. From virtually all studies it becomes evident that personal convenience and comfort are stronger drivers of behaviour than environmental considerations. In other words, although many people may already behave and act in a 'sustainable' way (by reducing energy and car use, recycling, buying energy-efficient appliances, etc.), this is not entirely out of a willingness to be friendly to the environment. Cutting down energy bills and home-related costs appear to be the primary motivations underpinning such actions.

One of the main conclusions of the BSA Survey (Christie and Jarvis, 2002) is that public awareness of and concerns about environmental degradation, climate change and air pollution do not stimulate appreciable changes in people's actual behaviour. These considerations mirror previous findings of a similar survey conducted in 1994 and those of the Powergen Energy Monitor (2003). This latter study highlights the mismatch existing between public concerns over environmental degradation and individual behaviour in energy use, by showing that considerations of economic nature, rather than environmental values and concerns, prevail in the way in which people consume energy. Moreover, demands for collective actions and support for environmental legislation go hand in hand with lack of trust in governments and industry and, more worryingly, resistance to behavioural change. Willingness to pay for environmental protection has reduced since the 1994 survey, but this, again, may

reflect a general sense of mistrust of the government's capacity to wisely allocate and manage public money.

Further evidence of the lack of awareness of energy use is presented in a study conducted on behalf of London Renewables (Brook Lyndhurst Ltd., 2003). After a series of pilot focus groups, a sample of 502 London residents aged over 16 years was interviewed face-to-face in their homes. Only 10% thought 'a great deal' about the amount of electricity they use in their everyday activities at home, whereas 18% said they never think about it. Over half of the sample claimed they try to save energy at least most of the time, mostly by actively turning the lights off. From the focus groups it emerged that people did not realise lights are a major cause of energy use and there was a feeling that the issue of energy lacks public profile. Only a minority are motivated to save energy because of environmental considerations, whilst the majority seems to be driven by cost, especially those who are more at risk of fuel poverty. However, the focus group discussion revealed that domestic energy costs were considered low relative to other more consistent bills (mortgage, council tax, credit card bills, etc.). Consequently, as costs are still perceived as low and there is dissociation between energy use and its associated cost, it will be difficult to have sufficient incentives to reduce energy consumption.

2.6 Public attitudes towards renewable energy and technologies

Several studies address specifically public awareness, knowledge and attitudes towards various renewable energy sources and technologies. Even on a cursory view, support for renewable energy is very strong, both in principle and in practical applications, despite a widespread lack of public awareness of the concept of 'renewable energy' and knowledge about any specific renewable technology. Positive attitudes are predominantly associated with solar and wind power, whereas other renewable technologies, mostly unknown to the public, are less readily and unconditionally accepted.

A telephone survey conducted in November 2004 for the London Assembly (ORC, 2004) investigated opinions and attitudes of home owners in London (N=601) towards a variety of renewable energy options available for residential customers. Few respondents felt they knew a great deal about any of the forms of renewable energy. Older people (55-64 years old), men and higher social classes appeared more confident about their knowledge level. The solar options (water heating and PV) were the most commonly known, whereas few people knew about micro wind turbines and green tariffs. Only 7% of the sample had signed for green tariffs. About 90% of the sample thought renewable energy was a good idea. Around 20% were likely to consider installing solar power in their home, with younger people (25-34 years old) more interested than older generations. Over half of the sample perceived that the strongest barrier was cost, and there were comments about the aesthetics of renewable energy home installations, resale value and attractiveness for potential buyers. Respondents expressed the need for more general and specific information about the possible options. When asked about their motivations to install renewable technology in their home, respondents mentioned "grants" and other forms of financial assistance. In contrast, concern for the environment resulted as a far less frequent motivation. Less than a quarter knew that financial help from government bodies existed, whilst

35% knew they could get more information from energy advice centres. Although rough estimates of the real cost of solar thermal installation suggest an expense in the range £2,000-2,500, most respondents believed they would have to pay around £5,000. In contrast, they believed government grants were more substantial (about double the actual amount of £400). Only 33% of the sample made the correct estimate about the expected percentage of annual hot water needs that solar systems can provide (around 50%), whilst 30% of people believed solar would provide less than half their water needs. In the case of installing PV systems, around a quarter of the sample did not know about costs. Most respondents underestimated the actual costs, which are in the range £8,000-15,000, as well as the grant available from the government (50% of incurred costs). About half the sample believed that a PV system would provide 50% of their annual electricity needs (the actual estimate is around 30%). Over 60% of the sample believed that a planning permission is necessary to install a renewable power system. When given more information about costs and performance of the renewable options covered in the study, most people would not change their opinions, although younger people (25-34 years old) were more likely to be more positive about the benefits of renewable systems.

MORI conducted a survey through face-to-face interviews with 585 residents aged 15+ in the South West of England, in the period March-April 2003 (MORI Social Research Institute, 2003). The survey addressed levels of support and opposition to renewable energy sources and was commissioned by Regen SW. Public support for renewable forms of energy was strong in general and for wind power in particular, with little opposition. Among those who are more likely to support renewables, as opposed to those who may have neutral views, are men and residents in the highest social classes.

The questionnaire by Brook Lyndhurst Ltd. (2003) showed that most London residents believe they know at least a little about wind and solar energy, while the qualitative research revealed that information gaps concern practical advice on cost and installation. Other technologies, such as incineration, CHP and anaerobic digestion are much less known and less intuitively labelled 'green'. Respondents seemed to support renewable forms of energy in principle: 81% agreed it is a 'good idea'. Strong advocates of renewable energy are more likely to be White British residents, aged 35-54, of a higher social class and environmentally active. About 18% have ambivalent or neutral perception of renewable energy. Those who support renewables mostly indicate general environmental benefits as their motivations. Attitudes towards the environment are explored in depth through the qualitative research, which revealed that although environmental issues are considered important, they do not necessarily imply personal commitment on a daily basis. When prompted, security of supply is given recognition in the focus groups. Solar and wind power appear very popular among London residents (81% and 75% respectively), whereas for other less known technologies support is more cautious. There is little resistance to local developments of solar panels and slightly more for wind farms. Attitudes to specific renewable technologies vary. There is a general lack of concern about solar power, the only problematic issues being cost and reliability ("not enough sun in London"). New housing and commercial buildings and offices were mostly identified as suitable locations for solar technology. Wind power raises very few concerns, mostly relative to lack of space and aesthetics. The qualitative research indicated that attitudes to the appearance of wind turbines are ambivalent (attractive vs eyesore). In contrast to solar and wind, more concerns were raised about

incineration of organic waste, mostly based on safety and public health concerns. There appears to be less opposition to the incineration of organic waste than municipal waste. The relationship between awareness and level of acceptance and potential demand for specific technologies appears to be highly contextual and no easy recipe is suggested. As concerning stated WTP for green energy, it emerges that London residents would pay a little more (slightly over £2) per month on their energy bills and 26% claim they would not pay anything at all. Most respondents said they had received no information on green tariffs from their suppliers. Barriers to adopting green tariffs include the lack of a tangible environmental benefit for those who make this choice and the 'hassle factor' of switching supplier. Attitudes towards adopting a PV system are strongly dependent upon the cost of the installation (support falls from 23% to 4%). Negative experiences concerning the reliability and performance of other energy-saving means, such as light bulbs, constitute a strong barrier to adoption. The focus groups demonstrated that there is a general feeling that not enough is being done for renewables in London and there is a lack of tangible examples. Most respondents believe that responsibility for taking renewable energy forward in London lies with the Government (75%). In contrast, 29% cited the Mayor of London and only 8% said the general public would be responsible. From the qualitative research it emerges that the Government is seen as a 'key driver', the local council a 'key implementer', and the Mayor as a 'key pioneer' capable of creating a sense of belonging to the community and catalysing public interest towards the environment and air quality. There was great agreement among participants that all new houses and offices should incorporate renewables, and that regulation should encourage energy providers to implement the necessary changes.

The DTI commissioned a series of studies addressing public attitudes to renewable technologies, in view of achieving the targets (meeting 10% of electricity demand from renewable energy by 2010) set out in the Energy White Paper. The first stage of the investigation consisted of qualitative work and included a series of discussion meetings with members of the public across England, Wales, Scotland (MVA, 2003a) and Northern Ireland (MVA, 2003b). The findings from this qualitative research were fed into the design of a second, quantitative phase based on a large-scale questionnaire. Results from both types of research were then combined together with the aim of drawing recommendations for engaging the public with the development and diffusion of renewable technologies. In particular, by using insights from participants' suggestions about possible contents and methods of information campaigns, several recommendations were made about future effective communication about renewable energy.

The first qualitative stage (MVA, 2003a) sought to probe public knowledge, perceptions and expectations around several types of renewable energy, namely wind power, hydro power, biomass, wave energy and solar power. MVA conducted 20 discussion groups with members of the public of different demographic and socio-economic characteristics, and living in different areas (urban, rural and coastal). Groups were differentiated according to participants' geographical proximity to renewable energy installations, in order to compare findings across groups from 'informed' and 'uninformed' locations. Concerning awareness and knowledge of renewable energy, all groups showed low awareness of the term 'renewable energy' but could, when prompted, recognise some technologies they had already heard of. Since hydro electric had been known and used for many years, many participants had never thought of it as a renewable source, especially in Scotland. Some participants

found it difficult to associate wind and biomass with the concept of renewable energy, which in turn was frequently associated with energy efficiency and recycling, and seen as a natural extension of those activities. Some participants realised how much electricity is taken for granted. Participants living near an existing or planned renewable energy installation ('informed' groups) did not seem to be more knowledgeable than their 'uninformed' counterparts. People in Scotland seemed to be more aware of hydro power and on-shore wind, due to greater exposure, and participants living close to a biomass plant appeared more favourable than other groups. Concerning wind energy, more people had heard of on-shore wind rather than off-shore and visual impact was the main issue raised. Few participants had heard of the term 'biomass' and people living near a biomass plant would refer to the material being burnt. Participants found it difficult to distinguish biomass from incineration. Most participants had heard of hydro power but did not know how it worked. Groups held in Scotland were most familiar with this technology. Public awareness was particularly low about wave energy, which raised confusion and misconception. In contrast, participants had a high awareness of solar power but less with the term 'photovoltaic'. Questions were raised about costs and how solar energy could be effective given the scarcity of sun in the UK. A group held in Selby, a coal mining area, showed support to renewable energy in general but was concerned that renewable schemes would create less jobs than coal. People seemed to accept the coal power stations near which they lived. Concerning sources of information about renewable energy, participants cited the media and in particular television news, documentaries, national and local press. In some areas it emerged that children had brought information home from school and families recognised the strength of 'pester power' in adopting more environmentally friendly behaviour. Some participants mentioned the internet and personal experience of renewable installations and exhibitions. Participants were generally trusting of the information they had received from the media, but they showed some distrust of both the Government and pressure groups, such as environmental organisations (especially in Scotland). Participants were generally positive and supportive of the diffusion of renewable technologies in the UK and were aware of the problems associated with fossil fuels, especially their future availability. Solar power was the most readily accepted form of renewable energy.

Among the disadvantages, visual impact, noise, and negative effects on the environment, tourism and house values were mentioned mainly about wind power. Biomass raised concerns about emissions and odours, the amount and origin of the materials to be burnt and the increased traffic caused by lorries transporting them. Participants felt worried about the expected reliability of the power supplied by renewables and the possibility of storing the energy produced. They also wanted to know about how many new plants would be required, of what size and about costs of installation and maintenance. Participants raised questions about how benefits would be distributed and cited cases in which local communities had been deprived of their resources for the benefits of others. Some participants wanted to know how locally produced electricity from renewable sources would be transferred onto the national grid.

Among the advantages, participants believed renewable energy sources were environmentally friendly (with some concerns about biomass) and freely available; they would provide employment but maybe not in great numbers; off shore wind was preferred to on-shore; and finally solar power appeared more interesting because

everyone could participate. While discussing about future energy sources, participants recognised that fossil fuels are limited and it is necessary to seek alternative sources of energy and improve energy saving, while trying to be more self-sufficient. People favoured small-scale renewable schemes, i.e. powering homes. Most participants were not keen on nuclear energy. The Government's targets were regarded as too low. Many people suggested that new homes, offices and factories should incorporate renewable energy technologies, through new law that would make renewable energy compulsory for new buildings and Government buildings. High installation costs were seen as major barriers, as well as the lock-in into fossil fuels which makes companies less inclined to opt for renewables. Participants discussed about the benefits that local communities would expect from renewable energy schemes and some highlighted that in the past promises of cheaper electricity (for hydro power in Scotland) had been unmet. People expected that grants would help individuals to take up renewable technologies in their homes and strongly favoured incentives from the Government. Many people believed that renewable energy projects should reflect the type of energy source that is most appropriate for the area and that greater acceptance might be achieved if local communities were offered some kind of recompense. People welcomed increased information on renewable energy in general and about specific local schemes in particular. Some participants felt that schemes should start at very small-scale and increase as acceptance increases. It emerged that renewable energy issues should be taken forward by an independent 'energy commission'. As for communicating about renewable energy, the most favoured means were the media (TV, radio, newspapers and magazines) combined with education at school and campaigns fronted by celebrities, rather than politicians. When asked to design a campaign designed to promote renewable energy, many people focused on themes such as 'clean', 'green', 'ecologically' or 'environmentally' friendly, 'healthier' and 'everlasting'. Associations were made with the 'children's future', more employment and with other energy-saving activities, such as recycling and energy efficiency.

The same investigation was conducted in Northern Ireland (MVA, 2003b) and the outcome was broadly similar to that of the rest of the UK. Some differences are: higher level of awareness of some forms of renewable energy, especially wind; the cost of present energy supplies and future renewable sources was more debated; the effects of renewable schemes on house prices were not an issue; less concern about the visual impact and noise of wind turbines; stronger association between the concept of 'renewable' and that of 'recycling'.

The quantitative part of the research consisted of a large-scale survey, administered to a sample of 1279 people across the UK (including Northern Ireland) through in-home, face-to-face interviews (TNS Consumer, 2003). Over 75% of the sample was aware of some forms of renewable energy, though they would spontaneously tend to mention a specific technology rather than use the term 'renewable energy' (RE). On-shore wind power was most frequently mentioned (60%), followed by hydro power (35%), off-shore wind (34%) and solar (29%). Wave, tidal, biomass and other sources were mentioned in very few cases. The highest level of spontaneous awareness was shown by people aged 35-44 and 55-64, and predominantly by men. When prompted, most people mentioned solar (80%) and on-shore wind (79%), followed by hydro-power (75%). Low levels of awareness emerged for other technologies, such as wave, tidal, biomass, sewage and landfill gas. Respondents had mostly got information through the television, personal experience (visited or seen wind farms) and national and local press. The term 'renewable energy' was understood in relation to recycling (17% of

respondents), to the possibility of re-using energy (17%) and to the concept of 'infinite' energy. Claimed knowledge of specific renewable technologies varied considerably. Respondents were more confident about their knowledge on solar power, followed by hydro-power and on-shore wind, than for other forms of renewable energy, however less than 10% felt they knew a lot about any of the RE technologies. When asked about their interest in finding out more about renewable technologies, few people showed great interest. Respondents with the least knowledge were less likely to show any interest for getting more information. In contrast with the low levels of knowledge and interest, 90% of the sample agreed that RE is a good thing and almost two thirds claimed that it is much better to use RE than fossil fuels. Over 90% agreed that the Government should encourage the use of renewable energy, but only a few (7%) were aware of the Renewables Obligation. Among the reasons underpinning favourable opinion, respondents mentioned perceived environmental benefits (47%) and concerns about the depletion of fossil fuels (40%). The large majority (93%) believes that using RE is a way of taking care of future generations, however, perceived costs act as a barrier to individual households to adopt some kind of RE. Almost two thirds of the sample agreed that RE would be acceptable if some form of compensation was offered to the local community. There was large variation in opinions of different technologies, with solar power attracting the highest support whilst landfill gas, sewage gas and biomass at the bottom. Positive public opinion of RE is mainly driven by the better known technologies (solar and wind). Almost two-thirds of the sample agreed they would be happy to have a 'clean' renewable power station built in their area, whilst 15% disagreed and a further 15% were ambivalent. Disagreement was stronger among older respondents and Welsh residents. Solar power attracted the highest levels of approval, followed by off-shore wind, tidal and wave power. Respondents showed more resistance to biomass, landfill and sewage gas, probably due to low awareness, knowledge and bad connotations associated with those words. Statistical analysis showed that more resistance was associated to the less knowledgeable groups (aged 16-24 and over 55, unemployed or retired or part-time). Less than 20% would not support an on-shore wind farm being developed in their area, whilst 28% would be strongly approving. Among those living near an existing wind farm, 94% showed support and only 2% was resistant. Onshore wind raises concerns about visual impacts and, to a lesser extent, noise. Most respondents would like wind farms to be built far away from where people live.

Further evidence about public attitudes to wind energy in particular can be found in a report issued by the British Wind Energy Association (BWEA, 2004), which presents a review of more than 50 studies carried out between 1990 and 2004. The major finding is that a consistently high level of public support clearly emerges, with around 70-80% of people in favour of wind power both in principle and in practice, as residents living near wind farms. Direct experience of wind farms appears to dramatically increase the level of support, and a shift towards more positive attitudes can be found by comparing ex-ante and ex-post surveys in areas where wind installations have been developed (these claims are supported in several polls, including ICM Greenpeace, 2004 and MORI Scotland, 2003).

The study conducted by the Welsh Consumer Council and Friends of the Earth (2004) found that nearly half of the sample was supportive of on-shore wind and over a half was supportive of off-shore wind. A large minority of people were undecided or ambivalent. The study also identified geographical and demographical differences in attitudes, with North-West Wales showing more support for both on-and off-shore

wind, and respondents aged 45-54 being the most likely to be concerned about climate change and in favour of wind power.

Another study conducted in Wales (Market Research Wales, 2002) found overall support for doubling the number of wind farms, with a large proportion of people (87%) saying they would prefer this route to building one nuclear power station.

3. Public attitudes and behaviour towards energy and the environment at EU and international level

Findings from studies addressing attitudes and behaviour in other European countries and continents are broadly in line with those of UK-based studies. Country-specific tendencies are nevertheless present and warrant careful examination of the distinctive characteristics of renewable energy projects and their local publics.

In his review of research studies addressing public attitudes towards renewable energy, Walker (1995) reveals that generally opinion polls show favourable attitudes towards renewable energy across the US, the European Union and UK, which contrasts markedly with negative public opinion towards nuclear power. He stresses that public attitudes to individual technologies or projects grouped within the broad umbrella of “renewable energy” are nevertheless rather diverse. In the case of hydro power, geothermal and tidal energy, for example, past public resistance appeared exacerbated by the lack of public consultation upon the characteristics of the project, the distribution of the expected benefits and unanticipated adverse effects.

Walker (1995) adds that wind energy has been the subject of considerably more social research, with notable differences across countries. In Sweden and the Netherlands public opinion was probed at an early stage in the development of wind energy, whereas in the US and UK there has been a more “reactive” approach. He also claims that most studies report an overall positive public opinion about actual or potential wind farms. Additionally, longitudinal studies addressing ex-ante and ex-post attitudes to the development of wind farms reveal that direct experience increases the chances of public support and acceptance. Negative opinions (mostly related to visual impact) are nevertheless present and become more evident in pressure groups such as environmental organisations. Public responses to wind farms cannot however be easily generalised, as it is difficult to isolate general features of wind energy from specific and contextual characteristics of the population surveyed. Public attitudes are to be considered as a complex set of evaluations and perceptions with physical and symbolic attributes. In some studies it is recognised that what people oppose is not wind energy *per se* but rather the characteristics of the specific project and the approach taken by the developers. The experience with wind energy developments in the UK reveals mixed public responses with a substantial presence of protests and dissent, which in turn have been widely emphasised by the media with the resulting image of an “anti-wind” public.

Trying to summarise the nature of public opinion towards renewable energy, Walker (1995) warns that “green” characteristics of renewable energy technologies do not guarantee widespread support by the public in all circumstances, and that the local specific contexts in which they are implemented are crucial. Conflicts may be triggered, in fact, by the scale of a project, considered excessive for the local area; the lack of tangible benefits for the local population; the failure of addressing

environmental impacts at an early stage; and, especially in technically complex situations where public understanding is low, lack of public trust in those who are in charge of the project.

Examining public views on three existing wind turbines in the Netherlands, Wolsink (2000) criticises the concept of 'NIMBYsm' arguing that public resistance to wind installations often stems from poor planning decision-making and is exacerbated by institutional constraints that leave out public views and concerns from the planning process. Following Healy (1998) he calls for the development of 'institutional capital', which is borne out of collaborative, rather than top-down, approaches to planning.

Similar considerations concerning the need of improved dialogue and understanding between planners and local residents are presented in the survey by Krohn and Damborg (1999). Their study collates evidence from a range of studies on public attitudes to wind power across different countries, including the UK, US, Canada, Sweden, Germany, Denmark and the Netherlands.

At EU level, findings from a recent Eurobarometer survey (EORG, 2002) point to a high level of public concern about climate change and global warming (90%) coupled with rather low awareness of any European research activities in the field of energy. In general the image Europeans have of renewable energy is positive and support is strong. Unsurprisingly, citizens' views vary widely across countries. Most respondents believed that industry could have the greatest impact on energy saving and were in favour of measures which do not impose obligations on individuals. The survey found a general lack of awareness of the impact that individual behaviour has on energy saving and the environment, as well as that of transport. However, a significant proportion of respondents declared to be prepared to pay more for renewable energy and claimed that their purchasing preferences of domestic appliances were influenced by concerns over energy efficiency. Nuclear energy still raises safety and waste concerns among the European public.

Another Eurobarometer survey carried out in 2004 (TNS Opinion and Social, 2005) shows that European citizens are strongly concerned about environmental issues and demand for greater commitment from authorities and decision makers. Almost 90% of the sample claimed that the environment should receive priority even in other policy areas, such as economy and employment, and 70% believed the environment influences our quality of life. Environmental concerns appear to be mostly related to issues that affect life on a daily basis and vary across countries. Climate change, for instance, received greater attention from the former 15 Member States, whereas water, air pollution and growing waste are main concerns in the new Member States. There is a widespread lack of information in many environmental areas, however most European citizens would prefer to receive information about solutions rather than about problems. A large majority of respondents claimed they make efforts to protect the environment, however half felt their efforts will not have any positive impact. Citizens are engaged in recycling and reducing energy consumption at home. As far as solutions are concerned, respondents gave strong support to both short-term and long-term measures. Examples of the former type include stricter environmental regulations, fines for offenders, enforcing existing regulation and raising general awareness. The majority believed the EU and national governments are the best levels for decision-making on environmental issues.

4. Studies in the area of consumer research

A good starting point to understand what the multi-disciplinary area of consumer research has produced in relation to energy and environmental issues is the extensive review study by McDougall et al. (1981). Although the review is mostly focused on studies addressing energy saving (or energy conservation, as it is more frequently referred to in North America) published in several decades ago, it is nevertheless very useful to compare methodologies and topics of investigation, and to identify what was considered conclusive evidence or knowledge gaps at that time. The reviewed studies are categorised in two main groups: studies addressing consumers and their beliefs, attitudes and behaviours towards various forms of energy saving, and studies addressing the impact of energy saving initiatives on consumers' behaviour.

The first block of studies comprises in particular four types of research: 1) opinion research exploring public views on general energy issues; 2) survey-based research addressing self-reported behaviour in energy saving; 3) adoption/diffusion research seeking to understand the differences between adopters and non-adopters of specific energy technologies or energy-saving behaviours; and 4) studies modelling energy consumption by attempting to explain variation in actual consumption with various variables. Overall, this field appears somehow fragmented in many research efforts underpinned by different theoretical frameworks and characterised by an interdisciplinary nature. Opinion research studies have found that consumers generally express views supporting energy saving, although there is a lack of association and consistency between pro-saving views and actual energy consumption. Social desirability bias in public opinion research is thus highly probable. Similar considerations can be made about findings from survey-based studies addressing consumers' energy-saving behaviour. Self-reported behaviour appears to be exaggerated towards energy saving, with studies reporting considerable discrepancies between responses to surveys and direct observations made during face-to-face interviews. Adoption/diffusion research has been relatively less frequent than other types although it gives useful insights. Explanatory models of in-home energy consumption, based on actual data retrieved through electricity suppliers, have shown that variables related to characteristics of the house and the climate have generally been good predictors of consumption (capable of explaining around 40% of its variance), whereas attitudinal variables have considerably less predictive power. However, significant differences in research design (types of questions and data analysis) and assumptions across the reviewed studies do not allow to treat those findings as conclusive evidence. McDougall et al. (1981) point out several areas which warrant further investigation: a) the need for better conceptualisation of structural characteristics of houses, occupant life-cycle and life style; b) the need for longitudinal research attempting to link attitudes in one period with consumption at a future time; c) the need to account for the seasonal character of energy consumption; and finally d) the need to investigate energy consumption in private transportation.

The second type of studies comprises assessments of energy-saving initiatives, such as information campaigns and initiatives based on incentives, disincentives and restrictions. McDougall et al. (1981) identify a series of shortcomings in this broad group, including the lack of attention to issues of cost-effectiveness in assessing the

impact of the initiatives, the short time horizon used; and the use of limited samples and self-reported behaviour instead of actual consumption.

In summary, the review by McDougall et al. (1981) indicates that further research should address, amongst others, the following gaps:

- Concerning studies exploring consumer views, attitudes and behaviour, past research has been unable to identify the role of life-style and family member characteristics in energy consumption and to explicitly address barriers to energy-saving behaviour and the decision-processes leading to energy saving.
- As research methods are concerned, the widespread use of self-reports instead of (more costly) actual energy consumption data is of concern, as the likelihood of obtaining responses biased by social desirability is high. There is also the need for more longitudinal studies exploring the evolution of attitudes and consumes, and better conceptualised models of energy consumption.

4.1 Studies addressing innovation diffusion/adoption

Several papers published in the 1980s focused on solar energy as there were great expectations of future growth. Most of these papers explore, from the perspective of consumer behaviour research, the decision processes about the adoption of solar energy systems. The theoretical framework that informs these studies rests on the concepts of innovation adoption and diffusion, as proposed by Rogers and Shoemaker (1971). According to this approach, the adoption and diffusion of a specific innovation, being it a new product or a service, is influenced by several attributes of the innovation of which adopters and non-adopters may have different perceptions:

- Relative advantage, or the degree to which the innovation is perceived as being superior to the idea or product it replaces;
- Perceived risk, the expected probability of economic or social loss resulting from innovation;
- Complexity, the extent to which the innovation appears difficult to use and understand;
- Compatibility, the degree to which the innovation is seen as consistent with the innovator's existing values, past experiences and needs;
- Trialability, the extent to which one can experiment on a limited basis with the innovation; and
- Observability, the degree to which the results of innovating are visible to others.

The assumptions underpinning such theory have been criticised for their excessive focus on individual behaviour, their neglect of wider cultural, social and political factors, and in that they contrast markedly with the concept of innovation as a complex social process. This being said, the evidence provided by this type of studies can add useful insights to our understanding of the factors that affect people's choices about renewable technologies.

The study performed by Labay and Kinnear (1981) seeks to explore consumer choices in relation to the adoption of solar energy systems and to compare adopters' responses

with those of non-adopters. It acknowledges that findings from past studies show a high level of ambiguity and lead to contradictory conclusions, thus concluding that it is not possible to infer whether attribute perceptions are determinants of adoption or the result of experience with the innovation. It is found that adopters are primarily distinguished by their perceptions of solar technology as having low risk, low complexity and high compatibility with personal values.

Another study (Guagnano et al, 1986) focusing on consumer perception and adoption of solar heating technology largely confirms previous findings. Perception of financial risk was lower for adopters than for non-adopters. Absence of well-defined standards for solar technologies made it difficult for procrastinators and non-adopters to compare them to conventional ones. Other important factors were distrust in solar retail sales personnel and concerns about future availability of solar systems. This paper also emphasises that the idea that a major breakthrough is “just round the corner” is a common source of innovation resistance and deserves more attention. The paper concludes that financial incentives may be not enough to stimulate the adoption of solar technology and broader social and cultural determinants must be considered.

In some European countries, governments have tried to encourage the uptake of solar power in the residential sector by offering fiscal and financial incentives to adopters. By using a questionnaire survey, Jager (in press) explored the adoption and diffusion of photovoltaic (PV) systems in the municipality of Groningen (NL). The sample mostly consisted of middle-aged men of relatively high income and education levels. His research, informed by a behavioural perspective, found that environmental benefits and grants were the most important motives for adoption. Ads in the newspapers, word of mouth and social networks at large played a significant role in informing people about the initiative. The meetings held by the municipality in order to inform the public about grants and procedures have been successful and reduced people’s perception that installation and bureaucracy would be big barriers. People with higher awareness and concerns over the environment were more aware of the benefits of PV systems.

Further investigations into the adoption and diffusion of solar energy technology are presented by Faiers and Neame (in press). The study attempts to understand why policies aiming at encouraging the adoption of solar energy technology by residential customers in the UK have somehow failed to achieve their objective. The authors surveyed two groups of people: those who have installed a solar system in their home (N=100; 43 usable responses) and those who had previously adopted other forms of energy efficiency measures (N=1000; 350 usable responses). Among the perceived negative aspects of solar energy technology, the issue of long payback time was clearly predominant in both groups. The latter group also felt negatively about the levels of grant available, the visual attractiveness and the affordability of the systems. Interestingly, it emerged that adopters were mostly in retirement or approaching retirement, and they had spare financial resources to invest in a sustainable project.

4.2 Studies addressing consumer values, perceptions, attitudes and behaviour

In several disciplinary areas, such as psychology and economics, there has been great interest in studying public perceptions, attitudes and preferences towards energy and the environment in general, and specific technologies or projects in particular. Most

studies attempt to shed light on the possible correlations between public values and attitudes on one side, and actual behaviour on the other.

The research by Rowlands *et al.* (2002) addresses public perception of 'green power' in the Waterloo Region in Canada, where air pollution is a particularly serious problem, by using a survey questionnaire method. In particular, the study sought to explore consumer perceptions of the environmental impacts of different energy resources, and their relation to consumers' stated willingness-to-pay (WTP) a premium for green power. Among the findings, it emerged that the concept of 'green power' is interpreted in different ways. Additionally, those who have declared their WTP a higher premium for green power are more critical of nuclear power, large-scale hydropower and natural gas than those who have declared their WTP a lower premium or no premium at all.

Qualitative fieldwork reported in Gleason and de Alba (1996) and conducted in Colorado found that most respondents showed a very limited understanding of how electricity is generated, the cost of renewable electricity generation, and the impact of electricity generation on the environment. This study found that people preferred wind and solar power over other alternatives.

The study by Ek (2005) examines the general attitude towards wind power among Swedish electricity consumers, and analyses whether the general attitude towards wind power differs with respect to socio-economic factors. A sample of the Swedish population was administered a postal survey with the aim of eliciting general attitudes towards the environment, wind power and some of its characteristics and impacts (location, height, noise, etc.). It was expected that support to wind power would be positively linked to income and education and negatively to age, in accordance to previous findings. However, the study found that the probability of finding an individual with a positive view towards wind power is decreasing with age and income. People with an interest in environmental issues, who buy green products, are more likely to support wind.

Arkesteijn and Oerlemans (2003) performed a survey-based study on the early adoption of Green Power by Dutch households, from a social psychology perspective. Through a telephone survey, 55 adopters and 60 non-adopters were interviewed after an initial sample of 500 randomly-selected individuals from each group had been identified (250 each). The model that could best explain and predict adoption combined technical factors (such as ease of use and trust in the supplier), individual factors (responsibility to the environment, knowledge of renewable energy and environmental behaviour) and economic factors (willingness to pay and price perception). In particular, behaviour was an important predictor, whereas intentional variables (such as WTP) appeared less influential. Early adopters can be broadly described as knowledgeable about energy, renewables and environmental issues and are more likely to have shown environmentally-friendly behaviour in the past. Perceived relative advantage of the technology, use of communication networks and income appeared to have no influence.

The study carried out by Poortinga *et al.* (2004) focused on the role of values in household energy use and took the concept of quality of life (QOL) as a measure of human values. The study sought in particular to establish whether values, general environmental concerns and specific environmental beliefs are related to household energy use, acceptability of specific energy-saving measures and support for environmental policies. The theoretical framework for the study is provided by the

hierarchical model for environmental behaviour (Stern et al., 1995) which links values to environmental behaviour through intermediate variables, such as beliefs and attitudes. The study (based on 445 questionnaire responses) found that the value representing “environmental quality” led to environmental concern and behaviour, whereas “self-enhancement” was related to low environmental concern. In turn, more environmental concern was linked to support for government regulation and action over environmental matters, whilst low environmental concern was associated with support for the free-market and a tendency to assign responsibility to others. The study noted that the relationship between values, environmental concern and behaviour appears more complex than it is often assumed. It could confirm some previous findings (by Gasersleben et al., 2002) which claim that home and transport energy use is more strongly associated with socio-demographic variables (such as household size and income) than attitudinal variables. The study concluded that a purely attitudinal motivation model is too limited to explain environmental behaviour and contextual factors should be taken into account, such as the individual opportunities and abilities to perform certain types of behaviour.

Bang et al. (2000) sought to understand the failure of marketing renewable energy (RE) to American consumers and to identify possible solutions. The population sample consisted of 2600 residential electricity payers in Southwest USA, of which 347 responded to the mail questionnaire. Among the findings, it emerged that consumers have a general low knowledge of renewable forms of energy. Consumers with higher levels of knowledge, concern for the environment and stronger positive beliefs about RE are more likely to be willing to pay more for RE, although corresponding levels of WTP are not as high. Another finding points to the lack of any associations between environmental concern and knowledge of RE, and between knowledge of RE and positive beliefs about RE. It appears that beliefs, rather than knowledge or concern, are more important in shaping WTP.

From the perspective of the Reasoned Action Theory (Ajzen and Fishbein, 1980), Roe et al. (2001) investigated US consumers’ willingness to pay for green electricity (i.e. electricity generated from renewable sources). The study surveyed a population sample composed of 1001 individuals recruited from shopping malls in 8 different US cities of which 835 provided usable responses. Respondents were presented with two different hypothetical electricity services, with different costs and environmental impacts, and asked which one they would be willing to buy. The resulting data were analysed through conjoint analysis. It emerged that respondents’ willingness to pay for marginal reductions in air emissions without alteration of the fuel mix was small and positive across all demographic segments. Increased WTP was expressed only by specific population segments for emission reductions accompanied by increased reliance on renewable sources. The addition of nuclear power in the fuel mix resulted in increased WTP as well, although this was true for certain social groups only. The study acknowledged that stated WTP tends to be greater than the actual price people would pay if given the real opportunity.

Zarnikau (2003) reports on the findings of a study addressing consumer demand for green power and energy efficiency in Texas. The population sample was administered a questionnaire and then invited to town meetings (named “deliberative polls”), in which participants were presented various green energy options and actively engaged in discussions with experts, decision makers and utility managers. Another similar questionnaire was then administered after the deliberative poll and compared with the previous one. Statistical analysis revealed that willingness to pay a premium for

renewable energy and energy efficiency, expressed in the pre-poll questionnaire, was related to demographic factors, such as age, salary and education. Participating to deliberative polls increased public attention to energy efficiency as a primary energy option, at the expense of interest in renewable energy. Nonetheless, comparing post-event data with pre-event ones revealed that providing information and engaging the public increased the willingness to pay a modest premium for renewable energy and energy efficiency. However, several areas that needed further investigation were identified, such as the role of different presentation styles and information material in communicating with the public and the difficulty of predicting the actual public response to a green energy programme. It is acknowledged that people, faced with real-world choices, may not behave as they said they would in a questionnaire.

The research conducted by Kaiser et al. (1999) addressed the relation between environmental attitudes and ecological behaviour, from an environmental psychology perspective (informed by the Theory of Planned Behaviour of Ajzen, 1985). The study examines responses to a questionnaire from two Swiss transport associations with opposite ideologies (environmentalists as opposed to car users). Looking at the relation between values, knowledge and behavioural intention, the study found a statistically significant correlation between environmental values and knowledge on one side, and ecological behavioural intention on the other in both social groups. When taken in their broader meaning, ecological intentions predict behaviour very well. The role of external influences on individual behaviour is particularly stressed, as ecological behaviour is not completely dependent upon one's will but is delimited by socio-cultural constraints or "non-psychological factors". Examples include weather conditions and home characteristics affecting household energy consumption; the cost of water affecting water consumption and conservation; and household characteristics enabling or preventing recycling.

The role of socio-demographic characteristics in profiling green consumers is investigated by Diamantopoulos et al. (2003), who drew upon an extensive literature review. The study concludes that associations between socio-demographics and environmental awareness and sensibility are rather complex and difficult to disentangle from other factors. This is also due to the different approaches and methodologies used in the reviewed studies. In sum, it would appear that socio-demographic characteristics do shape environmental attitudes, whereas they have no influence over environmental knowledge and behaviour.

5. Discussion and conclusion

The reviewed studies have provided rich and diverse insights, which have been grouped and discussed under different themes. The vast majority of the reviewed literature consists of quantitative research studies, principally based on questionnaires and various kinds of opinion polls. Only a minority is based on qualitative types of research, such as discussion groups or focus groups, and if so, the qualitative part of the research work is often of a preparatory, pilot nature. Although most quantitative studies offer statically significant data and give an idea of major patterns in public opinion, much more detailed and variegated observations emerge from the qualitative research studies, especially when the specificities of certain local contexts do matter.

One thing that clearly emerges from this review (see also Walker, 1995) is that it is difficult to generalise from such a diverse range of studies, each characterised by a specific methodological approach and focus on different issues. It is also misleading to speak about 'the public' especially when considering the outcome of qualitative work, from which a broad variety of 'publics' emerges. It is also worthwhile to acknowledge the dynamic nature of public views and attitudes, in that they can change and also be contradictory.

This paper sought to address three main questions related to public attitudes and behaviour towards a variety of energy and environmental issues. To summarise the findings, each question will be addressed separately as follows.

What are public values, beliefs, attitudes and behaviour towards energy and environmental issues, in the UK and at international level?

Although people seem to be concerned and interested about the environment, in particular in relation to widely debated issues such as climate change and global warming, those concerns do not usually come up spontaneously when people are asked about concerns affecting their daily lives. Social issues, such as crime, health and terrorism, have greater predominance. This is particularly true in the case of energy. Few people express confident knowledge about the ways in which energy and electricity are produced, and around issues concerning costs and security of supply. Public opinion seems to be divided over nuclear power, with significant proportions of people showing support and opposition. Although people appear to be generally aware of the human contribution to climate change, their knowledge and understanding of environmental issues is superficial and often inconsistent, and many demand for more information they can trust.

Concerns about the environment do not generally translate into behaviour and commitment on a daily basis, in fact personal comfort and cost-effectiveness are stronger drivers of behaviour. Although recycling emerges as a popular choice, few other environmentally-friendly or energy-saving actions are deliberately taken for environmental motivations. Cutting down costs and bills is key in this respect. Few people are aware of the impact of their personal energy use, in the home and for transportation.

Nevertheless, public support for actions to tackle climate change and improve security of energy supplies appears to be widespread. While personal efforts are generally considered ineffective, a large proportion of the public strongly favours measures

implemented by the government, such as incentives and subsidies to renewable energy and 'clean' technologies, and regulations and taxes to curb the use of polluting fuels. Despite this support for collective action, there seem to be a worryingly high level of public distrust of the government, as well as of industry and certain lobbies. Few people seem to be aware of the Government's existing and planned actions to tackle energy and environmental problems.

At international level the situation mirrors that of the UK, with obvious country-specific differences.

What are the determinants of environmentally-friendly behaviour? Is there a correlation between values, knowledge, beliefs, concerns and attitudes, and actual behaviour?

The studies that have been reviewed here offer mixed results that cannot be easily summed up together. It appears that this area of research is still fragmented and there are many different approaches rather than a unifying theoretical framework.

There are still many doubts about the predictive power of attitudinal variables and the relevance of self-reported behaviour. There is always the risk of social desirability bias in responses to questionnaires. Behaviour in energy use and towards the environment appears to be the outcome of a negotiation among many factors, inclusive of various personal, economic and contextual determinants, and further research is necessary to assess the relative importance that can be attributed to each of them.

What are public attitudes and behaviour towards specific energy technologies, such as new and renewable energy, and other technologies associated with energy and the environment?

Existing evidence indicates that there is, in principle, strong support for renewable energy. However, attitudes to specific technologies, projects and schemes can vary widely. Most people are unfamiliar with such abstract concepts as "renewable energy" and "sustainable development", and prefer to speak about specific technologies and the practical contexts of use (where they will be located, what benefits they will bring and to whom, what risks or nuisance they may cause, who will be responsible to ensure everything is duly managed, etc.).

Renewable energy is mostly supported for its environmental benefits. Among renewable sources, solar and wind appear to be particularly favoured and widely known. However, most people feel their knowledge on any of the renewable technologies is low and limited to a superficial understanding, principally gained from popular media sources, such as TV and newspapers. Hydropower is an established technology for most and few had ever thought of it as 'renewable'. Less known technologies, such as wave, tidal, combined heat and power (CHP) and biomass, for example, raise more concerns than solar and wind, and are less readily accepted. Biomass, in particular, is not easily associated with the concept of 'green' energy and raises health concerns among most people. However, the majority of the reviewed studies do not attempt to explain the relationship between awareness and knowledge on one side, and acceptance on the other. Clearly, this is an area where further investigation is needed.

Most people feel that cost is still a great barrier to the deployment of renewable sources, and lack of practical information and advice about the various options (cost, grant availability, installation, maintenance, performance, etc.) is hindering adoption in the residential sector. Among the disadvantages that people find about renewable energy technologies, reliability is often mentioned in relation to solar power (“not enough sun in the UK”), whereas aesthetics, lack of space and intermittency are associated with wind. People feel highly unsure of expressing any opinion about other less known renewable sources.

A number of studies have addressed public resistance to local renewable projects and tried to understand the reasons behind opposition. What clearly emerges, in contrast with the simplistic notion of ‘NIMBYsm’, is that more complex motivations can shape public acceptance or resistance to a certain project, and that the process of developing a project and the local context in which it is implemented play a key role. In other words, publics can in principle be supportive of renewable, ‘green’ technologies, but in practice they can oppose specific projects. More deliberative approaches, capable of appreciating the specificities of the local context, may be a way forward and provide a remedy to the widespread erosion of trust in governments and institutions.

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