Public Attitudes, Understanding, and Engagement in relation to Low-Carbon Energy:
A selective review of academic and non-academic literatures

Report for RCUK Energy Programme

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Summary and Recommendations

1. Background

Purpose of the report

This study on public attitudes to, and engagement with, low-carbon energy draws together the results of UK-relevant social research and evidence, as of October 2010, in order to inform the RCUK Energy Programme at both strategic and operational levels. Our sources were identified through a systematic search of bibliographic databases and a formal call for evidence issued to practitioners and academics in order to identify non-academic ('grey') sources and forthcoming academic publications. The authors are all active in energy social science research.

Overview of the report

The report provides an introduction to some of the most relevant social science theory and concepts relating to public engagement (chapter 3), before reviewing findings on attitudes and engagement relating to energy supply, storage and distribution technologies (chapter 4); energy demand attitudes and engagement (chapter 5); and energy systems and research engagement (chapter 6). We also discuss cross-cutting themes, knowledge gaps and recommendations for public engagement in the RCUK Energy Programme.

Public perceptions of energy matter

Current and emergent energy and environmental targets imply significant change to UK energy systems. In particular, decarbonising those systems while ensuring sustainable, affordable supply has major ramifications for the public, who will be asked to accept new energy infrastructure and technologies, and to change patterns of demand. Understanding public attitudes to these changes, and the ways in which energy and technologies are themselves understood and used, is vital. This understanding is all the more important given recent media coverage of climate science which some fear have undermined public confidence in science and eroded trust in scientists.

There are good reasons to engage the public in energy research

There are a wide range of reasons for engaging the public in energy research, upstream in the RD&D chain. These may include dispelling ignorance and misunderstanding; raising scientific literacy, increasing trust in scientists, mobilising favourable attitudes to scientific and technological innovation, changing behaviour, and using public perceptions as a resource of inspiration, oversight and legitimacy that may temper and moderate scientific and technological innovations with uncertain and potentially risky outcomes. There is also a normative (value-based) rationale for public engagement: the public arguably have a right to influence decisions about public-funded research and technologies or policies that may affect them.

2. Theory

Theoretical underpinning

Attitude theory from psychology dominates studies of public perceptions of energy and engagement in energy research. Attitudes are hypothetical constructs that refer to an individual's evaluation of something. Attitudes are considered to have three main dimensions: knowledge, relating to the intellect and cognition; affect, relating to emotion and feeling; and behavioural intentions. Attitudes can change and are influenced by a range of factors, often ambivalent or uncertain. Attitudes to objects (such as climate change or

energy efficiency) are frequently not predictive of behaviour (such as turning off unnecessary lights or supporting new, local energy infrastructure).

Attitudes can sometimes be changed through persuasion and experience, but they can also change as a result of behaviour change itself. This relates to a second, less commonly used, but increasingly popular theory of behaviour change: the *'practices'* approach from the sociology of consumption. In this approach, 'attitudes' rarely feature and are considered secondary: in terms of explaining behaviour, habits and routines are seen as primary factors. Changing the social, economic, political and technological context of individuals' daily lives is seen as the main route to behaviour change. The context in which individuals live is seen as constraining behaviour change and conditioning attitudes. Thus the practices approach reverses the assumed causality: attitudes follow from behaviour, not the other way round, and the social and technological environment strongly influences what behaviour is possible.

This emphasis on the way in which people are embedded in and influenced by their environments is also prominent in *socio-technical transitions* research and *Science and Technology Studies*. The first of these provides theoretical explanations of how the transition to new energy systems may take place. To date, the role of the public in these theoretical accounts has arguably been under-explored. Science and Technology Studies argues that while technology, research and risk governance have generally been restricted to experts and policy makers, there are nonetheless good reasons for involving the lay public, as outlined above. Science and Technology Studies also argues that it is legitimate to perceive energy technologies in a variety of ways: opinion divergence is not necessarily a sign of ignorance or misunderstanding.

Finally, there is also a strengthening body of theoretically-informed work on why the concept of NIMBYism is problematic and unhelpful in explaining public objection to new energy infrastructure. This work argues, for example, that the NIMBY concept overlooks the way in which individuals form strong attachments to locations and that places can become a part of individuals' identities. Understanding public objection to a new infrastructure proposal as a threat to individual identity and to locally valued environments begs the question of whether a proposal or its presentation can be modified so as to be more consistent with local opinion. Research in this direction in turn draws on *environmental governance* concepts, which includes concepts relating to power in planning and economic systems, and institutions, procedures and fora for negotiation and deliberation with the public.

3. State of the field

Before outlining the main lessons from the literature in terms of public engagement, we first list below particular gaps in the literature that our analysis has exposed, and that we consider important areas for future research. These give an indication of where future research and engagement priorities may lie:

- Governance structures and issues relating to public engagement in energy policy and planning at local, regional, national and international levels
- The conditionality, contingency and fluidity of energy perceptions and attitudes. In particular, development of attitudes before, during and after the construction of wind-farms or implementation of transport policies
- Public attitudes to nuclear fusion
- Unlocking and locking-in socially-embedded technology use and practice

- Public attitudes to energy-efficient and/or low emission vehicles
- Public attitudes to low-carbon diets
- Public attitudes to and demand for air-conditioning
- Willingness to save energy associated with cooking behaviours
- Segmenting on particular energy-use attitudes/behaviours, e.g., cooking, heating (rather than environmental attitudes)
- Public responses to less well-known renewable energy technologies, e.g., biomass and geothermal
- Interdisciplinary work on energy consumption which integrates economic and social sciences
- Applying theoretical perspectives to both supply and demand side issues (e.g., place identity and domestic energy use) to integrate (cf. need for energy *systems* research)
- There is little information on how attitudes to new energy infrastructure evolve over time, from the development proposal through to living in proximity
- There is little literature on attitudes to gas pipelines; this may become more significant with use of CCS
- Most of the UK research on attitudes to micro-generation has been commissioned by government agencies and is relatively limited in quantity
- There is hardly any work on UK attitudes to energy systems and scenarios, perhaps partly because of the multi-disciplinary challenges
- The value of conventional, consumer-oriented marketing has yet to be fully investigated for the purpose of encouraging domestic investment in microgen and energy efficiency measures
- Energy consumption should be examined at household (as well as individual) level, and include group dynamics and negotiation of energy decision-making and practices at the household level
- Early studies suggest that marine energy technologies may not be the 'Out of Sight Out of Mind' option that some may have thought. More research is needed as more devices are deployed and information on impacts moves more from theoretical models to monitoring results.

Table (i) overleaf provides an impressionistic summary of the availability of the public engagement and perceptions literature, on a per-technology basis, with the rating being on an internally relative basis. Some one third of energy topics are rated as having received a relatively high level of attention in terms of engagement and attitudes, with another third having received relatively little attention. Note that, as for the study as a whole, this is largely for the UK-specific literature only. Of all the topics, public engagement in and perceptions of energy systems and scenarios is the least populated literature segment. We suggest that this relates to the interdisciplinary demands of the topic and the lack of appropriately tailored funding.

Table (i) Extent of literature by topic

		High	Medium	Low
Supply	**Large-scale wind energy**		■	
	Biofuels			■
	Bioenergy		■	
	Tidal and wave energy			■
	Geothermal energy			■
	Large-scale hydroelectric power		■	
	Energy from waste			■
	Micro-generation			■
	Fossil fuels	■		
	Carbon capture and storage		■	
	Nuclear fission			■
	Nuclear fusion	■		
	Nuclear waste		■	
	Hydrogen and fuel cells		■	
	Electricity and gas networks			■
Demand	**Energy-efficient domestic appliances/equipment**	■		
	Energy-efficient homes		■	
	Energy-efficient transport	■		
	Energy consumption	■		
	Low-carbon/differential energy tariffs		■	
	Domestic energy conservation	■		
	Shopping, eating and waste behaviours		■	
	Travel behaviours	■		
	Energy conservation interventions/policies		■	
	Energy systems and scenarios			■
	Energy research			■

4. Attitudes to energy technologies

In this section we set out the main findings of the literature synthesis, with respect to attitudes, on a per-technology basis.

Large-Scale Wind Energy

Survey research suggests that wind energy is one of the most familiar sources of renewable energy and that UK public attitudes towards wind energy have been consistently positive over the last decade. However, these levels of overall wind energy support mask some diversity across social categories and some moderate instability over time. For example, research suggests that older respondents hold slightly less favourable attitudes towards wind energy in comparison to younger respondents. Very little is known about the development of attitudes before, during and after the construction of wind-farms, or about attitudes to offshore wind. Resistance to wind energy developments appears to be primarily driven by negative perceptions of their visual impacts, with a considerable minority finding them unsightly and noisy. Research does not provide unequivocal evidence that benefits provision (paying compensation) increases the social acceptance of wind energy. Indeed, the limited evidence available suggests that while energy security framing can elicit strong support for renewable energy, economic framing may contribute least.

Bioenergy and biofuels

Bioenergy remains one of the least familiar renewable energy technologies to the UK public,

despite biomass combustion being an ancient technology, but awareness is increasing. About half of the UK population have positive views of bioenergy and Eurobarometer research shows that support for biomass in the UK is among the lowest in Europe. Burning waste for energy is perceived more negatively than use of biomass. There is very little publicly available literature on UK attitudes to biofuels. That major fuel suppliers generally avoid drawing attention to the biofuel content of retail fuel suggests that public views may be mixed or negative.

Tidal and Wave Energy

Relatively little is known about public attitudes to tidal and wave energy. Nonetheless, marine energy projects are likely to encounter many of the same issues as other renewable projects. These are likely to relate to the processes and institutions involved with the development (e.g. issues of trust, motives, distribution of benefits, contested desirability and level of environmental benefits). Although wave and tidal energy are often grouped under the term 'marine energy', their impacts and performance may prove to be quite different and public opinion may become more differentiated as more devices are deployed. The performance and impact of the first handful of wave and tidal stream energy developments have the potential to substantially shape public attitudes to the sector.

Geothermal Energy

Perhaps reflecting the fact that geothermal energy is only an emerging technology in the UK, the public perception literature is very scarce. UK specific findings are limited to asking about awareness of the technology. In 2006, a Eurobarometer survey found that 36% had heard of geothermal energy, which is lower than the EU average of 44%. The same survey also shows lower levels of awareness compared to other emerging technologies such as ocean energy (wave and tidal) or carbon capture and storage.

Micro-generation

Few UK studies have investigated public attitudes and decision-making on micro-gen and the literature on public perceptions of micro-gen, and particularly on engagement with research of the same, is very much smaller than that on attitudes renewables in general. Upfront capital cost has been a major obstacle to uptake of all micro-generation. Research with householders predisposed to installing new heating systems found that positive motivations for adoption of renewable heat technologies included perceptions of low running costs, self-sufficiency, ready access to raw materials and positive environmental performance. Barriers to uptake included lack of awareness or understanding of the options (particularly heat pumps); (very) high installation costs and long payback times; uncertainty as to efficiency, effectiveness, consistency and environmental performance; difficulty in finding credible installers and suppliers; concerns about ease and costs of maintenance; and the inability of renewable technologies to satisfy all heat requirements.

Energy from waste

Public concern about incineration, energy from waste and energy from biomass residues has been experienced in several European countries and there are a number of common concerns, including:

- Atmospheric Emissions: dioxins, acid gases, heavy metals
- Disposal of fly ash from incineration or residues from energy from biomass residue plant
- Noise, odour, traffic movements
- Lack of flexibility of contracts for municipal solid waste and their impact on new reduction or recycling initiatives and importation of waste from outside the region
- Insufficient justification of the plant (the principle, size or scale)

- Costs and security of finance
- The visual impact of the scheme on the locality
- The impact of the scheme on the character of an area
- The impact of the scheme on local house prices

Large-scale hydropower

Most (78%) participants in the 2008 BERR energy attitudes survey had heard of hydroelectric power and a large majority approve of it in principle. However, when asked about a potential hydro development 'in your area', a notable 27% say that they would be resistant to it and only 47% would approve it (TNS, 2003). Earlier qualitative research has suggested that, despite broad support for the technology, some expressed concerns about the visual or noise impact of such developments, and felt if such schemes required flooding of valleys the negative social impacts would be unacceptable. This suggests *contingent* support.

Conventional Fossil Fuels

The literature on public perceptions of traditional fossil fuels is very limited in the UK. Public attitudes to fossil fuels are often not studied in isolation, but generally considered within a wider set of energy sources. Few of the UK public (20%) are in favour of using any of the three main fossil energy sources on an on-going basis, a level of support that is comparable to that of nuclear energy. However, levels of opposition to coal, oil and in particular gas are lower than to nuclear. The low levels of support for fossil fuels is confirmed by research showing that very few people think that coal, gas or oil fired electricity power stations should be built in Britain in the next 10 years. Coal is particularly negatively evaluated as it is regarded to cause air pollution and climate change, create dangerous waste, spoil the landscape (even more so than wind energy and nuclear power stations), and an inefficient source of electricity, while only one out of ten think that coal is a clean source of energy.

Carbon Capture and Storage

As CCS is an unfamiliar technology, public perceptions are heavily influenced by the information and framing provided by researchers. This information may or may not set CCS in the context of other energy and emissions reduction options; it may provide light or heavy detail on CCS and its climate change rationale; and interaction with the information may or may not be highly controlled by the researchers. While there is much commonality between the findings of various studies, the foregoing factors likely account for much of the variation. Overall, research suggests that CCS tends to be supported in proportion to the extent of high quality information provided. Without a convincing explanation of the merits of CCS, and without adequate responses to public concerns by trusted people, the public tends to prefer a renewable energy future and to perceive CCS as an end-of-pipe, unsatisfactory solution. Serious local opposition has been experienced in the vicinity of at least one proposed onshore storage site in Europe (Barendrecht, NL). While it should not be assumed that offshore storage will be free of negative public opinion, it is likely that opposition to offshore storage will be lower.

Nuclear Fission

Against a backdrop of highly negative historical connotations attached to both nuclear fission as a result of a number of accidents and the unresolved issue of the disposal of radioactive waste, it is perhaps not surprising that public support for nuclear power is generally low. Nationally representative studies have shown that only about a third of the British public hold favourable views about nuclear power. The relatively low levels of support for nuclear energy appear to be driven by concerns about the disposal of radioactive waste, risks of accidents and radioactive contamination, and nuclear energy installations being potential terrorist targets, but also because 'better solutions' are considered available. However, lack of support and opposition are not the same and opposition has been declining

in recent years. Whilst in 2002 about two out of five opposed the building of new nuclear power stations in Britain to replace those that are being phased out over the next few years, in 2007 fewer than one in three did so. In 2008 less than one out of five indicated to oppose new-build. Researchers have perhaps rightly characterised the UK public's approach to nuclear power as one of 'reluctant acceptance'.

Nuclear Waste

The long-term disposal and storage of nuclear waste is seen by the general public as the greatest disadvantage of nuclear energy as a source of electricity. Despite there being some softening on the idea that nuclear energy might contribute to a broad policy of reducing CO_2, for a majority in the UK, the negative aspects of nuclear, such as waste disposal seem to outweigh this advantage. Even local communities who have been found to be broadly accepting of nuclear power remain highly concerned about the storage and transport of radioactive waste. Radioactive waste is negatively evaluated on a range of psychometric characteristics relating to risk, including unknown consequences, risks to future generations, dread, being informed, control, unfair distribution, and moral concerns. Eurobarometer found in 2008 that "if there was a permanent and safe solution for the management of waste", more than half of the UK public would be in favour of energy production by nuclear power stations. A large majority (94%) tended or totally agreed that "a solution for high level radioactive waste should be developed now and not left for future generations", with about two out of five agreeing that deep underground disposal represents the most appropriate solution for the long-term management of high level radioactive waste.

Nuclear Fusion

As nuclear fusion is not a fully operational energy technology, there are hardly any studies on associated public attitudes. Only one Eurobarometer survey (2003) has asked about the future of nuclear fusion. Most of the UK respondents responded with "don't know" to these questions, revealing the unfamiliarity of the general public with the technology. Those responses that were obtained indicate wariness: more people thought that nuclear fusion is *not* safe against major nuclear accidents (29% versus 20%), would produce as much long term energy nuclear waste as today's nuclear power station (25% versus 18%), would contribute to global warming (29% versus 22%), and would use abundant fuel resources (27% versus 16%). Some of the public who participated in the Energy Research Dialogue for RCUK in 2007 discarded fusion as a potential beneficiary of their hypothetical R&D funding allocation, on the grounds that little progress had been made in return for historically large public investments in the technology.

Hydrogen and Fuel Cells

Much of the research on public understanding of, and attitudes toward, hydrogen energy has drawn similar conclusions; namely that overall knowledge of hydrogen energy, production processes, storage, and infrastructure is low yet general support for hydrogen technologies remains positive. Nevertheless, support is conditional upon concerns about safety, personal and global costs and benefits, and technological efficacy being met. The current literature reveals an emphasis on hydrogen use in transportation and related infrastructure rather than on hydrogen electricity production. Very little research has focused specifically on fuel cells.

Electricity and Gas Networks

Relatively few studies have been conducted to date in the UK on public attitudes to energy supply infrastructures such as gas or electricity networks, as distinct from fuels themselves. Indeed this review found no studies that had specifically investigated public attitudes to gas network technologies. Both survey and qualitative work indicates that electrical grid operators are not well-known to the public, who associate National Grid with the physical

infrastructure of pylons and cables rather than the businesses involved. This may have implications for the public engagement that will be needed for infrastructure renewal.

Energy-Efficiency Measures

There are both conceptual and attitudinal differences between purchase-related behaviours (including energy-efficient light bulbs and appliances) and so-called habits, which include energy curtailment behaviours such as reducing heat in unused rooms, reducing hot water temperature, putting on more clothes instead of more heating etc. That is, people perceive energy-efficiency measures and energy conservation as separate categories of 'behaviour'. Within the UK, a clear majority (70%) consider reducing household energy use as a virtuous thing to do for the environment (Green Barometer, 2007), although policy measures aimed at reducing household energy use are generally unpopular: few think that measures, such as 'green' taxes (34%), road pricing (30%), and carbon rationing (28%) are socially acceptable. Similarly, enthusiasm of individuals for changing their lifestyles appears to be somewhat muted. A recent representative British survey (Spence et al., 2010) found that while 65% of people tend to agree or strongly agree that they are prepared to greatly reduce their energy use to help tackle climate change, fewer than half of respondents (44%) are prepared to pay significantly more money for energy-efficient products.

Energy-saving light bulbs

Although no evidence was found on perceptions of the compulsory phase-out of incandescent bulbs, public attitudes to energy saving light bulbs seem generally positive. A series of national surveys on public attitudes towards climate change and the impacts of transport have shown that the willingness to use energy saving light bulbs in the next 12 months due to concerns about climate change rose from 66% in 2006 to 80% in 2009. This was only second after the most popular 'environmental behaviour' of recycling household rubbish. Research conducted by the Energy Saving Trust and DEFRA (2009) asked respondents who had at least one non-energy saving light bulb what was stopping them from fitting more. A substantial minority of 42% said that energy saving light bulbs did not fit their light fitting, with an additional 14% saying that the quality of the light is poor.

Energy-efficient appliances

A recent EST/DEFRA survey (2009) found that many respondents claim that they are already buying energy-efficient appliances and intend to continue to do so (60%). A clear majority of the people who had bought at least one appliance in the last year (70%) said that they had looked for the Energy Saving Recommended logo in the majority of purchases (DEFRA, 2007b); and a similar proportion (72%) said that the appliance they actually bought had the Energy Saving Recommended logo on it. The proportion of respondents that are looking for the Energy Saving Recommended logo and had actually bought an appliance with the logo on it had increased substantially since 2007 (EST, 2007), suggesting that the logo is helping people to make more energy conscious decisions when replacing or buying new household appliances. The most frequently mentioned barrier to purchase relates to the perceived 'utility' of energy efficient products and their higher cost.

Energy efficiency of homes

Attitudes to insulation and double glazing are generally very positive (Defra, 2009), with many people seeing an energy-efficient home to be worth more when sold because it saves on heating bills (EST, 2010b) and a large minority of respondents (42%) indicating that they are willing to pay more for a refurbishment if it also makes their house more energy-efficient. In terms of barriers, many households may lack the funds and/or access to credit to make these investments possible. Furthermore, renters can in most cases not be in a position to install insulation or double glazing and are dependent on the willingness of the landlord to make these investments. Focus group discussions also suggest that consumers

are often unaware of the possibilities and struggle to understand all of the issues. Individuals say that they are more likely to install energy efficiency measures if they can discern what the benefits would be in financial terms.

Energy efficiency in travel and transport

Little UK research has been conducted on the topic of public attitudes to energy-efficient and/or low emission vehicles. Moreover, buying a low emission vehicle, such as a hybrid, electric, biofuel, or less than a 1.4l engine, is among the least common pro-environmental behaviours in the UK (Whitmarsh and O'Neill, 2010). The 2009 EST/DEFRA survey shows that a substantial proportion of current drivers has either never thought about switching to or never heard of an electric/hybrid or LPG car (27%), or said they probably will not or do not want to switch (53%). Only 15% said they were thinking about switching to an electric, hybrid or LPG car. Slightly more car drivers said that they were thinking about buying a more fuel efficient, smaller, or diesel car (27%), while 26% said they had already done so. Yet research by the Energy Saving Trust (2010) shows that about two-thirds of the adult UK population would like a car with low carbon emissions if they could afford one and about three out of four would consider fuel efficiency an important factor when buying their next car. However only around one in four would consider an electric car the next time they buy a new car.

Energy consumption and conservation

Energy use is primarily driven by economic (income, cost, etc.), structural (location, home ownership, household size, etc.), and social factors (status, meaning, identity, etc.) and by everyday (consumption) practices and habit; environmental values tend to have relatively little influence. It would be misleading to assume that all, or indeed the bulk of, everyday energy use behaviour is financially driven. Research shows very strongly that energy use and travel behaviours can, and often do, move quickly from considered deliberations over perceived personal costs and benefits to the more habitual sphere. For example, survey work has found that 'habit' is the most common reason given for not switching off lights and appliances.

Low-carbon and differential energy tariffs

As of 2008 to date, uptake of renewable energy tariffs by households has been extremely low (0.3%). Awareness of green energy schemes is also relatively low: when shown a list of green energy suppliers' names or logos, 63% of the English public said they were not aware of any of the companies/schemes and 83% had never used them (Haddock Research and Branding, 2008e). Reasons for low take up include the cost of tariffs, limited information on green energy, the effort involved in switching supplier (switching 'inertia') and low levels of public trust about claimed environmental benefits of green energy schemes. Qualitative research indicates that differential tariffs, which can help spread demand, are viewed positively by many (though not by all) via their association with cost reductions.

Domestic energy conservation

Willingness to change energy habits, or at least stated willingness (i.e. surveys do not measure actual behaviour), does appear to be increasing. EST (2010) survey data indicates the proportion of the UK public stating they are doing 'lots of things' or 'quite a number of things' to reduce their energy use and emissions increased from 19% to 38% between 2008 and 2009. More, however, say they are doing small things (32%), while one in ten say they are unwilling or unable to reduce their energy use. It would appear that actions to save electricity for lighting are more popular than heat- and washing- related energy saving actions.

Shopping, eating and waste behaviours

There appears to be support amongst the UK public for buying local and seasonal produce,

with 73% in the UK claiming to make an effort to buy things from local retailers and suppliers, and 60% saying they buy fresh food that has been grown when it is in season (Defra, 2009). In respect of diet, 59% in the UK say they are willing to change their diet to reduce their environmental impact (Defra, 2009). Qualitative work commissioned by Defra (Defra/Opinion Leader, 2007) found that food purchase decisions involve a complex interaction of factors such as convenience, cost, health, habit, offers, taste and availability; but sustainable food production and consumption is rarely considered. In general, public understanding and social acceptability of a low-carbon diet, appears to be relatively under-researched despite this potentially offering considerable emissions savings. Avoiding waste is widely and increasingly accepted as a social and moral obligation across the UK. In terms of waste behaviours, recycling is now very widespread - 91% of the UK public claim to recycle (up from 70% in 2007; Defra, 2009). Defra (2009) also find that reuse is becoming more common with 83% taking their own bags when shopping and 75% claiming to reuse items. However, only 30% avoid buying products with too much packaging (Defra, 2009).

Travel behaviours

Although the vast majority of the public agree that action should be taken to tackle climate change and transport problems, most see the government rather than individuals as responsible for taking action. Consistent with this, there is more support for new technologies or policies to encourage behaviour change (e.g., improved public transport) – termed 'pull measures' - than 'push measures', such as increased taxes or tolls which might restrict individual freedom. Most people oppose increased road or fuel taxes and there is more support for restricting expansion of airports (47%) than for raising taxes on flying (32%; Haddock Research and Branding, 2008c). In general, there is resistance to changing travel habits, a finding which is consistent across countries. When asked about personal lifestyle changes to reduce their environmental impact, most people state they are recycling and conserving energy use in the home, but a minority say they have changed their travel behaviour. In the UK, only 21% car share, while the same proportion state they would not want to; 50% say they 'would only travel by bus if I had no other choice' and only 23% agree that 'for the sake of the environment car users should pay higher taxes' (Defra, 2009). Research on attitudes to and adoption of eco-driving suggest this is more acceptable than reducing car use with 77% claiming to drive in a 'fuel-efficient way' (Defra, 2009). A minority of Britons (24%) say that they have reduced the number of flights they are taking, while more (35%) would not want to and many others (23%) have not thought of it (Defra, 2009). Resistance to changing travel behaviour is not primarily due to lack of awareness of problems associated with transport, since there is high public awareness of and concern about transport-related problems, such as air pollution and congestion levels and a majority of the public also appears to acknowledge the link between transport and climate change. Indeed the gap between awareness and concern on the one hand, and behaviour on the other is often most apparent amongst well-off, environmentally-aware sections of society.

Energy conservation interventions and policies

Since much energy consumption is inconspicuous, habitual and routine, *information campaigns* to foster energy-saving habits should be expected to have only modest effects. Assessments of energy *smart meters* (i.e. that show consumption clearly) show they can help lead to energy savings of 5-15%; there also appears to be widespread public support for the technology and a clear preference for informational feedback in monetary terms. *Carbon labelling:* only one UK study has examined public response to carbon labelling, and found that public support of carbon labelling of products is moderated by scepticism about the motives of companies involved and also comprehension difficulties. *Carbon calculators*: initial assessments of these tools show they can increase interest in reducing carbon emissions, although not necessarily produce actual behaviour change. *Advanced energy*

billing: e.g. providing social comparison data – trials are under-way and it is too early to draw conclusions on the net influence of knowing how one's consumption compares to a neighbourhood norm (for example). *Economic incentives*: to be accepted, these must be perceived as equitable. Hence revenues from the London Congestion Charge have been used to enhance public transport within the city, while non-hypothecated fuel duty increases have tended to lead to protest by those most affected.

Energy Systems, Scenarios and Research

There is very little work on public attitudes to energy systems, scenarios and energy research, perhaps partly due to the interdisciplinary demands, but also due to a lack of related programmatic funding and referee challenges. The Big Energy Shift for DECC/OST found that people are supportive of changes in energy supply and consumption, providing their quality of life remains the same and that they are helped to change. The Energy Research Dialogue for RCUK made recommendations on how to engage the public in energy research strategy development. Work in Manchester with the GRIP energy-emissions model found that the public in focus groups had little trouble envisaging their role in a 42% reduction in domestic (residential) CO_2 emissions, made up of reduced gas consumption, changes to the electrical grid mix and domestic power and heat generation. The timescale over which this was envisaged as being achieved, however, is probably over-optimistic. Forthcoming UKERC-funded work at Cardiff University will explore public opinion of energy scenarios.

5. Lessons

This section summarises lessons in terms of public engagement in energy research. These lessons are best considered together rather than split by technology: types of engagement vary not so much by technology as by objective, though technologies and objectives may sometimes be related (for example technologies that have not yet reached the market are likely to be more suited to deliberative techniques than deployed technologies, which may, for example, be more amenable to encouraging familiarity via site visits). We present here only a relatively applied interpretation of the synthesis 'lessons' – please see the full report for a fuller account.

- Most of the UK public are aware that climate change and energy security are serious problems and that we need to make substantial changes to our energy systems. They would much prefer a renewable energy future, but will reluctantly accept a role for nuclear. Reluctant acceptance may also apply to CCS, but it is too early to know.
- Most people are willing to make modest reductions in energy consumption, but few seem willing to make unilateral, particularly large, reductions in energy consumption. The public expect government, industry and other nations to play their part and to also, where appropriate, help them to reduce their emissions. However the public do not see convincing evidence of these other actors making substantial changes and this perceived inaction may be bolstering a reluctance to make what are perceived as sacrifices.
- The public is often able to frustrate attempts to deploy new energy technology when local impacts are considered unacceptable. Naming this as NIMBYism is not helpful: defending local territory against external threats is understandable. The extent to which local objections should be acted upon and responded to is a vexed issue and inevitably political, but early dialogue is universally recommended.
- Public engagement does require some level of resourcing, even if small. Generally, costs increase along a continuum from *consultation* (at its most basic, an on-line

questionnaire with a web-link emailed to public stakeholders and e-lists) to *deliberation* (e.g. a consensus conference or citizens' jury).

- Awareness-raising events (exhibitions, displays, educational activities) are engagement of a sort and are valuable in their own right, but they cannot satisfy the deliberative, dialogue-based aspects of engagement. Creating technologies and engaging the public in their development are both political acts: they both shape the world. Many if not most commentators believe that the public has a *right* to be involved in shaping their world.
- Public engagement with energy is fundamentally influenced by social trust and institutional relationships: attitudes to energy technology do not develop in isolation.
- Getting the timing right is critical when investigating attitudes and planning engagement activities: usually, earlier is better in terms of public engagement and research, not least because this in principle allows social learning – specifically, for making changes to technological trajectories that account for public concerns.
- 'Undesirable' energy-related attitudes are unlikely to change without associated change in the socio-economic, political or other aspects of the wider environment that help to maintain the attitudes in question. It is important not to under-estimate the significance of this: it means that information-based persuasion ('ad campaigns') will not be sufficient to change attitudes when strong contextual drivers run counter to the intended direction of change.
- When studying public perceptions of energy technology, different attitudinal and behavioural measures have differing advantages and limitations. Generally, deliberation (e.g. in a focus group) is required to elicit detailed attitudes to novel, unfamiliar or technical issues.
- Averages and simple survey questions can be misleading: public attitudes are often demographically segmented and individuals can play multiple roles in relation to energy issues and research governance. Moreover, attitudes can be conditional and are influenced by the way in which problems and questions are framed (i.e. by phrasing, the information provided and the contextual setting of that information).
- Research on public attitudes to and engagement with low-carbon energy draws on a range of theories and perspectives, but often theories developed in relation to one energy topic are not transferred to another.
- Each of the above themes draws together issues that should be considered when thinking about or planning public engagement in energy research. These include:
    - the need to define engagement objectives (e.g., correcting misperceptions, changing attitudes to science or energy issues, viewing the public as resource of inspiration, oversight and legitimacy);
    - the need to define engagement forms (information provision, education, and consultation and deliberation) and the limits and challenges associated with each;
    - the need to define 'successful' engagement (e.g., makes a difference to decision-making; is transparent; has integrity; is tailored to circumstances; involves the right number and right types of people; treats participants with respect; gives priority to participants' discussions; is reviewed and evaluated to improve practice; participants are kept informed etc.); and
    - the need to learn from related engagement activity, such as public engagement with climate change.

6. Recommendations

In developing these recommendations, we have focussed on where the RCUK Energy Programme is best placed to add value in respect of public engagement with low-carbon energy. While public engagement with low-carbon energy is pursued by many organisations (including, policy, industry and non-governmental groups) for a variety of reasons, research funders are uniquely placed to bring the public into decision-making about the *strategic direction* which energy *research* should take in order to meet societal needs and aspirations. At its broadest level this decision-making could include the relative importance of behavioural versus technological types of research to ensuring a low-carbon, secure energy supply for the future. More specifically, it could include prioritising particular energy technologies and infrastructures to be the focus of research and development funding. At a more operational level, too, the Energy Programme is well-placed to *educate* the public about public funded technological and social innovations, and to *learn from* the public about how these innovations may (or may not) be taken up and used in diverse ways. With respect to the potential functions of public engagement – (a) to disseminate information and educate the public, and (b) to involve the public in strategic decision-making – we give the following recommendations on where the Energy Programme might focus its resources for public engagement.

We would stress that these two broad approaches to (and rationales for) public engagement are not mutually exclusive. Indeed, there will often need to be an educational component to interventions designed to include the public in decision-making, notably where technologies are new or little understood.

Dissemination and education

There may be normative or pragmatic rationales for public communication of research. The normative argument speaks to the public's 'right' to learn about and shape public-funded research and innovation. From a pragmatic perspective, communicating research results may contribute to a more informed populace, potentially better able to make decisions about energy for their own benefit and that of society and the environment, and perhaps to a more inspired populace, who support energy research and scientific careers. However, we have argued that more information does not necessarily lead to behaviour change or to support for particular decisions or groups. On the other hand, *two-way information exchange,* whereby the public not only learns about energy research developments, but also provides answers about the social robustness of technologies and innovations, can provide significant benefits. This approach sees lay people as a 'reservoir' of knowledge, which may help shed light on whether and how technologies will be used; and the acceptability and efficacy of social (e.g., behaviour change) innovations. In addition, this approach allows the public to provide 'extended peer-review' of research findings and to open up and challenge expert understanding about certainty, risk and ethics. This may help expose 'blind spots', which those closely involved with scientific institutions become unable to see (e.g. through certain procedural rules, standardised objectives, research paradigms).

There are a number of areas where dissemination and education could be used to inform and learn from the public about energy issues. When prioritising areas for education-based public engagement the Programme should focus on areas where understanding is poor (i.e., either *public understanding* of the research or *researchers' understanding* of the social dimensions of their work) or where the Programme can add value. An example of this is in energy whole systems where the Programme has access to experts from a wide range of energy expertise (nuclear, energy demand reduction, CCS) and hence can play a role in bringing these people together to communicate a more complete picture of potential future

energy provision. Educational approaches might also focus on particular areas identified in this review as where public understanding is low, such as the relative contribution of different energy-consuming activities to causing climate change (i.e., improving carbon and energy literacy) and certain novel or smaller-scale technologies (bioenergy, marine, geothermal, fusion, hydrogen and fuel cell, and CCS technologies). More broadly, public understanding is limited in respect of energy systems and low-carbon, sustainable energy scenarios. In addition, as we outline in section 8.2, there are also gaps in researchers' understanding about public responses to and engagement with energy, which the Programme may wish to address.

For Energy Programme staff considering public engagement to *raise public awareness* about technological or social research outputs, it is also critical to consider (a) which groups within the public may benefit most from education (e.g., those most likely to be affected, those with particular interests), (b) how best to communicate with each group (using appropriate communication tools, media, messages, etc.), (c) to what end (e.g., to promote science or science careers, raise awareness about particular risks or innovations), (d) where researchers themselves may benefit from public engagement (e.g., in gaining feedback on results and debating their implications; to explore potential public reaction, uptake and/or use of novel technologies or social/behavioural innovations); and (e) how to evaluate the impacts of this communication. Further guidance is provided in sections 5.3.7 and 7.2.

Strategic decision-making

As discussed throughout this report, there is a key role for the public to play in strategic decision-making around energy research. There may be normative, instrumental, and/or substantive rationales for such 'upstream' involvement in the research and innovation process. In other words, public involvement in the strategic direction and conduct of energy research can help legitimise socially relevant and public-funded research; it may be used to increase acceptance from the public of potentially controversial areas of research; and – perhaps most importantly – it may improve the quality of decision-making by expanding the range of perspectives and types of knowledge involved. As mentioned above, the public may help elucidate social and ethical dimensions of energy research and innovation, and offer new and challenging perspectives on scientific assumptions and research objectives. Upstream engagement allows these social considerations and challenges to be considered and addressed early in the research process before attitudes become entrenched and potential controversy develops. Our recommendations at the level of strategic decision-making, then, include proposals for how research is funded and governed, as well as what research should be conducted.

For Energy Programme staff considering public engagement *for strategic decision-making* about energy research and development, it is critical to consider (a) which technological or social innovations are likely to most affect the public – either because a large number of people will be affected or particular risks are involved, (b) which innovations are likely to be particularly socially contentious – for financial, cultural, and/or moral reasons, and (c) which innovations are either upstream in the RD&D chain. Engagement should not be expected to resolve controversy, but it should at least increase mutual understanding among the concerned public and among energy experts. Given the above, it may be helpful to scope/screen RCUK energy technology research that meets the above criteria (i.e. early stage or contentious) and target this for engagement activity. This activity may be broadly conceived – including both educational and dialogue activity.[1]

[1] For a recent example of public-expert dialogue in the field of molecular biology, and associated issues, see e.g. http://www.nature.com/embor/journal/v10/n4/full/embor200943.html

No energy technologies or policies receive unequivocal public support or opposition. Public support is generally higher for renewable energy (especially solar) than for fossil fuels or nuclear energy; and for energy efficiency than for energy conservation. However, as we have shown, support or opposition is often contingent on the particulars of the proposed development, technology or policy, on concomitant proposed changes and measures, as well as how engagement has been conducted or attitudes measured. Our recommendations for the strategic direction of RCUK-funded energy research must be understood with this in mind.

While these considerations may help in prioritising where to focus public engagement efforts at the strategic level, we would emphasise that, ideally, public engagement should be embedded in all levels of Energy Programme decision-making and that public perspectives should thus be represented within Programme governance. This might include representation on the Scientific Advisory Committee, for example, and/or a dedicated citizen's panel or advisory group; or ad hoc surveys or focus groups.

In addition, in respect of future funding, we suggest encouraging, where appropriate, the integration of social scientists active in the field of public perceptions of and engagement with energy (both psychologists and sociologists) within engineering research teams. This might be achieved via a supplementary fund focussing on engagement and dialogue, or via more cross-council integrated, coordinated calls which incorporate social science research (on behaviour, attitudes, practices, etc.) with natural science and engineering research. A separate fund might be established for education, which is a very different activity, and potentially taken as a top-slice across the RCUK energy budget. We suggest building societal awareness training into the doctoral training given to engineers. This would aim to explain that technological developments frequently have political consequences and that technical expertise is not value-free. Finally, we suggest research is commissioned to address knowledge gaps about public attitudes and engagement (as detailed in section 8.2).

Acknowledgements

The authors would like to thank all those who responded to the call for information (see Appendix for all those who provided information and/or sources), enabling us to compile a unique set of references and synthesis of findings on attitudes to low-carbon energy in the UK. We also acknowledge the Leverhulme Trust for funding Christina Demski's PhD studentship.

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1 Introduction

The Research Councils UK Energy Programme aims to position the UK to meet its energy and environmental targets and policy goals – including achieving a secure, low-carbon energy system – through world-class research and training. Led by the Engineering and Physical Sciences Research Council (EPSRC), the Energy Programme brings together the work of EPSRC and that of the Biotechnology and Biological Sciences Research Council (BBSRC), the Economic and Social Research Council (ESRC), the Natural Environment Research Council (NERC), and the Science and Technology Facilities Council (STFC). For more details see: www.rcukenergy.org.uk.

Together the UK climate change target of reducing greenhouse gas emissions by 80% of 1990 levels by 2050 (34% by 2020), and energy targets such as 15% renewables by 2020, along with plans for new nuclear power and carbon capture and storage demonstration plants, investment in offshore wind and marine energy, and roll out of smart meters and electric vehicles (HM Government, 2009a), imply a significant change to UK energy systems to decarbonise while still ensuring sustainable, affordable supply. This change has major ramifications for the public, who will be asked to accept new energy infrastructure and technologies, and change patterns of demand. Understanding public attitudes to these changes, and the ways in which energy and technologies are understood and used, is thus vital, as is assessing the potential for the public to be actively involved in research and policy decision-making. This understanding is all the more important given recent media coverage of climate science (which some fear has undermined public confidence in science and eroded trust in scientists; e.g., Pearce, 2010), and high-profile cases of community opposition to energy developments (e.g., Van Noorden, 2010).

This study on public attitudes to, and engagement with, low-carbon energy draws together the results of UK-relevant social research and evidence, as of October 2010, in order to inform the Energy Programme at both strategic and operational levels. That is, it may be used to inform the direction of funded research, as well as how it is conducted, its use and communication of results. The synthesis encompasses attitudes to and engagement with: low-carbon energy supply, storage, distribution, demand, systems, scenarios and research. Within these broad topics, we examine engagement with a range of technologies: wind energy, biofuels and bioenergy, tidal and wave energy, geothermal energy, hydroelectric power, energy from waste, microgeneration, fossil fuels, carbon capture and storage, nuclear energy and waste, hydrogen and fuel cells, and electricity and gas networks, energy-saving equipment and appliances, low-carbon transport, energy consumption and conservation behaviours, low-carbon energy tariffs, energy policies and research. This synthesis builds on the synthesis on public attitudes to environmental change, commissioned by the Living with Environmental Change (LWEC) Programme in 2009.

As with the LWEC review, the scope of this review is wider than simply attitudes in the conventional social psychological sense of an individual's evaluation of, or orientation towards an issue/object. Rather we include literature on public **'engagement'** with energy issues, technologies, developments and research. Engagement includes attitudes, understanding, meanings, behaviour and practices at individual, community and cultural levels, and also refers to discrete engagement interventions (see section 3). Put another way, we conceive of engagement as both a state and a process. Furthermore, the report emphasises that low-carbon energy attitudes are best understood within their context and as in part contingent upon that context; that attitudes are in a sense *indicators* of other social and psychological processes, and opinion differs on the relative significance of those

processes. For this reason we have deliberately dedicated space to a review of some of the more relevant social science accounts of those processes (section 3), separately from our review of specific attitudes and engagement (sections 4-6), in an attempt to avoid losing generally-applicable insights. In addition, cross-cutting themes are drawn out in section 7.

This broader focus on engagement requires an interdisciplinary approach, and thus includes sociological, political science and other literatures, along with psychological research. Furthermore, the report draws on both academic and non-academic sources and studies with differing methodologies, epistemologies and scales. We are necessarily selective in our review: some of the relevant academic literatures are extensive and have long traditions. We focus here on what we judge to be the most immediately-relevant literatures, given the initial remit of the project.

Philosophically, we have assumed a broad approach to the underlying reasons for public engagement in research. These may include dispelling ignorance and misunderstanding; raising scientific literacy, increasing trust in scientists, mobilising favourable attitudes to scientific and technological innovation, changing behaviour, and using public perceptions as a *resource* of inspiration, oversight and legitimacy that may temper and moderate scientific and technological innovations that have uncertain and potentially risky outcomes (Bauer, 2009). There may also be a normative rationale for engagement, which assumes the public have a right to influence decisions about public-funded research and technologies or policies that may affect them (Stirling, 2008; see also section 3.6). In selecting and summarising theory and evidence relating to public engagement with low-carbon energy, the report gives equal weight to these very different rationales.

In this report, we conceive of **'public'** as citizens and consumers. We do not include other 'stakeholders', such as interest groups, policy-makers or industry (although these groups are sometimes included in the term 'public'; see Dietz and Stern, 2008). At the same time, however, we do not consider that the public is homogenous; rather there are multiple 'publics' reflecting diverse interests, experiences, beliefs and values (Nye et al., 2010; Walker and Cass, 2007; Wynne, 1991; Walker, 1996) and who engage with energy in diverse ways and adopt a variety of social roles and identities in respect of energy issues (see section 7.2.6). Thus, throughout the report we identify where engagement and attitudes differ amongst sub-groups or communities.

2 Methodology

This report parallels the structure and methods of an earlier, broader literature synthesis on public attitudes to environmental change and associated implications for public engagement, undertaken by several of the same research team for the UK Research Councils' Living With Environmental Change (LWEC) programme (Upham et al. 2009). Here we focus on energy in more detail and broadly retain the same methods and report structure. Assumptions relating to inference from various literatures are referred to in section 2.3 below.

2.1 Report structure

There is no single way of understanding or characterising public engagement with energy research, or any other form of research programme. Engagement can be variously defined and understood from different perspectives and at different levels. Engagement can be undertaken for a variety of reasons and with a variety of methods. The report is written for a cross-disciplinary audience and we define its scope in section 2.3 below.

We begin by providing an introduction to some of the most relevant social science theory and concepts relating to public engagement (chapter 3). While this can only be an introduction, sufficient material is provided for the reader to appreciate the variety of ways of thinking that underlie the 'findings' reviewed in chapters 4 to 7. Given a mixed audience, we arrange those findings in terms with which most energy analysts will be familiar: in chapter 4 we summarise findings on attitudes and engagement relating to energy supply, storage and distribution technologies; chapter 5 covers energy demand attitudes and engagement; and chapter 6, energy systems and research engagement. Chapter 7 on cross-cutting themes is where we interpret, integrate and discuss our findings and chapter 8 provides a concluding summary, an overview of knowledge gaps and future research options and recommendations for public engagement in the RCUK Energy Programme.

2.2 Data sources and analysis

A two-pronged approach to identifying relevant sources has been used. First, a systematic search of bibliographic databases was undertaken in order to update and extend the academic sources on energy attitudes and engagement that were included in the first review for LWEC (Upham et al. 2009). Second, a formal call for evidence was issued to practitioners and academics, in order to identify non-academic ('grey') sources and forthcoming academic publications, and to elicit views about gaps in current knowledge. The call was issued to contacts of the research team and to largely English language e-lists addressing energy from a range of perspectives. The call particularly asked for recent, in press and non-academic studies that we might otherwise miss due to unavailability in search engines and databases. The evidence base was then synthesised and analysed, with the terms of analysis including the concepts identified at the theory review stage, brought to bear so as to illustrate their relevance for engagement practice.

2.3 Scope of review

The review reflects tight time constraints and is limited to English-language documents available to us during September-October 2010. Nevertheless, we have included over 500 references, which encompass diverse academic and 'grey' literatures. While our primary focus is on public engagement with energy research and development (R&D) and low-carbon energy issues, this literature is in places scant, particularly UK-specific coverage of certain

topics. We therefore draw inferences from wider attitudinal and practice literatures, principally energy-related, but, where relevant, also using literatures relating to climate change, environmental psychology and governance, technology governance and assessment. Similarly, while our scoping of literature for review gives a relatively high weighting to practical utility for engagement practice, we have also endeavoured to convey the widely differing understandings of engagement evident in the literature. Engagement processes are thus understood broadly as including a wide range of motivations, agents, methods and practices; closer definition is provided in subsequent sections.

3 Conceptual Framework

Summary: Theoretical insights on public attitudes to and roles in low-carbon energy

- Attitudes are hypothetical constructs which refer to an individual's evaluation of something, and comprise knowledge, emotion, and behavioural intentions
- Attitudes are not static or de-contextualised; rather, they are dynamic, influenced by a range of factors, often ambivalent or uncertain, and frequently not predictive of behaviour
- Attitudes are changed through persuasion and experience, but also as a result of behaviour change
- The social, economic, political and technological context of individuals shape and constrain attitudes and behavioural responses to low-carbon energy (and associated risks)
- The 'practices' approach from the sociology of consumption provides a useful explanatory account of this form of influence: in terms of explaining behaviour, habits and routines may be at least as important as attitudes
- The concept of NIMBYism is problematic and overlooks the way individuals form strong attachments to place and how symbolic attributes of certain locations can form part of an individual's identity
- Threatened place identity/attachment, rather than irrationality or ignorance, is often at the root of 'place-protective' opposition to large-scale low-carbon technologies, e.g. wind farms
- Socio-technical transitions involve multiple societal actors and processes; the public may play a more or less active role in a low-carbon energy transition
- Technology, research and risk governance have generally been restricted to experts and policy makers, but there are substantive, normative and instrumental rationales for involving the lay public (i.e., public engagement can improve decision-making quality by including diverse knowledge; allow explicit representation of social values in decisions about socio-technical change; and potentially foster trust, ownership and learning)
- Science & Technology Studies approaches stress the need to allow space for the multiple interpretations of energy technologies (rather than seeing divergence as necessarily a sign of ignorance or misconception) and the institutions in which they are embedded
- Technologies are unlikely to be universally seen positively or negatively and members of the public may bring their own experience and knowledge to bear on their assessment of the desirability of particular technologies

3.1 Introduction

This section provides an overview of cognitive, social, and environmental psychological theories and methods relevant to understanding attitudes, attitude change and learning, risk perception, place attachment and identity, social representations, and consumption. We also briefly review the (extensive) literature on models of behaviour change, but refer the reader to reviews of this literature, published elsewhere (e.g., Darnton, 2008) for further details. Relevant sociological literature is also discussed, including work on social practices, governance and science and technology studies. This chapter thus provides a foundation on which the conceptual and methodological dimensions of the following empirical chapters (4-6) can be better understood, and cross-cutting themes interpreted (see chapter 7).

3.2 Attitude and behaviour theories

3.2.1 Attitude theories

Attitudes are hypothetical constructs that refer to an individual's evaluation of, or orientation towards, an 'attitude object' (i.e., thing, idea, person, group, action, self, etc).

Attitudes are typically said to comprise three components: cognition (knowledge and beliefs), affect (emotional response) and behaviour (past and current behavioural response). These three components have also been ascribed to risk perceptions, as a particular form of attitude (Finucane and Holup, 2006; Lorenzoni et al., 2007). Attitudes form as a result of direct experience with the object or through second-hand (mediated) information about it, the former tending to result in stronger and more consistent attitudes than the latter (Fazio and Zanna, 1981). Attitudes may be said to have a particular intensity and direction; that is, people may hold a strong or weak opinion, which may be positive or negative. It is also possible to be ambivalent about an attitudinal object, and thus hold both positive and negative attitudes. Attitude strength may be determined by a range of factors, such as certainty, ambivalence, confidence, involvement, importance, emotional intensity and underlying values (e.g., Stern et al., 1993; Krosnick and Petty, 1995; Maio et al., 2001; Verplanken and Holland, 2002).

Attitude measurement is often via direct elicitation of an expression of support or opposition (e.g., via a questionnaire), but may also be inferred from more subtle reactions to the attitudinal object (e.g., Smith and Mackie, 2007). Importantly, there may be a difference (or even contradiction) between the former (explicit attitudes) and the latter (implicit attitudes), because of particular biases in the way people report their views, such as social desirability (i.e., saying what they think they should say or is the 'right answer'; Spence, 2005). So, for research into potentially unpopular attitudes such as prejudice, researchers may employ techniques such as facial electromyography (EMG; Petty and Cacioppo, 1986) and Implicit Association Test (IAT; Greenwald et al., 1998) to assess respondents' implicit attitudes, which do not rely on participants' willingness or ability to report their beliefs or feelings. Implicit attitudes can often explain more variance in behaviour than explicit attitudes, highlighting that behaviour is often not driven by deliberation but by unconscious processes (e.g., habit; see Maio et al., 2007).

Crucially, none of these methods is entirely free from bias or contextual influence, and each provides different aspects of an individual's views. Attitudes (unlike personality traits) are known to be dynamic, influenced by a range of factors, often ambivalent or uncertain, and frequently not predictive of behaviour. Indeed, some have argued that the concept of attitudes should be abandoned altogether (Wicker, 1969), while others have questioned whether attitudes are really held by individuals or are purely a social construction. Indeed, the concept of 'discourses' as resources or repertoires constructed through social interaction and used to explain or justify action is preferred by sociologists and psychologists in the more constructivist traditions (e.g., Potter and Wetherell, 1987; Bourdieu, 1992), as discussed further below. On the other hand, it is not necessary to reify or decontextualise attitudes to acknowledge that they have certain instrumental and symbolic functions for individuals, such as helping organise knowledge, inform decisions, express identity and seek connections with others (e.g., Maio and Olson, 2000). Furthermore, the concept of attitudes is helpful in understanding how individuals interpret and respond differently to the same information. Pre-existing beliefs and views (i.e., attitudes) have been shown to bias perceptions and guide behaviour: people are more attentive to, and accepting of, attitude-consistent information and tend to ignore or reject dissonant information (Nickerson, 1998). This characteristic of attitudes is central to this review, as it highlights the heterogeneity of the public and helps explain the diverse effects of communication (including on energy and environmental issues).

3.2.2 Theories of attitude change and learning

Attitude change has long been a central concern of social psychologists and may occur through communication (i.e., persuasion) as well as other forms of learning. According to the well-established Elaboration Likelihood Model (Petty and Cacioppo, 1986), there are two routes through which individuals may be persuaded: core (systematic) and peripheral (superficial). Often attitudes will be influenced through the peripheral route – i.e., as 'snap judgements' based on heuristics, such as whether the communicator is attractive, expert or familiar; or even through the 'mere exposure effect' of being frequently exposed to the attitudinal object. In other cases, when individuals are sufficiently motivated to engage with the issue, attitudes will be informed through more considered deliberation of the arguments presented (i.e., the core route), and in this case attitudes tend to be more resistant to change than in the case of more superficial processing. In general, messages that conform to an individual's motivations and level of interest are more persuasive (see Smith and Mackie, 2007). The process of attitude change may be sudden ('conversion') or gradual ('book-keeping'), depending on the amount and distribution of discrepant information encountered (Weber, 1997). Perceived social pressure also plays a role in this process (Katz and Lazarsfeld, 1964).

Importantly, though, attitude change need not precede behaviour change. In fact, action is one route through which attitudes may be formed or altered. Research indicates that people can infer their attitudes through their actions, and thus seek to establish an attitude which is consistent with their behaviour (Bem, 1967). This desire for attitude-behaviour consistency is accounted for in Cognitive Dissonance Theory (Festinger, 1957). Cognitive dissonance is an uncomfortable psychological state resulting from awareness of holding conflicting beliefs, or acting inconsistently with one's attitude. People typically act to reduce cognitive dissonance by changing their attitude to justify their behaviour, claiming (or perceiving) to have little or no choice in their action, or denying any inconsistency (Brehm and Kassin, 1996). Cognitive Dissonance Theory has important implications for environmental communication and behaviour change strategies: unpopular messages (such as the need to change lifestyles and reduce consumption) may be rejected or ignored to avoid confronting their implications for cherished behaviours (e.g., Stoll-Kleemann et al., 2001); and attitude change may follow behaviour change associated with compliance with legislation (e.g., congestion charging; see Downing and Ballantyne, 2007).

Theories of learning similarly highlight the tendency for individuals to attend to and integrate information that supports existing cognitive schema, while ignoring or rejecting contradictory information (Resnick and Chi, 1988; Marshall, 1995). One of the major social psychological theories of perception and social influence is Moscovici's (1988) Social Representations Theory, which identifies two key processes involved in understanding and evaluating changes in the social/physical environment: 'objectification' (translating the abstract into the concrete and tangible) and 'anchoring' (categorising according to pre-existing cognitive frameworks thus rendering familiar). Crucially, these cognitive frameworks arise from cultural, as well as psychological, origins and are often normative in nature: 'most of our reasoning in societies depends on categories of right or wrong more than those of true or false' (Moscovici, 1993, p.166). This appropriation of new knowledge in turn changes it, through processes of assimilation and accommodation (Piaget, 1970). This theory has been applied to understand the interaction of science and society, and the evolution and communication of scientific knowledge (as a function of subject, object and contextual factors; (Bauer and Gaskell, 2008), and is particularly appropriate for the area of risk, where concepts or issues are likely to be novel and unfamiliar (Breakwell, 1991).

3.2.3 Attitude-behaviour relationship and behaviour change models

While this review does not directly address behaviour, it is helpful to refer to the literature on behaviour in as far as attitudes relate to behaviour and behaviour change. Reviews of behaviour change consistently highlight the complexity involved in determining and changing behaviour. Action is influenced by multiple conscious and unconscious processes (Jackson, 2005). Pro-environmental action, can be somewhat simplistically characterised as a product of both 'internal' (psychological) and 'external' (social, economic, physical, etc) drivers and constraints (Stern, 2000; Nye et al., 2010). Consequently, there are numerous models of behaviour and behaviour change, all of which provide some insight into particular actions in particular contexts, but which often have little transferability across behaviours or contexts (Darnton, 2008). Important implications of this complexity include that: individuals' attitudes and actions are not necessarily consistent (the 'value-action' gap; Blake, 1999; Kollmuss and Agyeman, 2002); and an individual's behaviour in one context may be inconsistent with their behaviour in another context. Despite recent interest in the notion of 'spill-over' effects across environmentally-beneficial behaviours, there is very limited evidence for this (Whitmarsh and O'Neill, 2010; Thøgersen & Ölander, 2006). This is because the reasons why someone cycles to work, for example, may include considerations of health benefits, cost, availability of showers and cycle paths, with environmental concern as an additional motivator; whereas the reason why the same person flies to Spain for a holiday may be based on factors such as cost, time, convenience, and social convention (e.g., Anable, 2005). In other words, despite their environmental concern, there are likely to be multiple reasons why a person makes a particular choice over the alternatives (or indeed may not consciously 'choose' a course of action at all; see below). Although research has highlighted the significant correspondence between attitudes and behaviour, it is clear that attitudes only sometimes guide behaviour, and most commonly this is where attitudes are strong (e.g., certain, important, based on experience and knowledge) and where social and structural conditions support action (e.g., Krosnick and Smith, 1994; Stern, 2000).

Very often, though, behaviour is not even driven by conscious deliberation or 'choice' at all. In contrast to commonly used theories in social psychology (e.g., the Theory of Planned Behaviour; Ajzen and Fishbein, 1980) behaviour is often not preceded by intention, but is the product of habit (or 'routines'; see below). When an action is repeated satisfactorily several times, it becomes less considered and more automatic; this habitual action is automatically triggered in a particular situation (e.g., 'I need to go to the shop, so I will drive'; Verplanken et al., 1998; Verplanken and Wood, 2006). Many energy and transport behaviours are habitual, making them particularly difficult to change (APA, 2009; Nye et al., 2010). In particular, using conventional communication approaches to change behaviour will have little effect because habits attenuate attention to information about alternative courses of action (Verplanken et al., 1997). Rather, habits need to be disrupted either by individuals making specific plans to perform alternative actions or by using (or creating) changes in the environment in which individuals act so as to force individuals to reconsider behavioural options (Verplanken and Wood, 2006). For example, travel habits are broken when people relocate or change employer; so providing information about public transport just after people have moved house is much more likely to encourage modal shift, compared to providing this information under stable behavioural contexts (Bamberg, 2006; Verplanken et al., 2008). *Crucially, then, we emphasise the point that attitudes do not necessary predict behaviour, and thus changing attitudes (e.g., through information provision) does not necessarily lead to behaviour change.*

As mentioned, there are not only different models to explain and predict behaviour, there are also various models that can be used to describe and facilitate behaviour *change* (e.g.,

Darnton, 2008). Depending on the specific behaviour to be changed and the particular context, some strategies will work better than others. Importantly, a combination of interventions tends to have a greater effect than any single approach, because they will influence the multiple drivers and barriers for change (Gardner and Stern, 2002). Broadly speaking, behavioural interventions can be targeted at the individual, interpersonal or community, or structural levels (Halpern et al., 2004; Jackson, 2005) and aim to influence attitudes (change them to desirable attitudes or make desirable attitudes salient), norms (social or personal expectations of 'correct' behaviour) or broader opportunities and 'rules' for action. Interventions include informational (information campaigns, labelling, feedback, etc), social (eliciting a verbal commitment, social comparison and support, etc), structural and economic approaches (market-based instruments, investment in infrastructure, regulation, etc) (e.g., Steg and Vlek, 2009).

3.2.4 Psychological perspectives on energy use behaviour

Although environmental problems have never rivalled social or health problems as a focus for psychological investigation, since the 1970s, an impressive body of environmental psychology literature has developed on energy consumption and conservation behaviour (e.g., Brandon and Lewis, 1999; Stern and Kirkpatrick, 1977). In theoretical terms, four broad approaches to understanding or accounting for energy use behaviours have emerged, each of which offers a unique perspective on the role(s) of actors in a transition to a lower carbon economy. The two most dominant of these are 'expectancy-value' approaches, which rest on the premise that how one evaluates the anticipated outcomes of behaviour in terms of rewards and costs will determine one's intention to act (e.g., Ajzen, 1991); and norm-based approaches, which challenge the assumption that action is motivated in anticipation of tangible or social outcomes and focuses instead on 'internal' rewards associated with adhering to personal values (Axelrod and Lehman, 1993). A somewhat less dominant, but still well-established strand of research highlights the role of unconscious processes, such as habit, on behaviour, including energy use (e.g., Verplanken et al., 1998). Finally, more recent qualitative approaches within the socio-cultural, discursive and critical psychology literatures have provided an alternative to the traditional positivist paradigm, and which have much in common with the sociological perspectives on consumption discussed in section 3.4. These new trends - although often not explicitly linked to an environmental or energy agenda - have begun to expose the social construction of identity and consumption (e.g., Billig, 1999). Recent efforts have also focussed on providing integrative theoretical frameworks that encompasses these diverse determinants of behaviour including attitudes values, beliefs, contextual forces, personal capabilities and resources, and habit (Stern, 2000). For a review of economic and other models of energy use, see Faiers et al. (2007).

3.2.5 Theories of risk perception

Public perceptions of novel technologies often include considerations of risk. Paul Slovic and colleagues have been prominent exponents of psychological approaches to risk and contend that the form of rationality that can be modelled or calculated theoretically is impossible within individuals' day-to-day decisions (e.g. Slovic, 2000). This favours Simon's (1956) bounded rationality theory, which proposes that, as a result of cognitive limitations, decision-makers must simplify decisions and seek satisfactory rather than optimum outcomes. Hence people are considered to accept a range of outcomes that allow them to operate flexibly (Douglas and Wildavsky, 1982). Slovic (2000) suggests that a number of empirical generalisations are possible in relation to statistical and probabilistic knowledge and risk perception, among which are the following. First, people, including scientists, generalise on samples that are far too small to be statistically significant. Second, people have difficulty grasping the concept of randomness. Thirdly and relatedly, judgements of

likelihood are often based upon how 'available' the risk is i.e. how easy is it to imagine or recall the possible outcome; availability (or 'accessibility'; Kahneman, 2002) is affected by recency, emotional saliency and difficulty integrating new information and multiple sources of information, together with individuals' related use of heuristics (rules of thumb) in situations of uncertainty (Slovic, 2000). These aspects of risk perception can be summarised as susceptibility (is it likely to affect me?) and severity (if so, how bad would it be?), as described in the Health Belief Model (Becker et al., 1978).

In terms of the relationship of technology characteristics to public acceptability, Fischhoff et al (1990) found (perhaps unsurprisingly) technologies to be less acceptable to the extent to which they are new, involuntary, poorly understood, have a long time delay (to a point of known adverse consequences) and a certainty of death should the risk become actualised. Attention has also been given to the characteristics of technologies that become 'stigmatised', for example as nuclear has been (Gregory et al., 1995). Thus technologies may acquire negative images not because of their risk per se, but because they have other associations, often as a result of a critical event, such as an accident or report of a hazardous situation. Such stigmatised technologies tend to have common characteristics, including involuntariness; unequal distribution of risk (e.g. falling heavily on children, pregnant women or on a particular geographic region); unbounded impacts; damage to a 'right' and natural state; or when there are questions surrounding the competence, conflicts, values and level of precaution taken by the managing authorities (Gregory et al., 1995).

Finally, an important phenomenon that relates to individual psychology but which takes place socially is the 'social amplification of risk', which involves information processes, institutional structures, social-group behaviour and individual responses shaping the social experience of and responses to risk (Kasperson, 2002). An example is the Three Mile Island nuclear reactor accident. Although there were no deaths associated with this accident, its repercussions were felt widely in terms of increased safety demands and stricter regulations for all reactors worldwide. Overall the accident resulted in globally increased opposition to nuclear technology (Heising and George, 1986).

Borrowing from signal amplification in communications theory, Kasperson (1992) argues that each risk message has four components: factual (the content and source of the information); inferential (conclusions from the information and comparison in terms of performance criteria); symbolic (culturally symbolic images, e.g., 'big business', 'high-technology'); and value-related (symbolic references can hold strong value implications). Some messages regarding risk can have 'signal value' in that they indicate that there has been or may be a wider shift or problem (Kasperson, 1992).

Mary Douglas pioneered a cultural approach to risk perception, which emphasises that social and cultural affiliations dictate which risks are 'worried about' and which are ignored (e.g., Douglas and Wildavsky, 1982). Shared values are seen as affecting both the perceived likelihood and the perceived magnitude of an event, with potential challenges to particular values being seen as most risky. This approach moves away from the individual and the risk object as the units of analysis, towards the cultures and societies within which individuals are located. Douglas and Wildavsky also argue that there is a: "double edged thrust of science, generating new ignorance with new knowledge" (1982, p.49). That is, technological and scientific progress means that we can find risks faster than we develop ways to rank their importance or priority. They also argue that the difference between expert and lay approaches to risk is that lay actors use ethical, normative judgements explicitly in their arguments, and that this approach is preferable to hiding moral judgements behind a façade

of expert assessment. This approach favours the inclusion of a wider range of perspectives in the decision-making process. Douglas and Wildavsky (1982) argue that individuals delegate decision-making to institutions so as to avoid the inertia that might follow from giving full consideration to the many risks in people's lives: in effect they follow implicit social rules on what risks to ignore (e.g. when driving).

Turning to another prominent cultural thesis, the 'risk society', Beck (1992) argues that techno-scientific developments have produced more hazardous and geographically dispersed risk and that, coupled with the extension of the mass media and the growth of new ICT, this has resulted in greater public awareness of these risks. It is also posited that there has been a qualitative change in the relationship between experts and the lay public, entailing, for example, greater questioning of 'expert judgement', growth of distrust in the 'old' institutions and an increase in 'sub political' activity (i.e. actions outwith the formal political process) (Mythen, 2004). The ease with which information can be exchanged has enhanced the ways in which the public can communicate with each other and with 'experts'. Beck defines three discrete epochs in which risks differ categorically: 'pre-industrial society' (traditional society, a time of natural hazards); 'industrial society' (first modernity, accompanied by increasing industrial hazards); and 'risk society' (second modernity, in which we face environmental risks that are more global in scope and potentially catastrophic). Mythen (2004) offers a systematic critique of the risk society thesis, viewing it as a departure from the evidence, but its core components arguably do have some intuitive appeal.

The risk perception literatures, both psychological and cultural, seek to explain why perceptions differ according to risk characteristics, individual factors and broader social, cultural and institutional factors. These literatures also offer different rationales for some degree of public engagement in the setting of research agendas and assessment of its outcomes. The psychological approach summarised here tends to subscribe to a realist ontology and positivist methods (i.e. the belief that there is an objectively-definable reality and that we can define this via systematic observation). It thus implies a need for public engagement so that the truth (in this context, accurate risk estimates) can be better conveyed to and understood by the public. Sociological and cultural approaches tend more towards a social constructivist ontology (and epistemology) (Flynn, 2007; Flynn et al., 2008), in which public engagement is understood to be as valid and as important as scientific engagement. Experts are asked to comment on issues that relate to much wider social and political judgements, not purely questions of science (Stilgoe et al., 2006). As well as embedding (often) hidden social and political assumptions, Rip (2003) argues that the dominant focus on expert-led, 'evidence-based' policy deletes important issues that are not well understood, are subject to uncertainties, and are therefore 'difficult' for science to deal with. Indeed, science and expertise are not always capable of answering the questions that the public ask. There will be a variety of positions between these two points, with all acknowledging some degree of public engagement as desirable – but for different reasons.

3.3 Place attachment and identity

Policymakers and developers tend to view the locations where large-scale energy projects are proposed either as 'sites' to be developed or 'backyards' to be avoided (Devine-Wright, 2010). Both of these ways of conceiving spatial aspects of energy projects are deficient and problematic. Conceiving localities as sites strips places of the layers of subjective meanings and emotions that are an inherent element of their character (Canter, 1977; Easthorpe, 2004). Seeing localities as backyards serves to reinforce much-critiqued 'NIMBY' (Not in my back yard – see section 4.2 on large-scale wind energy) presumptions that public opposition to development proposals stems solely from self-interested concerns with the economic

value of private property. Furthermore, changes to 'sites' or 'backyards' are commonly conceived in zero-sum terms, pitting supposed 'global' benefits of low carbon energy projects against 'local' costs (Haggett, 2008). This way of thinking is also prevalent in energy policy (DECC, 2009b; Centre for Sustainable Energy et al., 2009) as the emphasis upon community benefit provision in onshore wind energy projects is founded upon a similar cost-benefit rationale. At an extreme, this perspective can lead to viewing the destruction of local places as a necessary step to avoid global climatic change—what has been dubbed a discourse of 'place sacrifice' (Ellis et al., 2007).

Conceiving spatial aspects of public engagement with low carbon energy in these ways is deficient and problematic because it overlooks important aspects of the human experience of space and place – of how people and localities connect and become intertwined. Localities are not just 'sites' that can be objectively assessed and altered by experts but are 'places' that residents and visitors can feel emotionally attached to, and which can become an important element of their sense of identity (Altman and Low, 1992).

In the disciplines of environmental psychology and human geography, a commonly agreed principle is that 'place' differs from related concepts such as 'space' or 'environment' in describing both physical aspects of a specific location and the variety of meanings and emotions associated with that location by individuals or groups (Gieryn, 2000). More specifically, place attachment has been defined as both the process of attaching oneself to a place and a product of this process (Giuliani, 2002). As product, place attachment is a typically a positive emotional connection with familiar locations such as the home or neighbourhood (Manzo, 2005), correlating with length of dwelling (Brown & Perkins, 1992), featuring social and physical sub-dimensions the relative importance of which may vary (Hidalgo & Hernandez, 2001) and leading to action, both at individual and collective levels (Manzo & Perkins, 2006). The related concept of place identity refers to the ways in which physical and symbolic attributes of certain locations contribute to an individual's sense of self or identity (Proshansky et al., 1983). Bonnes et al. (1995, cited in Bonaiuto et al. 2000) argued that a place such as Rome may represent both personal and social aspects of the self, distinguishing between 'personal place identification' (e.g. 'Rome has become a part of me') and 'social place identification' (e.g. 'I feel completely Roman').

The impacts of change have been a persistent interest of place researchers, sometimes labelled as 'disruption' to place attachment (e.g. Brown & Perkins, 1992) or 'threat' to place identity (e.g. Bonaiuto, Breakwell, & Cano, 1996). In both cases, studies have revealed how change can make explicit the bonds between person and location that are typically latent (Brown & Perkins, 1992), resulting in negative emotional responses such as anxiety and loss (Fried, 2000), and a sense of displacement that can lead to psychiatric trauma (Fullilove, 2004). The causes of disruption vary, from sudden ecological change such as floods or landslides (Brown & Perkins, 1992), to human-induced change such as the demolition of homes and neighbourhoods in urban regeneration schemes (Fried, 2000). Of relevance to this review is the link between place identity threat and behavioural response. Stedman (2002) investigated the impacts of proposals to develop new housing in a lakeshore area of Wisconsin. Seeking to explain residents' willingness to engage in 'place-protective' actions (i.e. voting for new laws or joining a protest group), the results showed how opposition was contingent upon strong place attachments and the adoption of specific place meanings: interpreting the place as 'up north' rather than as a 'community of neighbours'. Stedman concluded that '*we are willing to fight for places that are central to our identities .. this is especially true when important symbolic meanings are threatened by prospective change*' (p. 577).

Devine-Wright (2009) argued that the literature on place attachment and place identity offers a useful conceptual foundation to explain 'place-protective responses' to low-carbon technologies, such as wind farms, yet in so doing to avoid much-critiqued 'NIMBY' presumptions. From this perspective, conceiving opposition to stem from economic concerns about the value of privately-owned spaces is a fundamentally deficient perspective that fails to recognise the emotional and identity-related connections that may bind individuals and groups to certain locations that have important, yet often latent, symbolic-affective dimensions. Of importance in understanding these symbolic aspects are the 'guiding principles' of identity processes proposed by Breakwell (1986) comprising distinctiveness, continuity over time, self-esteem and self-efficacy. A place-based approach was argued to be useful in explaining both oppositional *and* supportive responses to low carbon technology projects, since it is at least theoretically possible that such projects may be viewed as enhancing the symbolic qualities of a given place – maintaining continuity with the past or enhancing local distinctiveness and in so-doing contributing to local pride (Devine-Wright, 2009).

Although such issues are rarely considered in the process of technology development, for the reasons outlined above concerning locations being commonly conceived as 'sites' and 'backyards', there is some evidence to support a place-based perspective. Vorkinn and Riese (2001) studied local people's attitudes towards a proposed hydropower project in Norway. Using a questionnaire method, their results indicated that place attachment significantly explained attitudes to the development, explaining more variance than socio-demographic variables. The more attached residents felt towards the affected area, the more negative beliefs were expressed about the proposal. From a more philosophical position, Brittan (2001) critiqued low carbon technologies such as large-scale wind turbines that were viewed as standardised objects that would inevitably lead to a weakening of local character, threatening the local distinctiveness of places.

A place-based approach can provide not only an alternative way of thinking about public responses to low carbon technologies, but a guide for future research. For example, studies can capture how different protagonists in technology controversies represent place change, for example when projects are framed by opponents as 'industrializing' hitherto 'natural' places, and how such interpretations are adopted by local residents, interacting with place attachments to produce (positive or negative) evaluative emotional, and behavioural responses. The approach also has applied implications, for example suggesting a less pejorative discourse on public opposition that goes beyond the labelling of opponents as irrational or ignorant, and a need to expect, rather than decry, emotional responses to change from local residents. Together, these suggest that a place-based approach is a useful conceptual approach to adopt in attempting to understand and explain public engagement with low-carbon technologies.

3.4 Social practices and transitions

3.4.1 Introduction

At the risk of over-statement, practice-based accounts of environmental consumption posit that environmental attitudes are an explanatory red herring. Practice theory has recently emerged as a distinct branch of sociology, which instead of talking about behaviours, holds social practices themselves to the central unit of enquiry (e.g., Giddens 1984). As such, the individual (for instance, in the role of consumer, normally so central to studies of behaviour

change) is relegated to a marginal position in the analysis; and with them, out goes the motivational apparatus which is commonly held to shape intentions, and so drive behaviour. Thus attitudes are rarely if ever mentioned in practice theory: human conduct does not arise from the motivational force of an individual's intrinsic motivations, but through the ongoing interaction between agency (mediated by lifestyles) on the one hand, and structure (as rules and resources) on the other (see e.g., Spaargaren & van Vliet 2000).

Giddens Theory of Structuration offers a particular exposition of practice theory; he gives the example of speaking English: "When I produce a grammatical utterance I draw upon the same syntactical rules as those that utterance helps to produce" (Giddens 1984:24). This example neatly captures the recursive nature of conduct as seen from a practice perspective; it will be noted that the individual as originator, exercising choice based on personal preferences, is in the background. Of course, there are still agents, but they operate not as owners or originators of behaviour, instead as "carriers of a practice" (see e.g., Reckwitz 2002). Instead of attitudes, authors in the practice tradition talk of "dispositions", or "meanings", which are socially-constructed, and arise at particular points in time and space, because of the paths and projects a person has hitherto engaged with (see e.g., Pred 1981). As Elizabeth Shove states: "There is little or no reference to attitude or belief in any of this literature, and where such reference is to be found, needs and desire are located as outcomes of socio-technical change, not as external drivers of it" (Shove 2009, p.5f).

Practice theory then represents a striking alternative to understandings of behaviour based on social psychological assumptions; given the dominance of those latter approaches in policy and policy-facing research, the language (and whole ontology) of practices can come as quite a shock. Yet practice theory is increasingly moving into the mainstream, particularly in relation to the study of environmentally-significant patterns of everyday consumption (see e.g., McMeekin & Southerton 2007, Hargreaves & Nye 2009, Gram-Hanssen 2010). Work is underway to operationalise this rather uncentred body of theory for policy purposes (see e.g., Darnton 2010). Accordingly we include practice theory here as an alternative approach to understanding 'low-carbon behaviours', and to the practice of public engagement with science. While this approach eschews 'attitudes' and 'drivers' it includes such constructs as 'dispositions' and 'meanings' and these in their own way respond to calls for increasing public engagement in lower carbon lifestyles.

3.4.2 Key concepts in practice theories of consumption

As is apparent in Giddens' and other 'structurationist' readings, practice is formed at the intersection between individuals and society. As a concept it is not part of any one grand theory, like Structuration; it can be traced back to numerous writers on sociological themes, from Wittgenstein and Heidegger through to Bourdieu, Foucault and Lyotard, each of whom gives their own reading of practice (see e.g., Warde 2004). According to Andreas Reckwitz, there is no single Practice Theory, just "*a loose collection of tentative praxaeological remarks*" by these writers and others (Reckwitz 2002). This diffuse body of thought was initially marshalled by Schatzki (1996), who set out the concept of "*practice as a temporally unfolding and spatially dispersed nexus of doings and sayings"* (Schatzki 1996:89). This core image of a nexus nicely captures both the reflexive quality of practice, as the point in time and space where agency and structure intersect, as well as its multi-stranded nature. Reckwitz subsequently brought together the "*loose collection*" of writings in his foundational work 'Towards a Theory of Social Practices' (2002); his definition is fuller than Schatzki's:

"A 'practice' (Praktik) is a routinised type of behaviour which consists of several elements, interconnected to one another: forms of bodily activities, forms of mental activities, 'things' and their use, a background knowledge in the form of understanding, know-how, states of emotion and motivational knowledge" (Reckwitz 2002, p.249).

Subsequent authors have boiled down the elements identified by Reckwitz, to the point where it is possible to elaborate a social practice as being the emergent product of three inter-related elements (see e.g., Shove, Pantzar & Watson 2008):

Materials *('things' in Reckwitz; also necessary infrastructure)*
Competences *(skills and know-how)*
Images *(also ideas and interpretations)*

Shove has memorably illustrated these elements in the context of the practice of daily showering (Shove 2008). In this example, 'materials' would be the plumbing, waterheating and showering equipment; 'competences' the know-how to make that equipment work, and to fit the practice into the daily round of other practices; 'images' the ideas of getting fresh daily as 'correct and acceptable' (to borrow Schatzki's phrase). Practice-based analyses such as this are particularly useful for explaining everyday practices such as showering; once looked at through a practice lens, the notion that people might be regularly deliberating over the choice of whether or how to shower, and that their personal attitudes are drivers of that decision, becomes decreasingly plausible. Indeed, adopting this perspective, all our 'behaviour' can be regarded as habitual or routine: a practice needs to be recognisable to be reproducible by the person who carries it (out).

On the one hand, this leaves no space for motivational constructs in the analysis; yet, if we work at the level of the elements within a practice, we can see that 'meanings' are an essential strand in what makes a particular practice cohere (e.g. without the meaning of 'freshness', no daily showering). Being socially-constructed, meanings are fundamentally unlike attitudes (which emanate from the individual's psyche); and yet even on their own psychological terms, individuals' attitudes borrow something from social norms and dominant cultural values. There is a potential point of contact here between two otherwise incommensurate approaches, although on the practical question of where to intervene, the two approaches are miles apart – for psychology, in hearts and minds, for practice theory, out there in society, where practices live.

3.4.3 Examples of environmentally-relevant practice studies

Using a practice theory perspective, consumption can be understood not as a class of behaviours or end goal, but as the by-product of a range of otherwise diverse social practices: "Consumption occurs as items are appropriated in the course of engaging in particular practices" (Warde 2005). Consequently, much consumption is 'inconspicuous', and energy consumption in particular is 'invisible' as we highlight throughout this report (e.g., Burgess & Hargreaves, 2008).

Much of the work adopting a practices paradigm to examine environmental implications has focussed on energy consumption in domestic households. Thus, Elizabeth Shove and Dale Southerton (2000) examined the adoption of the freezer in British households and the way in which this appliance, which in 1995 accounted for 26% of energy consumption by domestic appliances, (DECADE, 1995, in Shove and Southerton, 2000) increased from an ownership rate of 3% of households in 1970 to 96% by 1995 (DECADE, 1997, in Shove and Southerton, 2000). The account that Shove and Southerton give (ibid) is relevant to the

uptake of any domestic technology, be this an energy efficient replacement or an environmentally undesirable appliance. This account is framed not in terms of attitudes or the functions performed by the object, but in terms of the way in which freezers have fitted into the changing organisation of domestic life, particularly the increasing participation of women in the workforce and associated sales narratives. They also note the symbiotic relationship between the freezer and another kitchen appliance – the microwave oven, capable of rapid defrosting. The freezer is described as being 'chameleon-like', being a symbol of modernization in the 1970s, a pre-condition for domestic and economic efficiency in the 1980s and a device of convenience in the busy 1990s – a 'time-machine' that plays its role in a kitchen that is now designed around its appliances (ibid). Moreover, the freezer partly creates the conditions that it alleviates – by helping to solve the problem of limited domestic time under conditions of increased working hours, it in part perpetuates that condition by enabling it to continue (ibid). Thus the problem of increased domestic energy consumption is framed in terms of its social context of changing female labour patterns, company sales narratives and domestic practices, rather than attitudes to any of these phenomena or individuals' 'needs'. As we discuss below (section 3.4.4), this can be understood as the changing socio-technical regime that serves to 'lock in' practices.

In a separate study, Chappells and Shove (2005) examined the socially-constructed nature of indoor temperature comfort, mindful of the need to avoid the installation of excessive air conditioning in the context of climate change. They interviewed 13 specifically-selected architects, building services engineers, property developers, manufacturers and regulators, and held further discussions with 17 workshop participants, to provide insights into the ways in which indoor temperature-related comfort is currently conceptualised, and how these professionals planned to respond to climate change. They comment that although the market for domestic air conditioning has yet to take off in the UK (writing in 2005), some industry commentators conclude that it will only take two or three hot summers for a momentum to build (Giles, 2003, in Chappells and Shove, 2005). This is in contrast to their findings from the professional interviews and workshop noted above, which suggested that for those involved in building design and regulation, the definition of indoor temperature comfort is still flexible and amenable to societal debate.

Chapells and Shove (ibid) ask whether design standards are 'self-fulfilling' in the sense that they inadvertently construct and reproduce increasingly standardised concepts and conventions of comfort (Baker, 1993; Humphreys, 1994; Shove, 2004), implying that the 'need' for air-conditioning need not be seen as a 'natural' consequence of the human condition (Shove, 2003). Chappells and Shove (ibid) refer to field studies such as those undertaken and reported on by Nicol et al (1999) and Humphreys (1994), which show how people of different cultures manage, value and maintain very different indoor conditions and interpretations of comfort. Unfortunately, despite Chappells and Shove's interviewees viewing comfort as open to societal debate, many of them nonetheless expected conventions of comfort and clothing to stabilise and standardise still further, with the likely outcome being an increased 'need' for cooling in particular (Chappells and Shove, 2005).

3.4.4 Role of energy consumers in a low-carbon transition

The emerging "transitions" literature, and particularly the "multi-level perspective" (MLP) of Kemp and Rip (1998), provide a valuable analytical framework to understand the drivers of and barriers to innovation within socio-technical systems. The MLP identifies three functional levels within any societal system, namely "niche", "regime" and "landscape"(Rip and Kemp, 1998; Geels and Schot 2007). The *regime* comprises dominant actors, institutions, practices and shared assumptions (Rotmans *et al.* 2001). While it provides

stability and cohesion of societal systems, it also tends towards optimising the current system through incremental change, using the capabilities and resources of dominant players. System innovation, or radical change, is restricted since habits, existing competencies, past investment, regulation, prevailing norms, worldviews and so on, act to lock in patterns of behaviour and result in path dependencies for technological and social development (Geels 2005; Chappells and Shove, 2005). At the micro-level, *niches* have been identified in historical empirical studies of transitions as the typical loci for radical innovation, operating as safe spaces for inventors/entrepreneurs at the periphery of, or outside, the dominant meso-level regime. The macro-level comprises a *landscape* of changing economic, ecological and cultural conditions, in which the regime may be more or less well-suited to fulfil its functions. As this landscape changes, the regime may experience stress and is typically slow to adapt, whereas niches more quickly evolve. The gradients within the socio-technical landscape, which may naturally create gaps in the regime or allow for its deliberate erosion, determine how easy or difficult particular changes are to bring about (Kemp and Rotmans 2004). Transitions analysis thus highlights the interplay of short-term and long-term processes of change across different levels of the MLP.

Nye et al (2010) distinguish between active and passive roles for energy consumers in a low-carbon energy transition. Consumers are relatively passive where energy supply is decarbonised and they are encouraged to adopt low-carbon technologies and conserve energy; whereas a decentralised energy supply system assumes consumers are generating energy and potentially 're-writing' the rules of consumption. They propose a framework of five measures to involve consumers in a low-carbon transition of the energy system:

1. Facilitating deliberate energy conservation through changes in the visibility of energy: How might changes in the socio-technical regime affect the 'visibility' of everyday energy use patterns or systems of energy provision? Are consumers more aware of their energy use habits and routines, or able to make more informed choices in this area?
2. Changes in habits/ routines or shift to more sustainable lifestyles: How might changes in the socio-technical regime affect the more habitual or routine aspects of everyday energy use patterns? Have unsustainable routines been disrupted and replaced with more sustainable patterns of action?
3. Changes in normative/ conventional understandings of proper energy use: How might changes in the socio-technical regime, or the actions of niche-level social innovators or influential pioneers, affect conventional or normative understandings about the proper use of energy? Have individuals made positive changes in the symbolic or conventional uses of energy in their everyday lives?
4. Increased demand for, and new uses for, low-carbon/more-efficient technologies: How might normative and symbolic changes associated with energy use lead to changes in consumer choices for low-carbon technologies? To what extent could 'new functionalities' (see Geels 2005) for low-carbon technologies, as developed by (innovative) domestic users, assist in the acceptability and diffusion of these artefacts? How might day-to-day habits/routines, in turn, be disrupted by adopting and 'domesticating' (again, see Geels, 2005) these new technologies?
5. Influencing the shape of the socio-technical regime: How do the actions in parts 1-4 influence the politics and technological character of the socio-technical electricity regime? To what extent do changes in electricity demand, or the domestication of new niche technologies at the domestic level shape the trajectory of transition at regime-level?

3.4.5 Implications for public engagement

'Practice'-focussed accounts offer an alternative perspective to 'attitudes', focussing on the social and institutional context of action rather than cognitive or affective 'drivers' of behaviour. This shifts attention away from the individual as the unit of enquiry to the socially-constructed meanings associated with action. Practice accounts also highlight that energy consumption/carbon impacts are a by-product of particular practices; 'energy behaviours' are not a recognisable suite of behaviours per se (theoretically or in the public eye). Although this practice perspective is a very different (perhaps incommensurate) perspective on public engagement with energy than the psychological perspective, many psychologists share with sociologists the recognition that energy-related behaviours are often routinised/repeating rather than the outcome of conscious deliberation and that changing attitudes may do little to change behaviour (see section 3.2).

The literature on socio-technical transitions also highlights the complexity of energy systems, and the need for multiple changes and actors to bring about change. The role of the public within this complex system and in fostering innovation may be more or less passive, and the report outlines these different roles on both the demand and supply side. In section 7, we develop the implications for public engagement of the multiple roles of publics in using energy and changing energy systems.

3.5 Science and Technology Studies

3.5.1 Science and technology studies

Science and Technology Studies (STS) is based on the premise that science and technology are thoroughly social activities. Case studies in the field are often concerned with documenting the process by which certain technologies become dominant, looking behind the post hoc explanations of technical superiority (e.g. Pinch and Bijker, 1984). An STS approach stresses that technologies do not become dominant in a linear process in which the 'best' wins out. Rather the process is a complicated one with many feedbacks as the technology develops influenced by the various social groups that see themselves as potential winners and losers (Reason et al., 2009; cf. section 3.4.4). STS investigates how scientific knowledge and technological artefacts are constructed, considering in particular the specific ways in which scientists and engineers have been trained and socialised as well as individual characteristics and positions (standards, methods and logic). A social constructivist ontology often underlies this field, with STS authors differing substantially in terms of the extent to which they consider science and technology to be socially mediated (Sismundo, 2004). Whilst the previous section on Governance focussed primarily on rationales for upstream involvement during the research and development phases, this section considers the applicability of the STS approach at the deployment stage for energy technologies.

3.5.2 Wider social constellations

Irwin (2001) presents technology as the enactment and embodiment of the relations between society, nature and knowledge. In responding to a particular energy technology or development, members of the public may be responding to the relationships that the development represents to them. The study of technology therefore offers a major site for the exploration of relationships between society and nature. From an STS perspective, the way in which technologies develop is argued to be far from independent from the social. Rather constellations of policies and institutional arrangements have facilitated the dominance or development of certain technologies, at certain times, in certain places (MacKenzie and Wajcman, 1999). In terms of energy technologies, the climate change and

energy security agendas may be important factors in the justification and explanation of how these particular developments have 'come about'. It is unsurprising that respondents may decide upon the acceptability of a specific technology in a specific location based, at least partially, on assessments of its related social and institutional constellations. Therefore, as Owens (2002) has identified, local opposition to particular facilities is often tied up with concerns over much wider policies and developments (e.g. renewable energy, climate change, urbanisation of rural areas, commodification of nature etc). Given the environmental justification of the need for renewable energy developments, the way in which nature and environment are seen to be being protected or attacked by a particular energy technology may play a significant role in determining how it is interpreted by the public.

3.5.3 Calculating and assessing the impacts of energy technologies

Discussions of technological controversy are often focused upon the impacts that that technology will have. Impact assessments imply that technologies are amenable to a single objective and independent assessment, rather than multiple interpretations. An STS approach stresses the need to consider the multiple ways in which the technologies and their impacts are experienced and defined by different publics.

STS in its more social constructivist forms aims for a renegotiation of science practice and scientific knowledge, rejecting these as to be handed down from institutions in forms that are already validated and closed (Wynne, 1995). It throws open the issue of defining what is a technical or scientific issue and what is a social or cultural one, with Wynne (1995), for example, arguing that such a divide is impossible. This is not to deny the existence of hazards or impacts, in a strong constructivist tradition, but to identify that risks are assessed, presented, interpreted and experienced in different contexts and assessed against different values and priorities. Deciding which questions to ask and which methods to use to 'answer' them cannot be divorced from social assumptions. The analysis is critical of work conducted under the 'public understanding of science' (PUS) moniker that is primarily educational in its objectives, assuming a lack of knowledge on the part of the public (Sismundo, 2004). In terms of public responses to risk, disagreement with expert assessments was first characterised within the PUS literature as ignorance, then misunderstanding and finally as a desire for an impossible "zero risk" (Wynne, 1995). Wynne argued that these constructions understate the public's level of understanding and result more from experts' unwillingness to recognise and openly discuss the conditionality of their own work and the normative commitments that it embodies.

3.5.4 'Lay' and 'expert' assessments

In his study of the effects of post-Chernobyl fallout on Cumbrian sheep farming, Wynne (1996) called for the inclusion of 'lay knowledge' in decision-making. This was based on the argument that deciding which questions to ask, what possible actions to investigate, and the development of criteria on how to assess and compare alternative courses of action were inherently social and moral questions. As such, they should not be the domain only of science or experts. As well as 'opening-up' these social judgements, which are embedded in expert information, Wynne stresses the value of including 'lay knowledges' in decision-making processes. In particular, in the case of sheep farming, official recommendations were at odds with the experiential knowledge of farmers on how sheep behave and thrive. Wynne (2002) stressed the need to examine the social and epistemological assumptions embedded within both expert and lay assessments of risks and impacts. Expert and lay assessments should be examined with equal care, rather than seeing expert assessments as objective, value-free knowledge and lay assessments as being subjective and values based.

More generally, Yearley (1995) identifies several possible reasons for divergence in lay and expert assessments:

a) Both scientists and the lay public base a significant part of their assessment of information on the characteristics of the source institutions and experts (i.e. it is not just what is said but who says it that is assessed)
b) The public often have expertise that bears on the problem and this may conflict with scientific constructions of problems and solutions
c) Scientific knowledge often embodies assumptions that people may recognise and disagree with (e.g. climate change, decentralised energy policy, peak oil, security of supply)

Consequently, STS theorists have argued for the acknowledgement of plural 'knowledges' and understandings as legitimate. Indeed Yearley (1995) argued for STS specialists playing a more active role in policy-making, given their understanding of the role of expertise in policy. Issues such as this as being discussed in the current ESRC seminar series on 'Critical perspectives on public engagement in science and environmental risk'[2].

There is also much discussion in both academic and policy circles relating to a crisis of trust in the role of expertise in decision-making. Collins and Evans (2002, 2003) term this the 'Problem of Legitimacy'. This lack of trust or legitimacy has led to many calls for an increase in 'participation', 'consultation' and 'engagement' (Collins and Evans, 2003, Collins and Evans, 2002, Stilgoe et al., 2006, Wynne, 1996, Irwin, 1995). However, as discussed in the governance section (section 3.6) a simple linear relationship between increased 'consultation' and support should not be expected.

3.5.5 STS and engagement with energy technologies

STS is a very broad field embracing a wide of range issues, perspectives and methods. Even the partial treatment above should serve to illustrate the field's relevance to public engagement with energy technologies. Treating any engagement as a one-way exercise, particularly in potentially controversial cases, is unlikely to be satisfactory in any meaningful respect. Instead, STS reveals engagement as a space for deliberation, not a communication based on dissemination of information or plugging deficits in public understanding (i.e., the 'Public Understanding of Science' model). STS indicates a need to allow space for the multiple interpretations of energy technologies (rather than seeing divergence as necessarily a sign of ignorance or misconception) and the constellations of policies and institutions in which they are embedded. Technologies are unlikely to be universally seen positively or negatively and members of the public may bring their own experience and knowledge (including experience of the institutions and actors involved) to bear on their assessment of the desirability of particular technologies. Impact assessments, whilst a useful source of information for stakeholders (including the public), have the potential to hide the selection of methodologies, areas for investigation and judgements regarding 'acceptable risk'. In order to investigate the issues behind opposition and support positions, quantitative attitude surveys must be complemented with more qualitative and exploratory work.

[2]With one seminar on Power, participation and energy futures:
http://www.uea.ac.uk/env/esrcsems/sems/part

3.6 Governance

3.6.1 Introduction

Building on the STS perspectives discussed above, this section introduces the literature on the practice and history of the socialised governance of technology innovation, as the wider context of public engagement in energy research and development. We show that while publicly institutionalised technology assessment in the US and Europe has generally been restricted to experts and policy makers, arguments for involving the lay public have a long history and a variety of rationales. Quite how the public should best be involved in technology innovation, particularly given that these institutionalised processes have been disbanded, has not been consensually resolved. We address these practical questions in more detail in later sections, focussing below on the governance debates relating to technology assessment.

3.6.2 Definitions and rationales

Until recently, governance was largely seen as the remit of government; since the 1980s, however, political scientists have increasingly reserved the term for any non-state actors involved in some form of controlling activity (Kjaer 2004). This activity – governance – in general involves the setting, application and enforcement of rules, which in turn requires the establishment of institutions or networks (Kjaer 2004).

Among the many possible motivations or reasons for seeking to engage the public in research programmes and projects, one is the democratic ideal: the view that public involvement in research endeavours not only provides some legitimacy for that research (Bauer 2009) but is also in some sense a right. Indeed, theorists of deliberative democracy have argued for more authentic public participation in public policy for at least two decades (Fisher et al. 2010) and science and technologies studies scholars have been concerned with the topic in a technology context for considerably longer (Wynne 1973). Overall, this trend seems to be part of a tendency towards more deliberative, pluralistic and inclusive policy processes across environmental policy and planning generally (Stirling 2008).

This notwithstanding, for many there remains a considerable gulf between principle or aspiration and practice: for example, while the internationally-applicable Aarhuus treaty mandates public access to environmental information held by public authorities, as well as involvement in environmental decision-making by these authorities (UNECE 1998), in Europe the options for formal public participation in major energy development proposals are limited and certainly not dialogic (Chiavari et al. 2009). In the context of technology assessment at the research and development (R&D) phase, i.e. significantly upstream and earlier than deployment, to our knowledge public engagement remains at the discretion of public officials.

Yet there are other cogent reasons for public engagement in technology development. Bauer (2009) alludes to these while discussing the three main attitudes to 'common sense' evident in the pages of Public Understanding of Science. In addition to the legitimation rationale, there is also the tradition of debunking in the sense of the 'deficit-model' of public understanding of science, frequently critiqued (e.g. Schibeci and Harwood 2007; Owens and Driffill 2008) and implicit in attempts to engage with the public that are motivated by efforts to dispel ignorance and misunderstanding. Another rationale views the public as the target of interventions that attempt to, for example, raise scientific literacy, mobilise favourable attitudes to scientific and technological innovation, change behaviour, and so on (Bauer,

2009). All of these rationales have some validity at particular times and in particular contexts.

Public engagement is also seen as having the potential to gather additional relevant knowledge. This approach sees lay people as a 'reservoir' of knowledge, which may help to make more informed and 'better' decisions (Dietz and Stern, 2008). Such knowledge may not be captured in expert approaches. Non-expert contextual knowledge may identify problems with the application of abstracted findings to a particular context. In addition, the public can challenge the decisions or advice from experts, holding them accountable to 'civic epistemologies', which apply different standards of knowledge or ways of considering certainty and risk (Jasanoff 2003; Wynne 2003). Non-experts may allow decision-making processes to be opened up to 'blind spots', which those closely involved with official institutions become unable to see (e.g. through certain procedural rules, or standardised objectives etc) (Surowiecki 2004). Stirling (2008) identifies three rationales for engaging in such 'opening-up' activities. His 'substantive rationale' relates to potential to improve the quality of decisions. The 'normative rationale' relates to the democratic 'right' that individuals and groups should have to be involved in decisions that affect them. The 'instrumental rationale' is based on the notion that stakeholders will 'like' and 'support' a decision more if they have been involved in the process by which it was made.

However, Collins and Evans (2002) suggest that this trend of 'opening-up' expertise has now gone too far, with the difference between 'expert' and 'lay' having almost entirely eroded. This 'Problem of Extension' makes it difficult to benefit from the expert knowledge as all claims are given credence. They argue for a normative theory of expertise, i.e. a way of discriminating between who has the authority (competence and knowledge) to speak on certain topics, rather than opening every decision (or every part of every decision) up to public scrutiny. Under this approach 'social' elements embodied in expert information are opened up to the public, who are deemed to have a right to be involved in such issues, but there is still a space for experts to define and discuss the problem in technical terms without the need for wider inclusion. Although explicit identification of the delicate issue of increasing engagement, whilst not losing the value of expert information, met with much approval from other scholars, Collins and Evans' specific proposals (2002) met with some fairly negative reaction (Jasanoff 2003; Rip 2003; Wynne 2003). These critics argued that they had been misrepresented by Collins and Evans in wanting to completely erase the boundary between expert and lay. They also stated that the approach of Collins and Evans potentially returned to closed shop decision-making, with not enough upstream public involvement in the setting of which questions to ask and which goals to pursue. Such an approach was accused of missing the opportunities for lay knowledge to influence the framing and objectives of policies and decision-making processes. Essentially this exchange hinged on what the purpose of such engagement is seen to be.

In terms of the rationale for engagement, we should also mention the environmental governance literature, which is substantial and which has a bearing on public engagement with energy technology, particularly via land use planning (including use of riverine and marine environments and associated siting and policy controversy). Broadly defined, this literature relates to the ways in which state and non-state actors interact with environmentally-relevant institutions, policy, law and regulations, competitively and collaboratively, at different geographical levels (local, national, regional, global). The public are, of course, a key non-state actor, as are NGOs and firms. A sense of the scope of the contemporary environmental governance literature may be gained, for example, from Newig 2008. Examples within that scope include the rise of environmental market based

instruments alongside regulated standards – e.g. Jordan et al. 2003; multi-sector environmental 'partnerships' such as the Forest Stewardship Council – e.g. Verdonk et al. 2007; and, relating more directly to public (rather than via civil society proxies such as NGOs), the proliferation of methods designed to facilitate public engagement in policy design (Tomei et al. 2006) – also see section 7 of Upham et al. (2009). (For a wide range of perspectives on technology governance in relation to sustainability, much of which is based on UK case studies, including several on energy topics, see (Murphy 2007).)

3.6.3 Technology assessment: history and politics

3.6.3.1 Context

Although public engagement in energy research is a highly contemporary and specific issue, it can be readily located within the broader context of public engagement in technology assessment. In fact there have been significant institutional responses to the need for technology assessment in both the USA and Europe, with the objective of accounting for public disquiet and dissensus over the consequences of technological innovation. It is notable, however, that these have largely remained the preserve of regulators and invited experts.

Before describing these institutional initiatives, one should be aware of their historically and economically specific rationale, for this has a bearing on both the rationale for public engagement in technology innovation and also the views of some of those who object. After many centuries during which technological innovation in Europe was barely perceptible, and after several centuries during which human progress was equated with technical progress, industrial societies have now reached a phase in which innovation appears almost compulsive (endemic might be a better term) (Gabor 1970). Moreover, as Gabor observes (ibid) the historical specificity of this phenomenon suggests an origin not in human nature, but in particular economic conditions - hence Schumpeter's identification of technological innovation as a fundamental impulse of capitalism (Schumpeter 1950). Williams (1991, pp. 124-5) draws attention to the normative aspects of this context in which technological innovation takes place, describing it as one in which:

- Nation states in the developed world are engaged in intense industrial and commercial competition and will remain so for the foreseeable future. This competition is shaped by government, led by companies and relies on technological innovation.
- The publics of these countries have mixed feelings about this innovation and its consequences.
- The enormous difference in the standards of living and levels of resource consumption between the developed and less developed worlds is widely seen as morally indefensible, possibly politically unstable and economically inefficient.
- Serious questions exist regarding the level of industrialisation that the planet and its localities can sustain, yet it would be overly optimistic to expect any early and radical change (Williams 1991).

Yet, despite Williams' reservations regarding the context within which technological innovation is taking place, there are good reasons to believe that such innovation will need to continue in some form as part of transitions to more sustainable states: systems modelling of unsustainable consumption and population trends suggests that technological innovation along modified trajectories will have a major and necessary role to play in averting an uncontrolled decline in per capita food output, energy use and industrial production (Meadows et al. 1993).

Nonetheless, however beneficial the promoters of an innovation promise their technology to be, major resistance can be incurred when impacts are unaccounted for and those concerned have little influence over the relevant decision-making process (Rip et al. 1995). In view of the uncertain consequences of technological innovation, three main types of issues involved in making technological decisions have historically been addressed by public policies of technology assessment:

1. Informational: how do we know what the effects of the technology will be?
2. Judgmental: how should we evaluate the possible outcomes?
3. Institutional: how are decisions to be reached? (Street 1992).

In the next section we consider some of the main debates and practices around publicly institutionalised technology assessment.

3.6.3.2 Institutional aspects and trends

In some contrast to the current patchwork of individual public engagement initiatives in the UK, referred to below, technology assessment was formally institutionalised in the USA several decades ago, by the enactment in 1972 of Bill Hr10243, requiring the establishment of the US Office of Technology Assessment (Janes 1996). At a European public policy level, technology assessment has also been conducted since the late 1970's, with the inception of the Forecasting and Assessment in Science and Technology Programme in 1979, the Scientific and Technological Options Assessment initiative, the VALUE II programme in 1992 and the European Technology Assessment Network in 1994. The US Office of Technology Assessment ceased operations in 1995. Although the European Technology Assessment Network produced its last paper in 1999, its mission is in some respects continued by the EC Joint Research Centre network. In the UK, while their remits are broader than technology alone, bodies such as the Royal Commission on Environmental Pollution (RCEP), the Sustainable Development Commission (SDC), the House of Commons Environmental Audit (Select) Committee and the Parliamentary Office of Science and Technology are among UK Government-established organisations that have played some role in assessing and interpreting technological innovations and potential for the wider social good. (Note, however, that DEFRA will soon no longer fund the SDC and is abolishing the RCEP).

A contested issue since the inception of technology assessment as a formalised group of methodologies has been the representation of a limited range of values and perceptions. Indeed the relationship of technology to social, economic and political groupings was considered a major challenge for technology assessment well over three decades ago (Wynne 1973) and remains so today (Hendriks 2010). Dutch analysts have been conceptual and practical pioneers in public and stakeholder engagement in technology development, envisaging a role for technology assessment at the centre of a comprehensive technology policy that seeks to involve users - though not always the wider public - not necessarily as a means of representing a more balanced set of values, but often as a means of dealing with mainstream policy concerns, such as the successful diffusion of innovations. Potential economic, social and cultural impacts, it is argued by some theorists, need to be treated as significant factors in the implementation of a technological strategy because these factors condition the chances of successful execution of innovation strategy (Leijten and Smits 2009). Similarly, Leijten (2009) argues that the socialisation of research is simply unavoidable in, and a logical consequence of, the shift to economies in which knowledge and the individuation (personalisation) of technology is increasingly significant (a trend most evident in telecommunications devices and software). This need is amplified by the significant cost of new technology development and the trend to network-based collaboration of public and

private organisations in R&D, and has the potential to be (and is being) facilitated by internet-based collaboration and networking technology (ibid).

A practical proposal in response to this debate in the Netherlands has been constructive technology assessment (CTA), which is concerned with constructively redirecting the process of technical change by actively organising relationships between developers and users (Rip et al. 1995). CTA attributes the failure of technology and risk assessment to avert the unwanted impacts of technologies to a separation of state technological promotion and control mechanisms. In general, CTA aims to avoid belated attempts at the control of market externalities by directly modulating the upstream dynamics of technological design. From the CTA perspective, technological innovation is seen as an opportunity for societal learning (Rip et al. 1995).

Thinking on methods for the social assessment of early stage technologies continues to evolve, particularly CTA. For example, van Merkerk and Smits describe how, for a nanotechnology medical application ('lab-on-a-chip') test-case, they developed, applied, and evaluated a 3-step CTA approach consisting of: (1) providing information to participants; (2) constructing individual scenarios; and (3) dialogue workshops (van Merkerk and Smits 2008). The participants in this exercise did not include the general public, but rather scientists, manufacturers, potential professional users, policy makers and investors. Interactive and participatory approaches to innovation process are nonetheless possible with the public, as, for example, Broerse and Bunders describe in their involvement of farmers, scientists and other stakeholders in biotechnology development for small-scale, resource-poor farmers (Broerse and Bunders 2000).

3.6.3.3 Ethical technology assessment

Another relatively small strand of literature relevant to this context focuses on the ethical aspects of technology assessment and associated public and stakeholder engagement. A useful entry point to this literature is work on radioactive waste management (Cotton 2009), which examines the utility and limitations of an ethical Technology Assessment (eTA) matrix (Palm and Hansson 2006). As originally defined, the ethical matrix uses four ethical principles – autonomy, avoiding harm, beneficence, and justice – and uses these to structure a consideration of specific technology concerns within a deliberative process. The matrix places the above ethical principles on one dimension and different stakeholder types on the other dimension. In the cells are entered specific issues relating to each principle in turn, as perceived by the respective stakeholder. The eTA is essentially a way of structuring stakeholder and/or public concerns in terms of relatively consensual elements of ethical theory, in order to facilitate structured ethical debate from a range of perspectives (Mepham 2000). The emphasis on discussion and deliberation is theoretically underpinned by the Habermasian idea of communicative rationality (Habermas 1984), which holds that valid social norms and values must be developed and tested via deliberation, not just the decision of an individual or single entity (Habermas 1976).

The eTA approach has been applied to a number of case studies, including bovine somatotropin, xenotransplantation, bioremediation and other food-related topics (e.g. GM fish) (Kaiser et al. 2007). A 2007 special journal issue on agricultural and environmental ethics (Haynes and Brom 2007) considers ethical tools from a variety of perspectives, and (Beekman and Brom 2007) consider the eTA alongside (a) forms of public involvement such as consensus conferences; (b) decision-making frameworks such as an 'ethical Delphi', which consists of iterative, anonymous consultation of experts; and (c) guidance on ethical communication along the supply chain (Deblonde et al. 2007). This work draws in part on

the European FP5 project 'Ethical Bio-TA Tools' (http://www.ethicaltools.info/). In short, ethical assessment as practised above is in many ways similar to constructive technology assessment and deliberative public engagement in science, but differs in its explicit reference to the alternative ethics involved in technological and other controversy.

3.6.4 Governance challenges

The defining features of contemporary, corporate and globalised capitalism are not easy to reconcile with public technology governance, be this via direct engagement or via the state, despite increasingly wide recognition of the potential benefits of public engagement in science and technology innovation (Stirling 2008). While Stirling (ibid) notes an irony in the concurrence of the two trends (globalised capitalism and recognition of public engagement benefits), there may never have been a particularly conducive historical moment for public engagement in private innovation – or, at least, there will always have been tensions between the visions and ambitions of innovators and those others affected.

In principle this tension need not be quite as stark in the case of state-funded research projects and programmes. In this context, arguably the state would have more influence and clearer legitimacy in terms of intervention. Yet in practice, states appear not to have readily embraced the opportunities. Hendriks describes how the pioneering Dutch Energy Transition Programme (ETP), despite shifting energy policy from being centrally led to a more decentralised, networked and cross-institutionalised mode of governance, remains largely controlled by expert and corporate elites (Hendriks 2008, 2009, 2010). To remedy this, Hendriks suggests a number of interventions that would enhance the representativeness and legitimacy of the networks: affirmative action (sometimes termed positive discrimination) for demographic inclusivity; direct linkage of citizen engagement and elected political representatives to the programme's governance structures (and supporting this with resources); use of media and communication techniques to connect the wider public to issues (where these are likely to be perceived as widely of interest); reframing of the policy discourses of the programme to those that include public participation; and monitoring the impact of policy outcomes on different social groups . In so doing, however, it remains important that engagement activities are not in reality constrained, top-down exercises in legitimating pre-existing policy and technology commitments (Stirling 2008).

To sum up the above, understanding public engagement in energy research and development programmes, past, present and future, also requires an understanding of public technology assessment, which has a history stretching back several decades and which continues in a variety of guises today. Technological innovation has long been of interest to social scientists because technology is seen as influencing social structures through legal, psychological and physical means (Sclove 1995). It can also reinforce those structures, whether this is an intended consequence or not (Bereano et al. 1985). In short, technology is seen as neither acultural nor apolitical, but as the result of choices that could have been made differently (Goldhaber 1986). When innovations are perceived as posing a potential environmental risk, it has long been recognised that a case can be made for involving a wide range of stakeholders at an early stage of research and development (Sclove 1995). From a perspective that recognises this social and political context of technological innovation, practitioners and analysts considering the governance challenges of public engagement in state-funded energy R&D will benefit from knowledge of the wider context of technology assessment that precedes it.

Finally, it should also be noted that there is also work on the governance of what might be termed meso-level or community-level generation – e.g. (Hoffman and High-Pippert, 2010;

Walker et al. 2007; Walker 2008; Walker and Devine-Wright 2008). This literature points to the way in which community energy policy at least initially emerged in response to instrumental policy drivers that were not sensitive to the communitarian expectations of participatory involvement, with different understandings of 'community' in this context. Trust among the actors involved is seen as fundamental to the dynamics of community renewable energy projects but should not be assumed and cannot necessarily be assured.

3.7 Summary

This section has reviewed some key elements of the literatures on attitudes, behaviour, risk perception, learning, place identity, practices, STS and governance. We have emphasised that public attitudes and responses to low-carbon energy are contextualised, dynamic, and determined by a complex interplay of psychological, social and structural factors. Furthermore, they are frequently not predictive of behaviour. Yet, they hold important functions, such as helping organise knowledge, inform decisions, express identity and seek connections with others. Also, the concept of attitudes helps us understand how individuals interpret and respond differently to the same information, since attitudes bias perceptions and guide (though do not determine) behaviour. In addition to psychological literatures, we have also illustrated theoretical approaches that are relevant to public engagement with low-carbon energy and in related research agendas, but which are not framed primarily in terms of attitudes. We selected for attention the 'practices' approach from the sociology of consumption, the literature on governance, and science and technology studies. These point to the context of the individual as being critically important and go beyond the focus on individuals' motivation and cognition. They serve to keep engagement in perspective and the purposes of engagement in mind. Indeed, engagement emerges as a practice in itself, based on multi-stakeholder deliberation, safe spaces for innovation, and deliberate efforts to disrupt regimes.

4 Energy Supply, Storage and Distribution

Summary: Energy Supply, Storage and Distribution

- The large majority of UK citizens believe that we need to reduce our reliance on fossil fuels and dependence on gas imports is widely seen as undesirable.
- While nuclear power is only reluctantly accepted, in principle attitudes to renewables are generally positive, though differentiated and nuanced.
- The little work on CCS suggests that it, too, is likely to be reluctantly approved of, specifically as a bridge to a renewable future.
- Knowledge of hydrogen and fuel cells is low but attitudes are generally positive, conditional upon safety, efficiency and cost criteria being met.
- Upfront capital cost has been a major obstacle to uptake of micro-generation. As the upfront cost of domestic energy measures may need to be kept below £4,000 for most people, linkage to other domestic upgrading (extensions, re-roofing etc) is advisable.
- Electrical grid operators are not well-known to the public, who associate National Grid with pylons and cables. This may have implications for the public engagement that will be needed for infrastructure renewal.
- The explanatory value of the NIMBY concept has been extensively critiqued: proximity per se explains little and objections can be as much about procedural justice as about technology-specific impacts.

4.1 Introduction

As noted by (Walker and Cass 2007), the UK energy system is shifting from an inherited, centralised system of energy supply towards a context in which there are several new roles for 'publics' in the transformation of energy systems – a plurality often overlooked in both policy circles and in the research literature. That is, in the emerging energy policy context, the public may be involved not only as a consumer, but also as a neighbour, co-owner and so on. Moreover, if we assume that the UK will shift to an increasingly decentralised and diversified energy system, then we do need to consider all aspects of that system, including a new electric grid and other infrastructure.

This chapter reviews primarily UK public attitudes to energy supply, storage and distribution technologies, together with the limited literature on public engagement with related research programmes. The chapter includes material reviewed for LWEC (Upham et al. 2009) but updates and extends this by considering a wider range of technologies and adding to the level of detail previously provided.

In reviewing studies, we retain their original, often implicit perspectives and assumptions. It should be noted that most of these are debated. For example, reference to drivers and barriers may be viewed as inadvertently obscuring the social embeddedness and context of a technology, by implicitly suggesting that decision-making is autonomous and rational (Guy and Shove 2000; Roy et al. 2007); this relates to debates over the extent to which attitudes cause or follow from habits and practices (i.e. the direction of causation). Beyond this, there are instances of lower level debate and conceptual development, common to academic work (though this is perhaps less evident than in other sub-fields, there being so little literature on microgen adoption). For example, whereas Faiers and Neame (2006) used diffusion of innovation theory (Rogers 1995) to examine attitudes to system attributes of domestic solar power systems, Roy et al take the view that while Rogers' diffusion model has some utility in a consumer context, it was not originally intended to be so used. Roy et al thus complement it with a 'properties of objects' perspective which was designed for a

consumer goods context and which characterises products and services in terms of: (a) their direct utility, (b) their capacity to complement other products/services and (c) their symbolism (brand appeal etc) (Murphy and Cohen 2001; Roy et al. 2007). Use of the differing conceptual models leads to differently-framed understanding: Faiers and Neame (2006) find that while individuals who already had installed a domestic solar power system ('early adopters') had almost universally positive views of such systems, individuals who had not done so perceived the financial, economic and aesthetic characteristics of domestic solar power systems as limiting adoption, despite having positive perceptions of the environmental characteristics (Faiers and Neame 2006). They argue that it is likely that these evaluative differences reflect individual differences in interest in new technologies and environmental concerns as well as experiences with the system itself (Fischer 2006). Roy et al (2007), on the other hand, by also focussing on the design features of microgen and energy efficiency products, find additional points of potential leverage to encourage both adoption and energy-efficient usage.

4.2 Renewable Energy

4.2.1 Large-Scale Wind Energy

The 2009 UK Renewable Energy Strategy made clear the important role that wind energy is expected to play in the growth of low carbon energy generation over the coming decades. Approximately two thirds (i.e. 20%) of UK electricity demand could be met by onshore and offshore wind energy sources by 2020, under DECC scenarios (DECC, 2009b). For this reason, understanding public engagement with large-scale wind energy projects is an important issue for research.

The results of survey research suggest that wind energy is one of the most familiar sources of renewable energy. Annual surveys indicate that over 80% of the UK public report being aware of wind energy and that this level has remained stable since 2006 (DECC, 2009a). Survey research over the past decade also suggests that public attitudes towards wind energy are both consistent and positive (McGowan & Sauter, 2005; DECC, 2009a). Nationally representative surveys have shown that, depending on the exact question asked, around 80% of the British population have favourable views of wind energy (Poortinga et al., 2006; Pidgeon et al., 2008a; Eurobarometer, 2006; DTI, 2006; BERR, 2007; 2008). A majority of people believe that expanding the use of renewable energy resources is the best way of tackling climate change (Poortinga et al., 2006; Pidgeon et al., 2008a), and also think that developing the use of wind power should be part of the government's focus to reduce our dependency on imported energy sources (Eurobarometer, 2006). Furthermore, an overwhelming majority agreed that wind power will make a substantial contribution to reliable and secure supplies of electricity in Britain in the future (Poortinga et al., 2006; Pidgeon et al., 2008a).

However, these levels of overall wind energy support mask some diversity across social categories and instability over time. For example, research suggests that older respondents hold slightly less favourable attitudes towards wind energy in comparison to younger respondents; 83% of those aged 16-24 indicated slight or strong agreement with the statement '*I am in favour of the use of wind power*' in comparison to only 74% of those aged over 75 (DECC, 2009a). These levels have also been shown to be volatile; levels of support amongst 16-24 year olds was consistent at 74% in 2007 and 2008, before rising to 83% in 2009. The oldest age group were also the most likely to actively disagree with wind power use (9% disagreed), but this disagreement is fell by 5 percentage points since 2008. Another source of attitudinal diversity is location of residence. For example, research suggests that

adults living in the Highlands & Islands region of Scotland have the strongest support for wind power (90% agreed compared to 81% in GB overall) and that such levels have been stable across 2008 and 2009. Yorkshire also showed a significantly higher level of support for the use of wind power (88%) compared with the GB average.

Very little is known about the development of attitudes before, during and after the construction of windfarms. Research conducted in the 1990s suggested that negative perceptions of local windfarms decline over time (Young, 1993; Bishop & Proctor, 1994), suggesting that familiarity may breed contentment. Research by Warren et al. (2005), van der Horst (2007) and Eltham et al. (2008) also suggests that people become more favourable towards windfarms after construction, although these conclusions are mainly based on retrospective self-reporting. Many residents living close to developments feel that their fears of anticipated problems have not been realised, as they have not experienced any problems, do not notice the turbines visually or aurally, and the windfarm has become part of the background. This suggests that the actual impacts of the developments in terms of visual intrusiveness, noise and despoliation are often far less than residents initially expected. However, very little systematic or in-depth research has been conducted that longitudinally 'tracks' public attitudes and involvement with such developments (Devine-Wright, 2005).

Public attitudes towards wind energy are supported by positive evaluations of this type of renewable energy in terms of it being clean, cheap, good for communities living nearby, good for the economy, and safe (McGowan & Sauter, 2005; Poortinga et al., 2006). However, wind energy (or wind turbines more specifically) is also seen as inefficient, spoiling the landscape and taking up large amounts of land (Poortinga et al., 2006; McGowan & Sauter, 2005). Resistance to wind energy developments appears to be primarily driven by negative perceptions of their visual impacts, with a considerable minority finding them "ugly" or "unsightly" and concerns about them being noisy (TNS, 2003; Warren et al. 2005). However, more than three quarters of the same sample agreed that "renewable energy schemes are less damaging to the landscape than fossil fuel generating plants" (TNS, 2003).

A promising new avenue for research comes from a study into the impacts of framing on public support for energy policies that increase the use of renewable energy sources such as wind energy (Lockwood 2009). In this study that surveyed over 3000 UK adults in September 2009, public support for increasing the proportion of energy generated from renewable energy to 15% by 2020 was subject to three forms of framing: to respond to challenges of energy security (i.e. to help reduce our reliance on foreign gas or oil), climate change or to create new economic opportunities. The results showed that the energy security framing was the most powerful in eliciting strong support for increasing renewable energy, and that the economic framing was least supportive, despite it being commonly deployed by policy makers during the recession.

Evidence for the scale of public antipathy towards wind energy is suggested by survey results showing that overall support drops from 82% to 62% when respondents are asked to rate their agreement/disagreement with the statement *"I would be happy to live within 5km (3 miles) of a wind power development"* (DECC, 2009a). The findings suggest that this lower level of support for local development has remained stable over time since 2006. Studies that have gauged public attitudes to onshore versus offshore locations for wind energy corroborate these findings: onshore locations are less supported generally than offshore (MORI, 2009) and this has led to a prevalent view that offshore wind energy will receive more public support than onshore locations (Haggett, 2008). Research has identified two

personal factors that relate to diversity of response towards local acceptance. First, gender seems to align with local acceptability, with men being more accepting of local development than women (70% vs. 56%), although the rationale for this link is poorly understood. Second, survey findings reveal significant regional differences in local acceptance, notably that 75% of respondents resident in the Highlands & Islands region of Scotland were likely to agree with this statement and 71% of residents in Yorkshire. These presumably relate to the varied spatial distribution of onshore wind development around the UK (since some regions have little or no development), as well as to different views of the opportunities presented by such projects for local communities. Approximately 15% of respondents consistently strongly disagreed with the statement about being happy to live within 5km of a wind power development. These individuals seem to have formed strong and stable negative attitudes towards the local appropriateness of this source of renewable energy and this form of renewable energy technology.

Public opposition to the siting of windfarms has often been characterised by media commentators, industry spokespersons and policymakers as 'NIMBYism' (Not In My Back Yard) (Burningham et al., 2006). NIMBY is a term that both describes and explains public opposition: *'In plain language ... [NIMBYs are] residents who want to protect their turf. More formally, NIMBY refers to the protectionist attitudes of and oppositional tactics adopted by community groups facing an unwelcome development in their neighbourhood…'* (Dear, 1992, p288). Intrinsic to the NIMBY discourse is a set of presumptions about the characteristics of individuals who oppose development: that they are selfish, ignorant and irrational; that they live closest to the site of development; and that they accept the technology in principle, just not proximate to where they live (Devine-Wright, 2005; Burningham et al., 2006).

Academics have responded to this prevalent discourse of NIMBY opposition by critiquing it in principle and by subjecting it to empirical investigation. Bell et al. (2005) critiqued NIMBYism by proposing a range of explanations for the apparent 'social gap' between high levels of public support for wind energy and low success rates in planning applications, of which only one draws upon the so-called 'individual gap' (i.e. a gap between a positive general attitude to wind power and opposition to a particular wind energy development). The first explanation draws upon the idea that there may be a democratic deficit in planning procedures; that, although a majority may be in favour of wind power, development decisions are controlled by a well-organised minority opposing wind power. The second explanation reflects the idea many people who express support may not do so without qualification. It is possible that public opinion surveys do not identify the conditions under which residents might support or oppose developments, resulting in the impression that people are making an exception to their general principle when a development has a direct effect on them, when in fact they are following their general principle of 'qualified support' that is poorly captured by survey questions. The third explanation draws upon the idea of an individual gap that people support wind energy in general but actively oppose any developments in their own area for self interested reasons, and is as such closely related to the NIMBY concept. The implication of Bell and colleagues' work is that the reasons for local opposition to wind farm proposals may not necessarily relate to the specific beliefs held by individuals, but may instead be more centrally based upon aspects of decision-making procedures or problems with methodologies that purport to capture 'public attitudes'.

A succession of studies has attempted to empirically test the accuracy and validity of various aspects of the NIMBY explanation for public opposition, typically through case study analyses of specific wind farm developments. These have produced surprisingly little support for the existence of a classic NIMBY response. Attempts to confirm the 'proximity

hypothesis' (i.e. that people living closest to a windfarm have more negative attitudes to the development than those living further away) have produced inconclusive findings. Although Warren et al. (2005) found a widespread NIMBY response at the start of wind power developments in Scotland and Ireland, the effects diminished substantially over time, suggesting that the 'proximity effect' (Devine-Wright, 2005) interacts with temporality, as argued by van der Horst (2007). This is likely to be the reason why some studies suggest greater support at greater distances (e.g. Swofford and Slattery, 2010), while others suggest that people living closest actually have more positive views of planned or established windfarms (Duddleston, 2000; MORI Scotland, 2003; Warren et al., 2005; Michaud and Carlisle, 2008; Jones and Eiser, 2009).

Attempts to verify the classic NIMBY attitude of technology support 'in principle' yet objection to its local siting have also been largely unsuccessful. For example, Ellis et al. (2007) used Q methodology to study the content of arguments of support and objection to the siting of a windfarm off the coast of Northern Ireland. Instead of a single attitude towards development, they found that both supporters and objectors displayed diverse reasons for their respective positions, and that support is often not absolute but qualified, as Bell and colleagues argued (2005). Moreover, many of those who opposed the wind energy project had values similar to those who supported it. Objection was sometimes motivated by acting out of environmental stewardship while being sceptical of the technologies, policies or organisations behind the proposal. As noted by Warren et al. (2005), there are strong 'green' arguments on both sides of the wind energy debate. Overall, Ellis et al. (2006; 2007) found that supporters' discourses were primarily focused on addressing climate change, whereas objectors were far more likely to stress the economic and visual-aesthetic aspects of development – an issue that Haggett (2008) has described as the 'disjuncture' between global-scale benefits and local-scale impacts of wind energy.

Attempts to remedy this disjuncture have led to policy on providing benefits to the communities directly affected by wind farm projects. A succession of policy guidance has emerged encouraging developers of large-scale wind farms to build community benefits packages (both financial and in-kind) into their project proposals (e.g. DECC, 2009b) and this seems to have become the convention in the UK at least with regard to onshore projects (Cass et al., 2010). This policy is based upon the presumption that "*the routine provision of meaningful benefits to communities hosting wind power projects is likely to be a significant factor in sustaining public support and delivering significant rates of wind power development*" (CSE & Garrard Hassan, 2009). However, empirical research does not provide unequivocal evidence that benefits provision increases the social acceptance of wind energy. Cass et al. (2010) have shown how providing benefits to communities is in practice often highly problematic, perceived by locals as a bribe to silence opposition and ambiguously portrayed by developers attempting to avoid publicly recognising any local 'blight' (e.g. aesthetic or economic) that may be attributed to their proposals. As a result, benefits packages may in some circumstances magnify local grievance rather than alleviate it, providing further evidence of the limitations of a cost-benefit approach to social acceptance.
Most studies on public attitudes to wind energy have focused on the acceptability of large-scale on-shore developments that are led by the private sector (Devine-Wright, 2005a). Private-sector developments are often perceived as invasive and led by 'big business' that provide little or no benefits for the local community (Warren & McFadyen, 2010). Indeed, providing no local economic benefits has been reported as one of the main negative aspects of windfarms (Warren et al., 2005). As a result, it has been suggested that community ownership can help to increase public acceptance of windfarms as both the costs and benefits of the development would go to the local community (Devine-Wright, 2005b;

Warren & McFadyen, 2010). Warren & MacFadyen (2010) also report the additional psychological effects of a sense of pride and ownership of 'their' windfarm ownership reflected in the giving the turbines affectionate nicknames. This ties with recent changes in energy policy: *'We will help take the poison out of many of the planning battles surrounding onshore wind by promoting community ownership of appropriately sited wind farms, allowing host communities to retain the additional business rates and providing electricity to local residents at discounted tariffs'* (Conservation energy policy, 2010, p20 – see also DECC, 2010d).

Empirical research suggests that the public does support greater community involvement and the sharing of benefits than is conventionally the case with industry-led developments. A study that followed a community initiated wind farm development in South Wales found that local support for alternative forms of community involvement (partnership developments with local communities, local use of generated energy, and profits of windfarms being put back into the local community) were consistently high across time (Devine-Wright, 2005b). Interestingly, support for community ownership was slightly lower, if still high, suggesting that this was less familiar and perhaps considered less realistic in comparison to the more conventional private-sector led business model. This finding was supported by Rogers et al. (2008), who reported that many residents view themselves as consultants rather than owners or project leaders of community-based renewable energy projects. This suggests that community ownership represents only one end of a spectrum of models of community participation, which involve different degrees of ownership, development processes, and objectives (Coleby et al., 2009; Warren & McFadyen, 2010).

To better capture this diversity of community involvement in low carbon energy projects, Walker and Devine-Wright (2008) proposed a two dimensional framework for categorising projects, referring to the degree of participatory involvement of local residents in the scheme (from high to low), and to the ways in which benefits were distributed (from distant and private to local and collective). Using the two-dimensional framework, six case studies of community-led renewable energy projects were analysed, including two onshore wind farms, with the findings revealing an inherent ambiguity in the ways that the term 'community' was applied to energy projects, as revealed by the diverse positioning of the six projects across the two dimensional framework.

Another avenue of research that has sought to better understand 'local' aspects of wind farm developments, covering reasons for both support and opposition, focuses upon the concepts of place attachment and place identity from the disciplines of environmental psychology and human geography (*see section 3.2 for further details*). Here the concern is with less tangible, more subjective aspects of public response to development proposals than issues of benefits packages and ownership structures. Case study analysis, drawing on a mixture of qualitative and quantitative data, showed the relevance of place attachment in explaining opposition to a proposed offshore wind farm in North Wales (Devine-Wright and Howes, 2010). It was found that in the coastal town where opposition was strongest (as evidenced by the presence of a local opposition group, by more negative attitudes to the wind farm and by higher levels of behavioural opposition, as captured by a large-scale survey of residents' opinions), the correlation between strength of place attachment and attitudes towards the project were strongly negative. Further analysis showed that the symbolic meanings that were associated with the coastal town by residents (i.e. as a 'natural' and 'unique' place) were fundamentally threatened by the meanings associated with the wind farm, which was represented to 'industrialise' the area and 'fence in the bay'. The outcome was a distinct sense of threat that led to negative attitudes and spurred active 'place-

protective' response of local residents to oppose the proposals. The results suggest that place-related symbolic and affective aspects are at least as significant as more tangible, economic and material aspects in shaping public responses. They also suggest that presumptions of social acceptance of offshore wind arising from greater spatial distance from homes may, in fact, be flawed.

While this body of literature has reached a certain degree of consensus on the limited validity and usefulness of the NIMBY concept for understanding public responses, a range of recent studies have sought to capture 'NIMBYism' in practice, by probing the ways in which policy makers and industry professionals conceive the public and broader issues of public engagement. What this has suggested is that many presumptions held by such actors about how the public engage with wind energy are in fact erroneous (Aitken 2010). Very often the public are conceived to represent an 'ever present danger' to wind farm projects (Walker et al., 2010) despite demonstrably high and stable levels of public support as shown by repeated survey findings. Protestors are viewed as 'emotional' individuals, who are out of place in a planning process that should remain rational and logical (Cass and Walker, 2009). The impacts of these conceptions of the public are practical: they lead to the strategic selection of certain engagement mechanisms over others. For example, research has indicated how they lead to the avoidance of public meetings and the holding of public exhibitions, in order to curtail the potential influence of emotional individuals and groups (Barnett et al., forthcoming).

Arising from these studies of dual aspects of public engagement (how the public conceives wind energy projects as well as how developers and policy-makers conceive public responses) is a heightened sense of the mutual inter-dependence of these two processes over time (Walker et al., 2010). One implication of this emerging conception of public engagement is that 'NIMBYism' may be a self-fulfilling prophesy, in which the motivations of protestors are falsely attributed to a discourse that leads to industry responses that only fuel further protest (Devine-Wright, 2010). Another is that the 'NIMBY' conception of the public should be replaced with more fluid and diverse ways of thinking about the roles individuals can play in relation to wind energy specifically, and renewable energy more generally, encompassing less spoken about and researched roles such as investor, co-producer etc. (Walker and Cass, 2010).

4.2.2 Bioenergy and biofuels

'Biomass' is the biological feedstock from which biofuels may be synthesised and/or bioenergy supplied. 'Biofuel' usually denotes liquid transport fuel of non-fossil organic, typically biological, origin (it is also possible to make transport fuel from municipal solid waste that may or may not include fossil-oil-based plastics). 'Bioenergy' is a wider term that is sometimes used to include biofuels, but which more commonly denotes the supply of electric power and/or heat from the thermal treatment of biomass (typically combustion or gasification).

Interest in the use of biomass for the supply of electricity, heat and transport fuels is currently driven by the European Parliament's adoption, in late 2008, of the *Directive on the promotion of energy from renewable sources*, which set new targets to be achieved by 2020: to cut greenhouse gas (GHG) emissions by 20%; to establish a 20% share for renewable energy; and to improve energy efficiency by 20*%* (20-20-20) (EC, 2009). There are many conditions on this in relation to biomass supply and the European Parliament has specified environmental criteria (essentially prohibitions on the use of biodiverse, high carbon stock and wooded land) for this purpose (EC, 2009). Regulatory constraints on the supply of

woody biomass are, at the time of writing, less stringent (EC, 2010). This position is, however, under review and bioenergy/biofuels policy in general remains highly controversial in the UK and elsewhere (Upham and Tomei, 2010).

In DECC's (2009a) national survey of attitudes to renewable energy, 59% of respondents 'had heard of' biomass or bioenergy. This was up from 45% in 2006. It is interesting to note that 77% of respondents 'had heard of' biofuels (up from 73% in 2008 when the item was first introduced to the survey). This may be explained by the levels of controversy covered in mainstream media regarding the 'sustainability' of biofuels. It is particularly challenging to investigate public views on 'bioenergy' given the range of fuels, conversion technologies and applications that the term covers. In addition, the perceived similarity between biomass and waste incineration facilities can also affect attitudes and levels of support.

With regard to biomass, Poortinga et al (2006) found that just over half of the British population have mainly or very favourable opinions or impressions – a favourability rating that is comparable to natural gas. Other nationally representative surveys (e.g. TNS Plc, 2003) produced similar findings: opinions of biomass are less favourable than of more 'traditional' renewable energy technologies, such as solar and wind power. However, on balance they are still positive. Eurobarometer (2007) research shows that support for biomass in the UK is among the lowest in Europe. It is then perhaps not surprising that relatively few people believe that biomass will significantly contribute to reliable and secure supplies of electricity in Britain in the future (Poortinga et al., 2006).

Qualitative work suggests that in principle support for bioenergy may be qualified. Barker and Riddington (2003) reported that many participants question the 'environmental friendliness' of bioenergy. Some found it difficult to understand how biomass is a renewable fuel, as it was perceived as having features of traditional fossil fuels. As such, participants were concerned about emissions and odours from bioenergy power plants; and there was some discussion as to whether the smoke would be filtered within the plant to reduce emissions. Participants also found it difficult to distinguish between biomass and waste incineration for energy production. When shown an image of a bioenergy plant, concerns were expressed about the aesthetic impacts on local landscapes. On the positive side, bioenergy schemes were seen as the most likely to provide employment, both within the power plant itself and for farmers growing the material; although some concerns were expressed about large lorries carrying straw for the local plant. These findings resonate well with quantitative research reported in McGowan and Sauter (2005) where "burning wood, straw or other biomass" is seen as polluting the air, contributing to climate change/global warming, harming birds other wildlife or their habitats, using fuel which will eventually run out, and spoiling the landscape. The relatively negative evaluation of biomass is further reflected in that more than half of the respondents of a national survey indicated to be slightly or strongly resistant to a biomass development 'in their area' (TNS, 2003); and that only about one in ten believe that biomass power stations should be built in Britain during the next ten years (McGowan and Sauter, 2005). Further research is required to identify if the increase in 'awareness' of bioenergy since this work was completed translates in to higher levels of support.

Burning waste for energy is perceived more negatively than biomass. More people believe that incineration pollutes the air, contributes to climate change/global warming, and spoils the landscape as compared to biomass (reported in McGowan and Sauter, 2005). A European study into attitudes to energy from waste found widespread and deep concerns about noise, odour, (toxic) atmospheric emissions, and the disposal of fly ash from

incineration, as well as concerns over the impacts on house prices and the character of the area (AEAT, 2001).

Upham and Shackley (2007) found very negative attitudes to the siting of a large-scale biomass gasifier plant in Devon. Local residents living close to the proposed plant expressed a wide range of concerns, including lorry traffic congestion/air pollution, the credibility of the developer, air pollution, odour and appearance of the plant. Further concerns were related to fuel waste, technological reliability, landscape changes, and the impact on house prices. However, some saw the development as offering a number of benefits, including: economic development and employment, as well as a reduction of greenhouse gasses. A follow-up survey (Upham, 2009) showed that the level of concern remained high up to the final withdrawal of the planning application, and the number of people viewing any benefits of the biomass gasifier plant had decreased substantially after planning permission was refused. The findings of Upham and Shackley, and Upham show that there is a great potential of local opposition to the siting of relatively large bioenergy plants, with local people seeing little to be gained for the community but much to lose. Furthermore trust in developers and district councils have been found to be low with regard to similar developments (Upreti and Van der Horst, 2004, Upreti, 2004, Sinclair and Lofstedt, 2001).

In McLachlan's (2010b) study of a Miscanthus and clean woodchip electricity plant in Staffordshire, local opposition centred on: the health implications of burning wood, the potential for other 'dirtier' fuels to be used in future, increases in traffic, the impact on local visual amenity as concerns over the process of consultation (particularly the communication of alterations made to the original plans for the development). There were also some positive assessments from local stakeholders and residents in terms of the development showing the area to be 'green' and 'pioneering'. Upreti's (2004) study of a straw plant in Cambridgeshire found local concern about traffic, pollution and noise as well as visual impact. However, the study also found that an 'open' approach from the developer, who revised the plans on the basis of local concerns as well as sponsoring 'fact finding' trips to operational straw plants for local stakeholders, led to a reduced level of opposition. Upreti argues that the extent to which: the development is felt to be imposed on an area, the technology is seen as familiar, the plant is seen to serve corporate profit rather than local interests as well as the level of involvement that local people have in decision making and can impact upon an escalation of conflict.

In Lane's (2000) study of individual transport use, he found that less than 5% of those surveyed had heard of biofuel as a fuel being considered for use on British roads. Lane calls for further education and communication on alternative fuels if consumer initiated change in terms of vehicle and fuel use is to be achieved. In research for the Department of Transport, King et al (2009) found that LPG and biofuels were not well known and that those that had heard of them tended to 'lump' them together as 'new and unavailable' (see also section 5.2.5). In a Belgian study, Van de Valde et al (2010) found that the public perceived a lack of information in relation to biofuels and a desire for scientists, environmental and consumer organisations to provide more information. In particular respondents desired further information on the tax (dis)advantages of biofuels and the environmental effects of biofuels. Van de Velde calls for further information provision but does warn against the assumption that this will automatically lead to a change in consumption patterns. Verbeke (2007) cites environmental efficiency, cost effectiveness, impact on overall security of energy supply and economic development and welfare as potential influences on the attitudes that the public may have to bioenergy and biofuels.

A study in Idaho, USA found that nearly half of those surveyed had never heard of biodiesel, despite it being sold locally. However, there were high levels of agreement with prompted positive statements relating to biofuels such as reducing dependence on foreign oil, being better for the environment, and being better because it is from renewable sources (Kinsey et al., 2003). In another USA based study, Delshad et al (2010) found that support for biofuels varies depending on both the technology and the feedstock. In a comparative study of Belgian and American consumers, Skipper et al (2009) found a general preference of for lower food prices compared to fuel. This finding was more pronounced amongst older respondents.

Whereas extensive research has been conducted into public responses to the siting of windfarms, comparatively little is known about the potential responses to other less well-known renewable energy technologies, such as biomass. Case study evidence to date identifies a range of issues that have the potential to be raised by local residents etc, including: noise, health, traffic, sustainability of fuel and environmental friendliness. Whilst the similarities between fossil fuels and biomass offer many technical advantages, it can also act against it in terms of public support. In addition, the process of consultation has again been found to be of central and formative importance in the development of opposition and support. In relation to biofuels, levels of awareness are higher but there is little empirical work on how they are interpreted by publics. Biofuels pose a different research and engagement proposition to bioenergy generally as the fuel could be widely used as opposed to static power plants. Mirroring bioenergy in general, perceptions may vary across different feedstocks and conversion technologies.

4.2.3 Tidal and Wave Energy

Wave and tidal energy are seen as potentially important contributors to the UK's energy mix, particularly post 2020. The UK has one of the highest wave energy resources in the world. Tidal energy is also thought to be able to make a valuable contribution particularly given its reliable and predictable nature (DECC, 2009b). Currently there is no 'dominant design' for wave or tidal stream energy devices (The Carbon Trust, 2006). Numerous devices are currently being developed at scale model, prototype and full scale levels. The UK hosts both the European Marine Energy Centre (EMEC) and Wave Hub (currently being deployed), which allow for testing of single wave and tidal stream devices and arrays of wave energy devices in real sea conditions respectively. Currently there are no multiple-device commercial wave or tidal farms operational. In July 2008 a Pelamis Wave Energy convertor was deployed off the coast of Aguçadoura in northern Portugal. In September a further two devices were deployed and the development was billed as the 'world's first wave farm'. Although twenty-eight devices were planned to be installed, in November 2008, due to technical issues, the three devices were removed from the water. The technical issues are said to be resolved but there is no timescale for returning the devices to the water, this is said to be the result of the global economic downturn (Blum, 2009). Given the lack of commercial scale developments and the relatively novel nature of wave and tidal stream energy it is unsurprising that awareness of the technologies amongst the general public is lower than some other renewable energy technologies. For example in DECC's recent national survey work (DECC, 2009a) 58% and 57% of the public 'had heard of' tidal energy and wave energy respectively.

A tidal barrage on the Severn Estuary has been discussed for some decades. A recent announcement by the Government has ruled-out public financing for such a scheme after a feasibility study; however, there is still scope for purely privately funded projects and there are other potential barrage sites in the UK (DECC, 2010a). As part of an extensive

programme of public and stakeholder engagement on the Severn proposals, the Sustainable Development Commission (Sustainable Development Commission, 2007) conducted a series of deliberative workshops, focus groups and a national omnibus opinion poll. In the national opinion poll respondents were given some 'top level information' on a barrage proposal and the advantages and disadvantages of such a scheme. After this information 58% of respondents across the UK said that they were in favour of a barrage and 15% said they were against. Across the different methods the majority of respondents were in favour of a barrage and there was a preference for the largest of the proposed barrages. This was due to the significance of the electricity that could be produced and a feeling that a smaller barrage would be replaced by a larger one in the long run which was seen as a waste of resources. However, the most significant disadvantages of the scheme were seen to be impact on important bird and fish species, high cost, landscape and visual impact, economic impact on some ports of restricted ship movement in the area and the noise and disruption caused by construction over several years. Stakeholders convened in regional workshops felt that the impacts could be more negative than the public and had greater 'conditions of acceptability' (Sustainable Development Commission, 2007). The irreversibility of impacts on nationally and internationally recognised sites was identified as a key concern as was the legacy of a barrage that local people would have to live with.

In the ESRC 'Beyond NIMBYism' project, a number of renewable energy cases (including wave and tidal cases) were investigated using a mix of qualitative and quantitative methods (Devine-Wright, In Press, Cass, 2008). One of the case studies examined was the Marine Current Turbines' 'SeaGen' tidal stream device in Strangford Lough, Northern Ireland (Devine-Wright, In Press). The study did to some extent support the common view that marine renewables are likely to meet with less public opposition as they are 'relatively unobtrusive'. In addition, the development was felt by some respondents to enhance the local distinctiveness of the area, effectively 'putting the area on the map worldwide'. However, the study did not find universal or unconditional support for the development with issues relating to negative impacts for local communities and the perceived fairness of the consultation and planning process.

McLachlan (2009) investigated the Wave Hub development off the coast of Cornwall. Whilst there was much support for the development there were also concerns raised and controversy in relation to: the effect on height and quality of waves and the related impact on tourism, implications for navigational safety, local fishers who would be prohibited from entering previously used sites and the economic impact on the local area. Stakeholders (including the public) interpreted the Wave Hub as having different symbolic meaning including: benign, industrial, for local people, for private profit, pioneering and experimental. These symbolic meanings were shown to interact with alternative interpretations of the 'place' in which the development is to be deployed (economically vulnerable, publicly owned, as a resource to be used, as nature in need of protection) giving rise to competing assessments of 'fit'. West et al (2009) also investigated this case study. Their findings reflected similiar areas of concern but did find general local public support for wave energy as economically beneficial and 'relatively benign'. Across the three case studies discussed here, the novel nature of wave and tidal technologies has led to the potential for a sense of civic pride and positive symbolic meaning, with the developments being seen by some respondents to put places 'on the map' (Devine-Wright, In Press, McLachlan, 2009, Sustainable Development Commission, 2007) . Whilst marine energy projects are likely to encounter many of the same issues as other renewable projects related to the processes and institutions involved with the development (e.g. issues of trust, motives, distribution of benefits, contested desirability and level of environmental benefits), their novel nature also

means that their likely impacts may be less well understood. Issues relating to the appropriate level of precaution and the applicability of model data to real sea conditions seem likely to be a source of potential conflict for the foreseeable future. The uncertain nature of operating in a complex system such as the sea and the lack of empirical 'real world' data perhaps means that there is much scope for different claims about potential impacts to be made at this stage by a range of actors (McLachlan, Forthcoming).

As various types of wave energy devices, barrages, lagoons and tidal stream devices can be used to harness marine power, each with potentially different environmental and economic benefits and disadvantages, a more in-depth investigation of public attitudes to the alternatives and their place in the UK's long term sustainable energy strategy is merited as these options develop. It should not be assumed that levels of public support for all types of marine energy will be uniform. Although wave and tidal energy are often grouped under the term 'marine energy', their impacts and performance may prove to be quite different and public opinion may become more differentiated as more devices are deployed. The performance and impact of the first handful of wave and tidal stream energy developments have the potential to substantially shape public attitudes to the sector. This is something that the industry is very much aware of, particularly with regard to the impact of tidal turbines on marine mammals (McLachlan, 2010a). From the few cases that have been studied to date, it seems unlikely that wave and tidal energy will provide an 'out of sight, out of mind option' in terms of public engagement.

4.2.4 Geothermal Energy

There is only one currently operating geothermal power plant in the UK and it is situated in Southampton. However, the UK Government has set up the Deep Geothermal Challenge Fund which provides up to £6 million to explore the potential for deep geothermal power in the UK (DECC, 2009b).

Perhaps reflecting the fact that geothermal energy is only an emerging technology in the UK, the public perception literature is very scarce. UK specific findings are limited to asking about awareness of the technology. In 2006, a Eurobarometer survey found 36% had heard of geothermal energy, which is lower than the EU average of 44%. It also shows lower levels of awareness compared to other emerging technologies such as ocean energy (wave and tidal) or carbon capture and storage (Eurobarometer, 2006). The annual renewable energy awareness and attitudes survey, carried out by the Department of Energy and Climate Change (DECC, previously BERR), has tracked awareness of geothermal power since 2006. Geothermal energy awareness has more or less stayed constant for the last 4 years, only increasing from 49% in 2006 to 51% in 2009. This is lower than all other renewable technologies on the survey (DECC, 2009a). A number of case studies involving attitudes to specific geothermal projects have been carried out in other countries (e.g. Hawaii, see Walker, 1995); however public experience with these types of project in the UK is almost non-existent. Considering the literature available from wind energy or biomass case studies, local land use conflicts may arise if geothermal energy projects are to go ahead in the UK. Hence further research is needed into public acceptability of this technology and its use.

Using heat from the surface rather than heat from deep in the earth's crust, ground source heat pumps are used more widely in the UK. They are mainly used as a microgeneration technology, however, and key public perception literature will be reviewed in the following sections.

4.2.5 Microgeneration

4.2.5.1 Context

Household heat and electricity use was responsible for 23% of total UK greenhouse gas emissions in 2007 (HM Government 2010). Of this total, 45% came from the supply of electricity for appliances and heating, while the remaining 55% of emissions mainly resulted from the burning of fossil fuels in homes to provide heat (ibid). The environmental purpose of microgeneration, to which we here add district heating, is to reduce that overall 23%. It should be noted that domestic energy efficiency and demand reduction are as or more important and are considered in section 5.

Section 82 of the 2004 UK Energy Act defines microgeneration as the generation of electricity or the production of heat by an installation that satisfies two criteria: (a) relying wholly or mainly on one or more of biomass and biofuels, fuel cells, photovoltaics and solar power, water, wind, geothermal sources, combined heat and power systems or other lower carbon technology that the Secretary of State so defines (e.g. passive flue gas recovery devices); and (b) the capacity of which to generate electricity does not exceed 50 kw for power, and 45 kw thermal for heat (300kwh thermal in England, under the Green Energy (Definition and Promotion) Act 2009 (HM Government 2004; HM Government 2009).

Using necessarily coarse estimation methods, Element Energy estimate that, as of the end of 2007, there were the following numbers of microgen units installed in the UK: solar PV - 2,993; micro-CHP – 200-1,000; wind – 2,323; micro-hydro – 73; solar thermal – 97,500 – 102,000; biomass boilers and pellet stoves – 1,400; ground source heat pumps – 3,415; air source heat pumps – 169 (Element Energy 2008). As there were 25.7 million UK households in 2009 (Hansard 9 Mar 2009), even though the number of residential dwellings will be lower than the number of households, the low level of uptake of microgen and the huge potential for its growth in use in the domestic sector alone are both evident.

There is also considerable potential for community-level micro-generation (groups of below 500 homes, as the economics of all distributed energy technologies improve with increasing scale (Element Energy 2008). The costs savings vary in source, per technology: for biomass, savings relate to bulk delivery and purchase of fuel to a community boiler relative to delivery to individual boilers; for solar PV, solar thermal and heat pumps, the savings relate principally to bulk purchase discounts; the benefit is greatest for wind turbines, for which order of magnitude changes occur between micro, roof mounted turbines and larger tower-mounted machines (ibid). Element Energy estimate that at 2008 fuel and technology prices, with no additional policies, community distributed energy generation could economically meet 4.3% of total UK energy demands (or 0.5% if renewable technologies only are considered), if householders were to act collectively. This represents 13% of total annual UK household energy demands, 6% of annual UK household CO_2 emissions, or 1.8% of total (2006) UK CO_2 emissions. These savings derive largely from geographically-specific communities: dense urban communities (500 home scale) using gas fired CHP and remote windy rural communities installing community scale wind turbines (100–500kWe), at wind speeds over 6.5m/s at 25m hub height (Element Energy 2008). Realising this will require financial support such as a national loan scheme, plus initiatives such as Energy Service Companies to co-ordinate diverse stakeholders (ibid).

In the UK, feed-in-tariffs for small-scale electricity generators came into effect on 1st April 2010 and the UK Department of Energy and Climate Change (DECC) is examining options for a renewable heat incentive. At the time of writing, DECC is consulting on a Microgeneration

Strategy for England, as obliged under the Green Energy (Definition and Promotion) Act 2009. Microgeneration is a devolved matter and the Devolved Administrations will develop their own plans for microgeneration (DECC, 2010c). The consultation is using a Working Group model rather than a document on which views are solicited. Working Group 4 is most directly relevant to public attitudes, awareness and engagement and is considering issues related to aiding both consumers and local agencies who may be involved in procuring or supporting microgeneration through planning processes (DECC, 2010c).

4.2.5.2 Scope

Few UK studies have investigated public attitudes and decision-making on micro-gen and the literature on public perceptions of microgen, and particularly on engagement with research of the same, is very much smaller than that on attitudes renewables in general. As an indicative measure, the search term 'renewable + energy + attitudes' returns 41,100 article links in Google Scholar, whereas the search term 'microgeneration + attitudes' returns 587 article links: a ratio of 70 to 1. Here we address perceptions generally rather than attitudes alone, and also refer to non-UK literature where relevant, given that there are few academic studies on microgen and related perceptions per se.

Non-UK studies not considered below, but which may be of interest, include (Banfi et al. 2008) on willingness to pay for energy-saving measures in Switzerland's residential buildings; (Nyrud et al. 2008) re users' experiences and attitudes to residential biomass heating in Oslo. A study of several years ago compares UK and French experience of sustainable housing and the limited incentives for this, including for solar PV (Pickvance and Chautard 2006). There are also academic UK WTP studies relating to environmental/green tariff electricity, e.g. (Batley et al. 2000) and below we also consider more recent work for the Energy Savings Trust (on WTP and from other perspectives). We make some reference to community-level generation, i.e. above the domestic level in scale, both below and in the governance section above.

4.2.5.3 Individual awareness of microgen

We are not aware of systematic, repeat-year measures of microgen awareness in the UK, but it is clear that awareness is a pre-requisite to use. From consumer awareness and innovation diffusion perspectives, Claudy et al (2010) make the point that awareness of microgen must precede its use: whereas most academic studies and policy reports aim to identify reasons why people buy (or fail to buy) these technologies, it is also important to consider the general level of consumer awareness (Claudy et al. 2010). Although Irish, we include a summary of this study here for its relevance to UK attitudes. Claudy et al (ibid) argue that ignoring awareness may lead to non-response bias in willingness to pay (WTP) studies of microgen, in that those who have not heard of the technologies may be less inclined to take part in WTP surveys (though this problem may be reduced via stratified sampling or post-hoc weighting relative to census data, to achieve statistical demographic representation).

Claudy et al (ibid) present results from a nationally representative study conducted in the Republic of Ireland, showing that awareness varies significantly between the individual technologies and potential consumer segments. The survey was conducted by a market research company as part of representative telephone omnibus survey of the Irish adult population (n = 1010), with sample leads generated via Random Digital Dialling. As a small, qualitative pilot-study revealed that many people were not familiar with the term microgeneration, this was referred to as 'renewable energy technologies people can install in their homes for heating and electricity production.' Taken as a whole, almost 80% of the

Irish population has heard of or seen Photovoltaic Panels, but only 18% are aware of Micro CHP. The other technologies fall between these two extremes, with a 75% level of awareness for Solar Thermal Heaters, 66% for Wood Pellet boilers, 58% for Micro Wind Turbines and 45% for Heat Pumps (Claudy et al. 2010).

When demographic factors were investigated, women were significantly ($p < 0.01$) less likely to have heard of the technologies; in terms of age, awareness followed an inverted U pattern, with young and older people less likely to be aware of microgeneration; there was a small positive relationship between awareness and social class ($p < 0.05$); and people in rural areas were significantly more likely to be aware of the technologies than those in urban areas ($p < 0.01$), a finding the authors think may perhaps be due to differing housing stock, including a higher level of renting in urban areas, and hence lower incentive to invest in energy-related measures (Claudy et al. 2010). These relationships largely held across the individual technologies, except in the case of PV, for which there were no significant differences, perhaps because these had the highest level of awareness (differences may be obscured or no longer present). Interestingly, internet access was a statistically significant predictor of awareness across all technologies except Micro CHP, perhaps due to this functioning as an indicator of technological awareness, while the other main predictor of awareness was region, as mentioned above (ibid).

4.2.5.4 Attitudes to microgen – by study

As the number of UK microgen attitude studies is fairly scant and limited to a few authors, we arrange these in terms of a summary of selected studies, drawing cross-study commonalities towards the end of this section. Beginning with two London studies (London Renewables 2003) and (Ellison 2004), in general, these find that attitudes to micro-solar are positive. However, there are concerns about the costs of installation as well as the lack of reliability due to a lack of sun (London Renewables, 2003). Similar reliability concerns have been expressed for other micro-renewables such as micro-wind (Ellison, 2004). Where a majority (57%) of a London-based sample indicated that they would consider installing solar cells on their roofs irrespective of costs, only 18% would do so if the initial costs of installing such solar cells would be substantial (ie £8000 with a payback period of 15-20 years). Focus group research with London residents produced similar findings: although initially very receptive to micro-solar, attitudes turned negative when presented with the envisaged costs (London Renewables, 2003). It is therefore not surprising that grants are mentioned most often as something that might motivate the public to install solar water heating, solar cells, or micro-wind turbines (Ellison, 2004). Research by Ellison (2004) suggests that many (in this case London) residents may have the wrong impressions of the costs of specific micro-generation technologies, overestimating the costs of solar water heating systems but underestimating the costs of photovoltaic systems. Additional barriers to micro-generation include concerns about the aesthetics, lack of knowledge, and practical difficulties with installation (Ellison, 2004). Where concerns about micro-wind turbines are mainly linked to lack of space and aesthetics, such concerns are virtually absent for micro-solar (London Renewables, 2003).

A notable source of more recent UK studies is the Open University Research Depository (http://oro.open.ac.uk/), from which work by Rob Roy and Sally Caird of the OU Design Group can be sourced. Focussing on the design aspects of low emission products, including domestic energy and microgen technologies, Roy et al argue that one factor in the slow take-up of such products by mainstream consumers is that often they have been designed without taking sufficient account of user requirements: the technologies often seem tend to have been viewed by designers and policy-makers as purely functional, technical devices,

without sufficient regard for their aesthetic and ergonomic design (Roy et al. 2007). Hence Roy et al point to the way in which motivations and adopter demographics differ across products. For example, a German study of fuel-cell micro CHP adoption found that early adopters were mainly older, technically educated males with their own homes, from middle class populations; similarly, most German adopters of solar water heating and domestic photovoltaic (PV) systems were well-educated professionals interested in technology (Fischer 2004, in Roy et al. 2007).

In terms of UK consumers, Caird et al. (2008) surveyed consumer reasons for adoption, and non-adoption, of energy efficiency measures and renewable energy systems, as well as their experiences of using these technologies. Data were gathered during 2006 via an online questionnaire associated with a BBC programme on climate change, obtaining nearly 400 responses, plus 111 in-depth telephone interviews from other sources (Energy Efficiency Advice Centre and National Energy Foundation enquirers). The respondents were mainly environmentally concerned, 'green' consumers. The paper outlines results for four energy efficiency measures (loft insulation, condensing boilers, heating controls and energy-efficient lighting) and four household renewables (solar thermal water heating, solar photovoltaics, micro-wind turbines and wood-burning stoves). Green consumers typically adopted these technologies to save energy, money and/or the environment, which many considered they achieved despite rebound effects. (The latter is an important issue – it is not just failure to adopt low carbon technologies that forgoes emissions savings potential, but also the tendency for people to 'trade-up' when purchasing 'eco-efficient' products and also to use these in ways not anticipated by their designers (Roy et al. 2007)). Reasons given by consumers for considering but rejecting these technologies include price barriers, but also other obstacles that vary by technology. Most adopters of renewables had previously installed several energy efficiency measures, but only a fifth of those who seriously considered renewables actually installed a system. Caird et al (2008) conclude that, given the relative attractiveness of energy efficiency over microgen for consumers, priority should be given to the former. While there was considerable interest in household renewables in the UK survey, especially among older, middle-class green consumers, as of 2006, only relatively few pioneers had managed to overcome the barriers to adoption.

In terms of more detail, Caird et al (2008) found that motivational reasons stated by the large majority of adopters of individual renewable energy technologies were: the desire to reduce fuel bills, 'save energy and the environment' (80% of online adopters of solar thermal cited these reasons). Three quarters of interviewed solar thermal adopters were also influenced to adopt by friends, colleagues or neighbours who already owned a solar thermal system. For solar PV, environmental concern and, for micro-wind, saving energy were the main stated drivers for adoption. Despite the existence of UK government grants, having funds available to invest was an important adoption factor for solar thermal and solar PV. For wood-burning stoves, saving energy, money and the environment were important, but the warmth and aesthetics of such stoves dominate as reasons for purchase (Caird et al. 2008).

Conversely, Caird et al (2008) state that high capital cost and long payback times, was the universal reason for rejecting solar thermal (online and interviewed respondents) as well as solar PV and micro-wind. The online survey identified additional obstacles: when rejected, wood stoves were perceived as having difficulties in terms of controlling their heat output, being dirty, hard work and requiring space for fuel. Other obstacles in about quarter of non-adoptions across renewable included: difficulties in finding a trustworthy installer, planning permission, finding a suitable location and worries about noise and vibration for micro-wind;

plus insufficient power output for PV. More than one fifth of each group of non-adopters were also uncertain about the performance and reliability of domestic solar and wind systems (Caird et al. 2008). Both adopters and non-adopters also mention more specific concerns: 31% of online respondents and 53% of interviewees raised the issue of whether solar-heated water could be used in their dishwasher or washing machines. Often, it could not due to plumbing constraints or because most new appliances are cold-fill only. For some this was a disappointment, while others were aware of this in advance. Adapter valves available in Germany and elsewhere to allow use of solar-heated water in cold-fill appliances were not supplied by UK installers. Several users had insufficient tank storage capacity for sunny days when their system could be delivering more solar-heated water. There were also concerns about maintaining often inaccessible components of solar thermal systems in lofts or on roofs (ibid).

Work as yet unpublished (Upham, in prep.) investigated the attitudes of those who are pro-environmental and hence who may be particularly likely to install micro-gen options. This study (using an internet questionnaire linked in an email from a climate change pledge scheme) found that, of 201 (highly educated) respondents subscribed to the scheme, the percentage who had installed micro-gen technologies was modest, with the exception of solar thermal. 27% of the 201 respondents had seriously considered installing solar PV and 36% solar thermal; of these, 18% went on to install PV and 42% solar thermal. More generally, though, with the exception of solar thermal, fewer than 20% of those who had seriously considered a micro-gen option went on to install it (i.e. conversion rates were low): 17% had seriously considered micro-wind and, of those, 9% had installed it; for biomass boiler, values were 9% and 15% respectively; for ground source heat pump, 7% and 3% respectively; for air source heat pump, 5% and 12% respectively. Respondents were asked for their reasons for not installing micro-gen options: by far the most frequent reason (cited by 36%) was the upfront cost being too high. The other main reasons were the payback time being too long (17%) and insufficient information (15%). Of those citing concern about visual appearance and noise as reasons for not installing, micro-wind was the main technology involved for about half of respondents. Micro-wind was also the technology involved for about a third of those not convinced of a technology's environmental value, a third of those concerned about its effect on house resale and a third of those concerned about general inconvenience. However, both solar technologies were also singled out by about half of those expressing concern about general inconvenience.

4.2.5.5 Willingness to pay for microgen

As Sauter and Watson (2007) observe, whereas large-scale infrastructure technologies such as windfarms require only a rather 'passive' acceptance by the local community (or perhaps better: an absence of active opposition), micro-generation technologies such as solar energy need 'active' acceptance in terms of the willingness to pay (WTP) for and install these technologies in their homes, such that householders become electricity users and producers at the same time. This means that policies to promote the installation of micro-generation technologies require somewhat different approaches to those used to promote the social acceptance of large-scale energy infrastructure projects: particularly considering that micro-renewables usually need a substantial up-front capital investment from households themselves (Sauter and Watson 2007). While finance, cost and consumer WTP is a major theme that runs through the whole microgen topic, here we focus on WTP in some detail.

An in-depth WTP study for the Energy Savings Trust and DEFRA (Quadrangle 2009) used a conjoint research design in the sense of asking people to consider alternative energy efficiency packages in relation to one another, and where attributes could be varied, so that

trade-offs and the relationships of cost, pay-back time etc to consumer 'uptake' could be identified. The main microgen options were included, except for air source heat pump. The study used two focus groups with London home-owners; 15 in-home, in-depth interviews with homeowners in and near London; and a nationally representative online survey of 2956 homeowners (representativeness was in terms of demographics, region, house type and wall type [cavity/non-cavity]). Participants were first taken through a process of increasing their knowledge and understanding of the possible energy saving measures, incentives and payback periods and then asked to consider the packages. In terms of findings (microgen only), the type of technology can be more important than financial saving: solar water heating and triple 'A'-rated windows were both more appealing than wall insulation (external or internal). Interest-free loans or payments were preferable to borrowing from banks, which were untrusted; repayment through energy bill was not popular due to the associated long pay-back period: in general, pay-back time (duration) is more influential than the monthly payback sum. People were indifferent to the source of a hypothetical tax rebate: it was the level that was of key importance (a stamp duty discount was not popular) (Quadrangle 2009).

Focussing on micro-gen only, percentages having never considered particular options are: wood fuelled boilers (88%), 'biomass' (97%), micro-wind (93%), ground source heat pumps (92%), solar thermal (66%) and solar PV (66%). Conversion rates (calculated by dividing the number of people that have installed a technology by the number of people who have both considered it and installed it) were: wood fuelled boilers (20%), 'biomass' (8%), micro-wind (5%), ground source heat pumps (2%), solar water heating (2%) and solar PV (1%). The top two measures considered but not installed were solar water heating and solar electricity (Quadrangle 2009). While these conversion rates are lower than those reported above for pro-environmental respondents (Upham and Carney in prep.), they are not substantially lower, which perhaps suggests that even strongly held environmental values are unable to compensate for or overcome the disincentives to installing microgen in the UK. For solar water heating, for example, the main barriers were cited as: purchase cost (69%); 'not sure it will save me money / too slow to pay back / energy saving too small' (34%); lack of knowledge about how it works (20%); 'the hassle or problems it could cause in my home' (Quadrangle 2009). The order of these key barriers is also reflected in the views of pro-environmental respondents (Upham and Carney, in prep.).

In terms of motivators, Quadrangle (2009) found that the while the majority of the most important motivators relate to cost or money, the third most relevant motivator was 'increasing the comfort of my home', which may echo Linguistic Landscapes' (2009) findings discussed below, in which the potential of non-technical and non-financial discourses are highlighted as a means of engaging home-owners. Quadrangle (2009), as AIA below (AIA Research 2010), also emphasise the opportunities that arise when people are making changes to their homes for non-energy related reasons. Hence 20% of all homeowners said that they installed an energy measure when renovating or extending their home, while 32% said this would motivate them to do so. 49% of home owners have previously made a change to their home (from renovation/ redecorating a room, to extending their home) and 62% are planning to make one or more of the changes (Quadrangle 2009). The following were statistically significantly associated with consideration and/or uptake of energy-related measures: extending or planning to extend the home; renovating or planning to renovate the outside of the home; renovating or planning to renovate rooms; planning to renovate the kitchen; planning to replace the boiler soon (ibid). Extending the home seems to have the biggest effect in both considering and installing not only one of the four energy saving

measures explored in the study, but also solar water heating (though the percentages involved are still very small: 1.6% vs. the 0.5% of the total population) (ibid).

In terms of advice and purchase channels, most people mentioned that they would search the internet, particularly Google, with the key word 'energy saving'. They would also trust their builder, architect or window fitter to give them correct information and product; also price comparison sites, consumer sites, the Sunday papers, council newsletter, government and independent organisations. Respondents had very little knowledge of support programmes (ibid). Quadrangle summarise the take-home message of their research as the adage – the need to offer the right price, via the right message, at the right time and in the right place. The right price seems to be <£4,000 and council tax rebates have resonance; the right time is when people renovate or extend, meaning that suppliers of products and services also need targeting; the right place includes the internet, particularly search engines (which are more a vehicle than a place), consumer websites and price comparison websites; the right message needs to appeal to heart and head, with appeals to home comfort as well as the opportunity for financial savings (Quadrangle 2009). It should also be noted that there are those who would not take up an energy saving measure even when the incentive is higher than the price: those not interested in energy saving and climate change (14.4% vs. avg. 6.5%); those 65+ who have owned their houses for >10 years; those who plan to stay in their home for a short period of time; those who are less educated and of a lower social grade (C2DE, especially E) (ibid).

4.2.5.6 Renewable heat attitudes

Paralleling the recent DECC consultation on renewable heat (DECC 2009d) and 'Warm Homes, Greener Homes: A Strategy for Household Energy Management' (HM Government 2010), AIA Research for the Energy Savings Trust describe marketing issues relating to the UK government's low carbon buildings programme (LCBP), which provides consumers with information and grants of up to £2,500 towards the cost of renewable energy sources (AIA Research 2010). Through 2010, the programme has aimed to attract some 18,000 applicants for renewable heat grants for Ground Source heat pumps, Air source heat pumps, and Wood-fuelled boilers and burners (ibid). The research method involved four mini discussion groups, each with four participants who were homeowners or undertaking own new build and looking to replace or purchase a heating system, water tank and / or boiler in the next year. All were living in a rural, non mains gas area. The first point to note in terms of marketing is that three categories of information need are identifiable: (a) existing homeowners looking to provide additional heat to specific rooms, whom AIA (ibid) judge primarily need information on the options; (b) existing homeowners interested in alternative sources of energy, either to add to or replace current systems, but who under no immediate pressure to make a decision: this group need information but also a reason to act on it; (c) those undertaking a new build, who have a more immediate need for heating systems, information, advice and financial support and who are more open to considering a greater range of technologies (AIA Research 2010).

In terms of perceptions, AIA found that positive motivations for adoption of renewable heat technologies included perceptions of low running costs, self-sufficiency, ready access to raw materials and positive environmental performance. Barriers to uptake included the following, which are more significant for those considering installation in existing properties: lack of awareness or understanding of the options (particularly heat pumps); (very) high installation costs and long payback times; installation upheaval and cost in the case of retro-fitting existing properties; uncertainty as to efficiency, effectiveness, consistency and environmental performance; apathy or uncertainty as to next steps and finding credible

installers and suppliers; concerns about ease and costs of maintenance; the inability of renewable technology to satisfy all heat requirements; fear of the unknown and not wanting to be a guinea pig for (take the early-mover risks of) the newer technologies (AIA Research 2010). Perhaps surprisingly, detailed knowledge about EST / LCBP grants for renewable technologies was minimal and very few had considered seeking out financial support (ibid). That said, in the AIA study (ibid), once people did know about the size of the available grants, they were disappointed.

In terms of specific heat technologies, all were familiar with wood burning stoves; the key installation reason was to provide additional heat in specific rooms; considered safer, cleaner, more efficient and controllable than open fires, as well as cosy and aesthetically pleasing. However, no participants were seriously considering a wood boiler, for which a key barrier was the perception of substantial space requirements. There was some concern that wood may become scarce and some doubts about its carbon neutrality. Most at least had heard about ground source heat pumps but detailed understanding and knowledge were limited. There was a widespread belief that this is more suited to new build due to the disruption of installation and questions were raised as to whether or not they really were environmentally friendly. Perceptions of the amount of land required and the cost of installation were also negative. Air source heat pumps were the least well known renewable heat technology, with little understanding or knowledge. There were many negative perceptions regarding its size and outward appearance, though of those with some knowledge, positives about the technology included its value use for cooling in summer and the belief that it is an economical, effective and environmentally friendly option that is easy to retro-fit. Solar panels (the source does not distinguish between PV and solar thermal) were perceived relatively easy and cheap to install but there was uncertainty about the need for planning permission and solar incidence requirements. People were uncertain whether wind turbines would work domestically and whether they would be noisy (AIA Research 2010). Many of these perceptions tally with findings as yet unpublished on the perceptions of city-level energy options by Manchester residents (Upham and Carney in prep.). They also seem to be consistent with other work for EST, including that on household microgen pioneers (Roy and Caird 2008; Roy et al. 2008).

Work by the Energy Saving Trust on a major UK field trial of electrically-driven air and ground source heat pumps (EST 2010a), also involving Roy and Caird, has assessed how heat pumps perform in real-world conditions for one year at 83 sites, monitoring both technical performance and customer behaviour. Householders reported 'good' levels of satisfaction with both space heating and hot water provision and there was no significant difference between users' satisfaction with ground and air source systems. Nonetheless, performance is sensitive to customer behaviour, among other factors, and many householders said that they had difficulties understanding the instructions for operating and using their heat pump. The trials show that a well-installed heat pump can lead to carbon savings and reduce heating bills for customers off the gas grid (EST 2010a).

4.2.5.7 District heating

This section draws on (Upham et al. 2010a), which is the only work we know of in relation to UK public perceptions of district heating. District heating distributes heat to consumers in industrial, commercial and domestic sectors through closed-circuit pipe networks that transfer heat to end-users via heat exchangers. Although the technology is mature and is deployed effectively in other Northern European countries (DECC 2009d), it is little used in the UK (Macadam et al. 2008). Several recent UK Government policy documents acknowledge the potential role of district heating: the 'Heat and Energy Saving Strategy'

(HM Government, 2009b), the 2009 'Heat and Energy Saving Strategy Consultation' (DECC, 2009d); and 'Warm Homes, Greener Homes: A Strategy for Household Energy Management' (HM Government, 2010). As dwellings account for some 70% of the UK's heat demand, compared to 1.7% for the sum of all other non-domestic and non-process heat demand (Koehler 2009), it is the domestic sector that merits closest attention for district heating, with non-domestic demand more likely playing the role of 'heat anchors', in the sense of providing base load (i.e. relatively constant) heat demand (ibid).

While there is a large literature on human perceptions of thermal comfort, including those of older individuals (e.g. Day and Hitchings, 2009), little of this work relates directly to perceptions of installing and using district heating, particularly for the UK. One of the few UK studies on the significance of consumer opinion for publicly-installed heat infrastructure serves as a salutary indicator that this deficit needs remedying. This relates to the partial failure to install free central heating in Lambeth, London (Armstrong et al. 2006). Armstrong et al (ibid) found that even though a new heating system was viewed as a significant improvement by the local council and there were to be no installation costs for the consumer, the majority of those approached to take part in the scheme declined. Given the relative unfamiliarity of district heating in the UK, any project endeavouring to make use of waste process heat for domestic and commercial space and water heating will likely be more difficult, if not impossible, without public/consumer support.

Investigating UK public perceptions of district heating, Upham et al (2010a) describe the results of two focus groups with a potential domestic client group, namely elderly people, and the postal questionnaire responses of 312 individuals living in the proximity of a large potential heat source, namely the Corus steel-works in Port Talbot, Wales. Both pieces of work provided detail on the nature of district heating, including on the one hand the likelihood of a reduction in heating bills and the other hand some installation disruption and the possibility of contract lock-in. While those questioned were broadly supportive of the idea of district heating, particularly if this would involve reductions in domestic heating costs, both the qualitative and quantitative work revealed concern about any long-term contractual lock-in. This is in some ways contradictory to the requirement of stable, long-term demand, involving some degree of consumer lock-in, for a commercially viable district heating system. Upham et al (2010a) conclude that a price inducement will be required to overcome consumer concerns in this context.

4.2.5.8 Wider considerations

Decentralised energy systems have important social, psychological, technical, and economic benefits (Devine-Wright 2007a; also see below). For some, generating their own electricity and self-sufficiency "is like growing your own vegetables" and a source of pride. Indeed, this echoes the suggestion by a discourse/semiotic study for the Energy Savings Trust that it may help uptake of greener domestic technologies/practices if 'eco' can be reframed from a rational argument to a positive emotional discourse (Linguistic Landscapes 2009). Hub Research Consultants report that people who chose to install micro-generation (active households) or living in a house where it has been installed (passive households) feel a great sense of pride, independence, and gain pleasure from talking openly to others about the technology (Hub Research Consultants 2005). The installation of micro-renewables may also be a catalyst for householders to engage emotionally with the issue of energy use. The qualitative research conducted by Hub Research Consultants (ibid) suggests that either choosing to install micro-generation or living in a house where it has been installed encourages people to become more aware of their own energy use and to save energy in other ways. That is, by becoming responsible for generating their own energy, householders

develop a sense of responsibility for consuming it. The passive households in the study were perhaps the most striking examples of the potential impact of micro-generation. Whereas active householders tended to be committed environmentalists whose decision to install micro-generation was based on making a stand, passive households generally had far lower levels of energy awareness before installation. Living with the technology however seemed to encourage far greater understanding and awareness around energy issues and often had a considerable impact on energy-related behaviours (Hub Research Consultants 2005).

Turning to governance issues, Pickvance makes two points that are relevant here: first, he warns against the indirect coercion of social housing tenants into accepting 'sustainable housing' or 'eco-homes', which may (but need not) include microgen (Pickvance 2009). This possibility follows from social housing in the UK now being required to meet higher levels of sustainability than new private housing, while at the same time social tenants have few housing choices. The 2006 Code for Sustainable Building (DCLG 2006) requires that all new social housing financed by the Housing Corporation after April 2006 should reach the EcoHomes "Very Good" standard, whereas new private sector housing (which constitutes over 80% of all new housing) is not – yet - subject to this requirement (ibid). Pickvance compared two social housing developments in Kent in which the housing association concerned took advantage of government subsidies to incorporate sustainability features, one high tech in Ashford using imported Swedish factory-built panels incorporating doors and windows and with integral plumbing and electrics, and one lower tech timber-frame design in Tunbridge Wells. Both were to have PV installed but councillors rejected this in the first case due to proximity to an adjacent historic windmill (ibid).

Second, aside from technical complications and high electricity costs in the Ashford case that are unrelated to microgen (a cautionary tale, nonetheless), the Ashford case illustrates the financial and regulatory disincentives to installing domestic PV as of 2006. Not only was the electrical export rate of the electricity purchaser at the time of the study about one third of the cost of their own electricity and the generation income small (£20-40 per year), but receiving this would have required the installation of a meter in each flat by the Moat Housing Group responsible for the development and setting up of individual contracts (ibid). It should be emphasised that while the wider research above suggests that the upfront capital cost of microgen is still likely to be perceived as prohibitive by most domestic consumers, particularly when above the £4,000 threshold identified by Quadrangle for EST (Quadrangle 2009), the Feed in Tariff legislation enacted in April 2010 (statutory instrument 678) (OPSI 2010), enabled by the 2008 Energy Act, does now provide a larger financial incentive to those who can afford the initial investment.

4.2.6 Energy from waste

While Energy from Waste (EfW) is most frequently associated with incineration, there are other EfW technologies and we refer to these briefly below. It would be fair to say that the recovery of energy from waste has been held back by public fears over alleged health effects associated with incineration, and fears that the development of suitable infrastructure would lock in wastes which could otherwise be minimised or recycled (DEFRA, 2007a). DEFRA comments that public and stakeholder concern over health effects is most frequently cited in connection with incinerators, though it is worth noting that the public tends to view combustion-related bioenergy as similar to incineration (Barker and Riddington, 2003) and raise concerns about the gaseous emissions from such plants (Upham and Shackley, 2007).
In DEFRA's view, research shows no credible evidence of adverse health outcomes for those living near incinerators (DEFRA 2007: 78). DEFRA states that the relevant health effects – primarily cancers – have long incubation times, but the available research demonstrates an

absence of symptoms relating to exposures twenty or more years ago, when emissions from incineration were much greater than they are now. DEFRA refers to a short position statement on the health impacts for municipal waste incineration, issued by The Health Protection Agency, which reaches similar conclusions. DEFRA (2007, p.78) argues that evidence from neighbouring countries, where very high rates of recycling and energy from waste are able to coexist, demonstrates that a vigorous energy from waste policy is compatible with high recycling rates. In the UK Government's view, the key to ensuring that both are achieved is, firstly, excellent quality consultation between stakeholders, at an early stage when local waste strategies are being developed; and, secondly, planning and building facilities with an appropriate amount of flexibility built in. This means flexible, for example, modular – buildings, and also flexible contracts, so that local authorities are not locked in to treating fixed quantities of waste.

Nonetheless, public concern about incineration, EfW and energy from biomass residues has been experienced in several European countries (AEAT, 2001). Common concerns were identified as:

- Atmospheric Emissions: dioxins, acid gases, heavy metals
- Disposal of fly ash from incineration or residues from energy from biomass residue plant
- Noise, odour, traffic movements
- For EfW: lack of flexibility of contracts for municipal solid waste and their impact on new reduction or recycling initiatives and importation of waste from outside the region
- Insufficient justification of the plant (the principle, size or scale)
- Costs and security of finance
- The visual impact of the scheme on the locality
- The impact of the scheme on the character of an area
- The impact of the scheme on local house prices (ibid, p.66).

At the time of writing, DEFRA has just closed a consultation on its Review of Waste Policy, with early results to be available in Spring 2011. In terms of waste management policy, one of the main issues is how incineration should best fit alongside other waste treatment options that use some of the same feedstocks and which can also contribute to energy supply: notably anaerobic digestion (AD), pyrolysis and gasification. While we do not review attitudes to these here, experience suggests that while most, if not all, waste treatment options are likely to experience negative attitudes if populations experience amenity loss or perceive health or safety threats, the environmental benefits of these alternatives, relative to incineration, may help to render them more acceptable.

4.2.7 Large-scale hydropower

Large-scale hydropower plants are the most economically cost-efficient renewable energy source. Currently, they account for around 2% of UK electricity generating capacity, but due to lack of commercially and environmentally suitable sites there is little scope for expanding its role (BIS, 2009). Little UK research has examined public attitudes to large-scale hydropower. (Note that micro hydro schemes are discussed in section 4.2.5.) Work conducted in the US and Europe (e.g., Malesios & Arabatzis 2010; Gast, 1973; Sjöberg et al., 1978; Vorkinn and Riese, 2001) finds the public to be more positive or neutral about hydropower than negative, and most believe the benefits (e.g., jobs, energy security) outweigh the potential risks (e.g., habitat loss, dam failure). However, a study of public response to a Norwegian proposal for a major hydropower development (Vorkinn and Riese,

2001) found place attachment moderated support: the more attached residents felt towards the affected area, the more negative beliefs were expressed about the proposal.

Most (78%) participants in the 2008 BERR energy attitudes survey had heard of hydroelectric power; this figure was highest in the Highlands and Islands region (where most hydro-electric plants are located) at 98%. Awareness has fluctuated somewhat over recent years, having reached a peak of 82% across the UK in 2006 (BERR, 2008). However, knowledge about the technology is lower, with only 41% (rising to 47% in Scotland) claiming to know a little or a lot about it (TNS, 2003). Furthermore, 45% do not know how far they live from a hydropower station (Spence et al., 2010). There is little desire to know more about the technology, though, with only 6% expressing this (TNS, 2003).

Nevertheless, approval of hydroelectric power appears to be widespread, with 83% saying it is a very or fairly good idea, and only 2% saying it is a fairly bad idea. Approval differs very little across UK regions (TNS, 2003). Spence et al's (2010) survey similarly find that 76% of the UK public express favourable attitudes towards hydroelectric power, and only 4% are unfavourable. These proportions are unchanged since a similar survey in 2005 (Poortinga et al., 2006). In 2005, a majority (71%) said hydroelectric power can help prevent climate change and felt hydroelectric would make a substantial contribution to reliable and secure supplies of electricity in the future (69%; Poortinga et al., 2006).

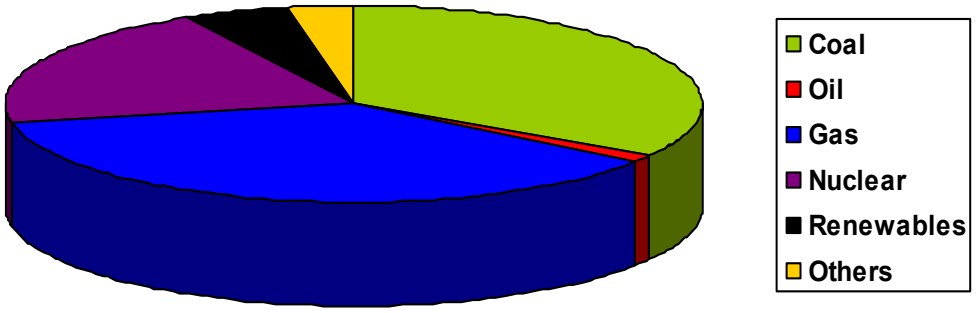
Eurobarometer (2003) research shows the public see hydroelectric as offering benefits in terms of price and environmental protection (though 'new' renewables, e.g., solar, are seen as cheaper and better for the environment). Consistent with the preference for solar and wind energy over hydropower, one British survey in 2004 noted that the public did not consider hydro to be a priority area for government energy investment: when asked 'If the UK Department of Trade and Industry has £5 billion to spend, which do you think should be the top priority?' only 6% selected hydropower as their first or second choice (most selecting 'New energy sources: solar, wind, or bioenergy/biomass'; Curry et al., 2005).

When asked about a potential hydro development 'in your area', a notable 27% say they would be resistant to it and only 47% would approve it (TNS, 2003). Earlier qualitative research suggested that, despite broad support for the technology, some expressed concerns about the visual or noise impact of such developments, and felt if such schemes required flooding of valleys the negative social impacts would be unacceptable (Barker and Riddington 2003). As noted previously, this suggests *contingent* support for renewable energy developments.

4.3 Conventional Fossil Fuels

Fossil fuels, such as coal, oil, and natural gas, are the main source of electricity in the UK (see Figure 4.1). In 2005, 37% of all electricity was generated from natural gas, 34% from coal, and about 1% from oil. The rest was generated from nuclear power (20%), renewables (5%), and a variety other energy sources (3%; DTI, 2006). In order to achieve the 80% reduction in greenhouse gas emissions by 2050, the target the UK Government has set itself in the legally binding Climate Change Act (Defra, 2008), the UK needs to substantially reduce its reliance on fossil fuels for the generation of electricity. Over the next two decades, many existing coal, oil and nuclear power stations will reach the end of their operational lives, and will need to be replaced by low carbon technologies, including renewables and carbon capture and storage, in order to reduce the amount of greenhouse gas emissions in the electricity generation sector.

The literature on public perceptions of traditional fossil fuels is very limited in the UK. Public attitudes to fossil fuels are often not studied in isolation, but generally considered within a wider set of energy sources, embedded in research that focuses on public attitudes to climate change, and/or juxtaposed to attitudes to renewables, in particular in relation to sustainable forms of low-carbon fossil fuel technologies, such as carbon capture and storage. As such, the evidence on public attitudes and understandings of fossil fuels are hidden



throughout the whole energy and climate change literature. It is however possible to draw some conclusions about how the British public perceives the various forms of conventional fossil fuels to generate electricity.

Figure 4.1: The UK Electricity Generation Mix 2005 (Source: DTI 2006)

The evidence shows that many people at least have a basic understanding of the contribution of the burning of fossil fuels to climate change. Pidgeon et al (2008a) reported that many can correctly identify one or two of the main human causes of climate change. For example, 29% of the sample mentioned burning of fossil fuels as a cause. In addition, 31% mentioned transport (including cars and planes), 19% industry and industrial emissions, 15% carbon dioxide, and 15% deforestation. In a postal questionnaire study, Whitmarsh (2009) found that many make a connection between climate change/global warming and fossil fuel consumption, carbon emissions, or (unspecified) greenhouse gas emissions. In a different study by Whitmarsh et al. (2010a), participants evidently recognized the main causes of climate change, including emissions from deforestation, industry, transport and (more generally) fossil fuel use. Furthermore, a clear majority indicated that fossil fuel use contributes "a lot" to climate change. Curry et al. (2005) showed that 81% of the respondents were able to identify coal burning power plants as a source of carbon dioxide.

Poortinga et al. (2006) showed that coal and oil are among the worst rated energy sources for the production of electricity, with a majority having negative general opinions or impressions. Eurobarometer (2007) research found that only very few of the UK public (around one out of five) are in favour of using any of the three main fossil energy sources, a level of support that is comparable to that of nuclear energy. However, levels of opposition to coal, oil and in particular gas are lower than to nuclear. The low levels of support for fossil fuels is confirmed by research showing that very few people think that coal, gas or oil fired electricity power stations should be built in Britain in the next 10 years (reported in McGowan and Sauter, 2005). A relatively recent study by Accenture (2008) shows that an overwhelming majority of nearly nine out of ten think that it is important or very important

for the UK to reduce its reliance on fossil-fuelled power generation (i.e. coal, oil or gas generated power)

Coal is particularly negatively evaluated as it is regarded to cause air pollution and climate change, create dangerous waste, spoil the landscape (even more so than wind energy and nuclear power stations), and an inefficient source of electricity, while only one out of ten think that coal is a clean source of energy (Poortinga et al., 2006). Similar disadvantages of generating electricity from burning coal or oil were reported in a review by McGowan and Sauter (2005) in that they pollute the air, contribute to climate change/global warming, use fuels which will eventually run out, are ugly to look at/spoils the landscape, and harm birds and other wildlife or their landscape. Perceived benefits of generating electricity by burning coal is that it is reliable, safe, and cheap (Poortinga et al., 2006). Natural gas is slightly better evaluated than coal and oil. Although generating electricity from burning gas is still thought to pollute the air, contribute to climate change/global warming, and to use fuels which will eventually run out, it is to a lower degree than for burning coal or oil (McGowan and Sauter, 2005; Poortinga et al., 2006). This generally reflects the findings of an earlier study conducted in Scotland: Hinds et al. (2002) found that seven in ten of those surveyed said that coal and oil power generation 'uses up natural resources that will run out' and 37% said it produces greenhouse gases. Results for natural gas were similar to those for coal and oil, though fewer respondents said that generating electricity by gas power stations uses up natural resources (51%). A sizeable minority consider the risk of a major explosion as a significant disadvantage of generating electricity from burning gas (McGowan and Sauter, 2005).

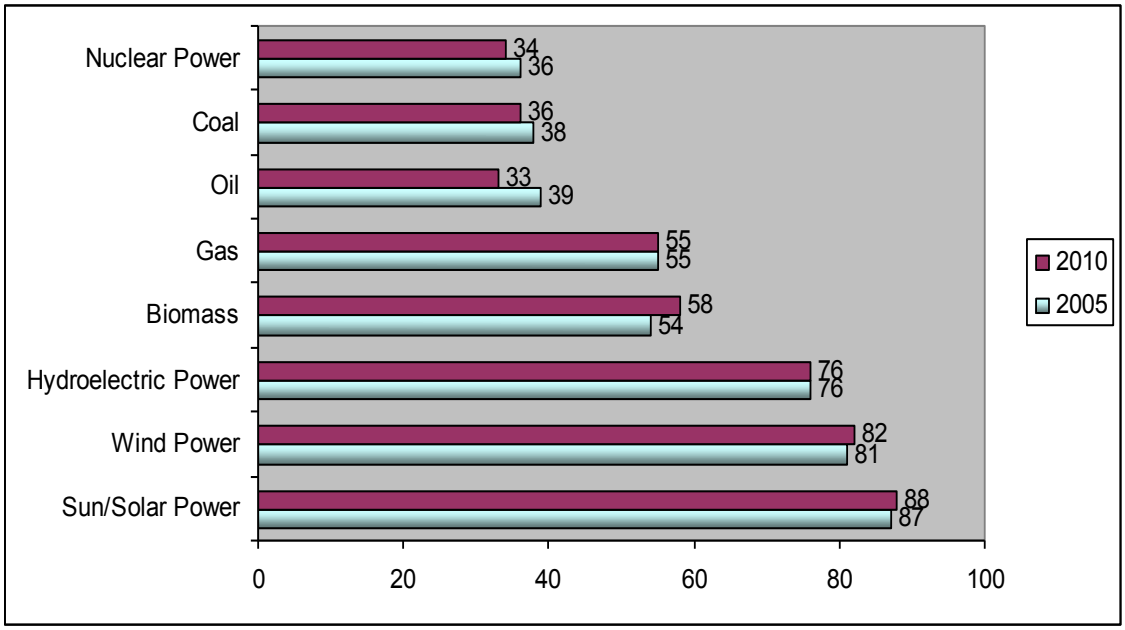


Figure 4.2: Ratings of favourability towards eight difference sources of electricity generation (see Spence et al., 2010). Results from the same question asked in 2005 (see Poortinga et al., 2006) are included for comparison. Bars represent the percentage of respondents who stated that they were mainly favourable or very favourable towards each energy source.

A more recent study by Spence et al. (2010) showed that fossil fuels together with nuclear power remain the least popular sources of electricity generation, but also that natural gas is the only fossil energy source that is evaluated slightly more positively. In the five years since

2005 public attitudes to the different energy sources has not changed dramatically, although figure 4.2 shows that the favourability ratings of oil have gone down even further. While in 2005 about two in five reported to have fairly or very favourable views of oil as a source of electricity generation, in 2010 only about one in three were favourable.

In our review of the literature, we found only one qualitative study on public understandings of fossil fuels. West et al (2010) used Cultural Theory as a heuristic device to explore different discourses about renewable energy developments, drawing on data from six focus groups undertaken in the south west of the UK in 2007. Although the study was designed to explore public attitudes to renewable energy, parts of the discussion related to taxation as a way to reduce people's fossil energy use. West et al. (2010) reported that many focus group participants used hierarchist discourse to suggest that households should be taxed for fossil-fuel use. However, individualist discourse objected to taxation on principle and disputed the environmental case for decreasing reliance on fossil fuels. Similarly, egalitarians saw taxation as penalising low- income households and those suffering fuel poverty and could not avoid higher taxes by installing renewable energy systems.

Also little evidence is available regarding public attitudes to new fossil fuel development. This could be considered surprising, as the majority of the UK's existing nuclear power stations reach the end of their operational lives over the next two decades, as do many older coal-fired stations. This leaves Britain with a potential future shortfall on the electricity supply side. Public attitude research in this area is essentially important in order to gauge what energy futures are acceptable to the British public. Some work has been conducted to examine under which conditions the use of fossil fuels is considered acceptable or unacceptable. This research, which mainly focused on the acceptability of low-carbon fossil fuel technologies such as goal gasification and carbon capture and storage (CCS), is discussed in section 4.4. A limited number of studies have included items to assess public attitudes to the building of new energy facilities in Britain or nearby. As reported above, very few people think that coal, gas or oil fired electricity power stations should be built in Britain in the next 10 years (reported in McGowan and Sauter, 2005). Spence et al. (2010) asked respondents how they would vote in a referendum on whether to build new nuclear power stations, new wind farms, and new coal-fired power stations in Britain. The least popular options were coal-fired power stations, closely followed by nuclear power stations. Fifty percent of the sample indicated they would probably or definitely vote against, while 36% would probably or definitely vote in favour. The opposition to coal-fired power stations was at a similar level as to new nuclear power stations. When respondents were asked to what extent they would support the possibility of new energy generating facilities being built within 5 miles of their own home, approximately 60% of the public either tend to oppose or strongly oppose the building of both nuclear and coal-fired power stations. However, strength of opposition is greater towards new nuclear power stations being built close to people's homes (39% strongly oppose it) than to coal-fired power stations (29%).

4.4 Carbon Capture and Storage

Carbon Capture and Storage (CCS) is increasingly recognised as an important, if somewhat contentious, technological option for reducing carbon dioxide emissions. The principle of CCS is to remove the carbon dioxide from fossil fuel combustion or gasification emissions and to transport the CO_2 to a suitable storage site, such as off-shore geological reservoirs including depleted oil and gas fields and saline aquifers. The 'attraction' of CSS is that it has the potential to permit the continued use of fossil fuels while minimising its contribution to climate change (Gough et al., 2001). De Coninck et al (2009) concluded that there are no major scientific, technical or legal barriers to CCS, but that appropriate economic incentives

and suitable regulatory measures are necessary. Furthermore, experiences with previous social conflicts surrounding innovative energy technologies have shown that public perceptions can be highly significant for its implementation. Conducting research on the social acceptability of CCS is, however, challenging as the technology is in an early stage of development, generally unknown to the general public, and technical and remote in nature (Shackley et al., 2005).

In this section we repeat and extend the review of CCS engagement and attitudes reviewed for LWEC in Upham et al (2009). Material is to some extent reviewed chronologically. We make some reference to international literature, as this is relevant, but limit these references. Overall, in part because CCS is a technology that is relatively unfamiliar to the public, perceptions of CCS seem to be heavily influenced by the information and framing provided by researchers. This information may or may not set CCS in the context of other energy and emissions reduction options; it may provide light or heavy detail on CCS and its climate change rationale; and interaction with the information, may or may not be highly controlled by the researchers. While there is much commonality between the findings of various studies, the foregoing factors likely account for much of the variation. Indeed several studies (mostly non-UK) explicitly point to the way in which perceptions of CCS are influenced by the provision of information (e.g. Ashworth et al., 2008; Itaoka et al. 2004, 2006; Shackley et al 2005; Sharp et al., 2006; Tokushige et al., 2007; Van Knippenberg and Daamen, 1996; in addition, Dutch work has shown NGOs to be more trusted more than industry organisations on CCS messaging, has examined the role of congruency between organisational mission and information message (Terwel et al. 2009b) and that people are more negatively influenced by sources perceived as of low integrity and more positively influenced by sources perceived as of high competence than vice versa (Terwel et al. 2009a). Other Dutch studies suggest that it is mostly the quality of opinion that changes in response to neutral information, rather than the opinion itself: accurate, balanced, and understandable information leads to more stable opinions, meaning that those opinions are less subject to change in light of new information and are hence better predictors of future opinions (e.g. de Best-Waldhober et al., 2008; 2009). Arguably, this question of which investigative method produces 'the most accurate' results is something of a moot point, in that different methods suit different purposes, but if the purpose is to develop well-informed opinion, then of course this will require a substantial effort in terms of communication and engagement.

In an early exploration of UK public opinion of CCS using a closely moderated focus group methodology, Gough et al (2001) found that CCS may be an acceptable bridging policy while other renewable sources of energy or energy efficiency are being developed. Concerns were raised regarding the viability and safety of carbon storage in the long term, in particular about the possibility of carbon dioxide escaping and about the ability of institutions to regulate and monitor storage sites. Overall, however, there was public agreement that the potential benefits outweigh the risks.

Shackley and colleagues (2005) further explored what the public thinks of off-shore CCS using Citizens' Panel and survey methodologies. They found that levels of awareness of the technology were very low, with very few respondents being familiar with CCS. On first hearing about CCS in the absence of any information, the majority of people either didn't have an opinion or were somewhat negative. In this case, when limited information was provided on the role of CCS in reducing CO_2 emissions to the atmosphere, opinion became more positive. Nonetheless, leakage of carbon dioxide from reservoirs remained as a concern, as was carbon dioxide as a potentially explosive substance. Although the lay public

still appears to have little knowledge of CCS, they also express little desire to learn more about this technology (Shackley et al., 2009). Both Gough et al (2001) and Shackley et al (2005) found that support depends upon CCS being considered as just one part of a wider strategy for achieving significant cuts in CO_2 emissions. A portfolio including renewable energy technologies, energy efficiency, and lifestyle change to reduce demand was generally favoured to CCS as the sole technical fix to climate change.

Curry et al (2005) and Reiner et al (2006) confirmed that awareness of CCS has been very low in the UK, with only two to five percent having heard of "carbon sequestration" or "carbon capture and storage" and many being "unsure" about the environmental problem CCS addresses. Probably influenced by the low levels of awareness of the technology, fewer than 30% of the respondents indicated that they would probably or definitely support CCS for addressing climate change, whereas about 50% were not sure. In line with the findings of Shackley et al (2005) Curry et al (2005) found that support for using fossil fuels with CCS increased dramatically when respondents were provided with some limited cost and current production information.

Paralleling the rise of CCS up the European policy agenda, there have number of EC funded projects on public perceptions (and also US studies). The European studies have generally included work in the UK and there is also little reason to expect UK opinion to differ markedly from that of most European nations (we observe below that this holds true even where electrical generation of particular European countries is skewed to one technology, as in France (nuclear) and Poland (coal).

Recent (and at the time of writing, on-going and unpublished) work under the NearCO_2 European project is examining the factors involved in contemporary European public opinion of CCS, including planned demonstration projects and pilot projects already in operation. Lessons from a range of low carbon siting controversies, in terms of public participation procedures and approaches to communication and dialogue have been reviewed (Desbarats et al. 2010) and the commonalities of CCS attitudes and engagement issues with other forms of energy siting controversy are emphasised. This work has also applied a conventional communications theory to CCS attitudes and engagement, drawing implications for communication in the generic terms of source, message, channel and receiver (Brunsting et al. submitted). Despite being a simple and mechanistic communications model, this work emphasises the wide variety of influences on communication and how much remains beyond communicators' control (ibid).

An unpublished study (Gough et al. in process) explores how newspaper reporting of CCS impacts on UK public perceptions of the technology. The study examines the role of newspapers in the development of knowledge and understanding amongst the lay public, within the context of a broader communication system. Through a series of guided reading interviews with regular readers of national newspapers in the UK, it explores the way in which readers select, interpret and respond to such articles. Although readers perceive print media as a useful information source, reading about CCS in the print news media was found to only partially improve readers' understanding of CCS, often raising further questions for readers, in relation to CCS. Readers were conscious of bias in newspaper reporting and of the political stance of individual papers and assimilated content in a selective manner. This work identifies factors that influence communication on CCS and suggests that newspapers serve a more subtle function than simply immediate transfer of information, namely the gradual shaping of opinion over time.

The NearCO_2 project has also undertaken one focus group on public perceptions of CCS in each of six European countries, including the UK, and the results are summarised as (Upham and Roberts in prep.; further papers and report to follow). This research design allowed opinion to develop in response to a specially-commissioned DVD that provided an overview of CCS, its rationale and arguments for and against CCS. Exposure was phased and a pre- and post-questionnaire was applied. The results concurred with much of the preceding work on CCS perceptions, namely a strong preference for renewable energy and a high level concern about the safety implications of CO_2 leakage. There were few strong differences between groups, with the exception of a higher level of concern about climate change in Spain, related to experience of drought. In all groups, concerns about safety quickly amplified and information on the difficulty in rapidly installing very high levels of renewable energy supply infrastructure had little influence on opinion. The researchers concluded that, in so far as the focus groups simulated the consequences of exposure to information on CCS without expert-moderation, they illustrate the importance of involving trusted parties in CCS communication processes, with the objective of moderating and responding to concerns as they arise (Upham and Roberts, forthcoming). Further NearCO_2 work, at the design stage at the time of writing, will include the UK public in an experimental study of the influence of graphics, text and diagram scale in CCS communications and perceptions; and also in a large scale survey of public opinion near capture, transport and storage corridors and sites.

The assessment of public perceptions of CCS formed a distinct work-package within the CASSEM (CO_2 Aquifer Storage Site Evaluation and Monitoring) project (Mander and Roberts 2010). The research sought to assess lay publics' reaction to CCS and how perceptions change as they learnt more about the technology and the wider issues around energy and climate change. The research was focused around a series of citizen panels in two UK locations at which CCS may be developed in the future: Pontefract in Yorkshire and Dunfermline in the Firth of Forth. The citizen panels provided selected local residents with the opportunity to meet with experts in the CCS field and learn about both the technology and the climate change context within which it is being considered. The research revealed that trust in the experts providing information was central to the formation of the participant's perspectives on CCS. However, the lay participants remained distrustful of government and business to implement CCS safely and were also concerned about the potential cost of CCS. Nonetheless, overall opinion of CCS became more positive through the course of the citizens' panels.

There are also practitioner-oriented publications that apply the insights from research studies to the practice of CCS communications and engagement: e.g. in the USA (NETL 2009; WRI 2010) and in the UK (Hammond and Shackley 2010). Referring to the experience of 7 Regional Carbon Sequestration Partnerships in the USA, Hammond and Shackley (ibid) emphasise that process matters: although providing technical information on health and safety is important for public trust, other factors are just as important, or even more so. In particular, the public need to be able to trust that the developer, regulators and government (at various levels), will:

- deliver truthful information and a safe project;
- operate a transparent and fair decision-making process;
- be accountable should things go wrong; and,
- treat local publics fairly in the distribution of economic benefits and any hazards (Hammond and Shackley 2010).

These social process and trust issues are increasingly understood to be a critical in perceptions and large-scale European survey work underway as part of the FP7 NEARCO_2

project will further add to our understanding of their role in public perceptions of CCS, by focussing on respondents in the vicinity of CCS capture, transport and storage sites (http://www.communicationnearco2.eu/home/).

4.5 Nuclear Energy

4.4.1 Nuclear Fission

Nuclear technology, using nuclear fission to generate electricity, has been part of Britain's energy landscape since the opening of Calder Hall in Cumbria in 1956. This was followed by the commissioning of a series of Magnox and Advanced gas-cooled reactor type nuclear power stations in the 1960s and 1970s. The last reaction that was commissioned and built is Sizewell B. This is the UK's only commercial pressurised water reactor power station and was commissioned and built between 1987 and 1995 (for an overview, see Pidgeon et al., 2008).

Public attitudes to nuclear power can only be understood within the historical context of the technology. The literature points to growing public concerns in many Western nations about the safety of nuclear power stations from the late 1970s onwards, following a number of high profile incidents and accidents , such as the 1957 Windscale fire in England, the 1979 Three Mile Island accident in the USA, and the 1986 Chernobyl accident in the then Soviet Union. These accidents together with environmental concerns about the disposal of associated nuclear waste have turned public opinion firmly against nuclear power. Early research conducted in the late 1980s, found high levels of opposition to nuclear power, in particular after the Chernobyl accident. Van der Pligt (1992) reports that in the UK over 80% were opposed to nuclear energy immediately after Chernobyl compared with 68% in the year previous to the accident; although post-Chernobyl attitudes were strongly predicted by individuals' attitudes to nuclear power prior to the accident, suggesting attitudinal polarisation as a result of alternative interpretations of the accident (Eiser et al., 1989). That is, people who endorsed nuclear power before the accident did not change their attitudes substantially. They considered the accident as an isolated event or as part of the overall acceptable risks of nuclear power. However, people who already held negative views about nuclear energy shifted towards greater opposition

Against a backdrop of highly negative historical connotations attached to both nuclear power as a result of a number of accidents and the unresolved issue of the disposal of radioactive waste, it is perhaps not surprising that public support for nuclear power is generally low. Nationally representative studies have shown that only about a third of the British public hold favourable views about nuclear power (Poortinga et al., 2006; Spence et al., 2010). The relatively low levels of support for nuclear energy appear to be driven by concerns about the disposal of radioactive waste, risks of accidents and radioactive contamination, and nuclear energy installations being potential terrorist targets (McGowan and Sauter, 2005; Poortinga et al., 2006; Knight, 2007; 2009a;b), but also because 'better solutions' are available (Accenture, 2008; also see below). Furthermore, a substantial portion of the British public believes that nuclear power stations spoil the landscape (McGowan and Sauter, 2005; Poortinga et al., 2006). Perceived benefits of nuclear power include it being a reliable and cheap supply of electricity, being good for the economy, not producing carbon dioxide during generation, and it reducing oil dependency (Poortinga et al., 2006; Knight, 2007; 2009b; Eurobarometer, 2008). As such, more than two out of five believe that nuclear power is a clean source of energy (Poortinga et al., 2006). There appears to be a three-way split between people believing nuclear power to be cheap, expensive, or neither cheap nor expensive (cf. McGowan and Sauter, 2005; Poortinga et al., 2006; Knight, 2007). Although nuclear energy is a low-carbon source of electricity relative to fossil fuel, a

sizeable minority of the British population believe that nuclear power contributes to climate change (Eurobarometer, 2002; McGowan and Sauter, 2005; Poortinga et al., 2006). This was confirmed by Curry et al. (2005), who found that more people believe that nuclear power plants lead to a net increase in carbon dioxide than a decrease.

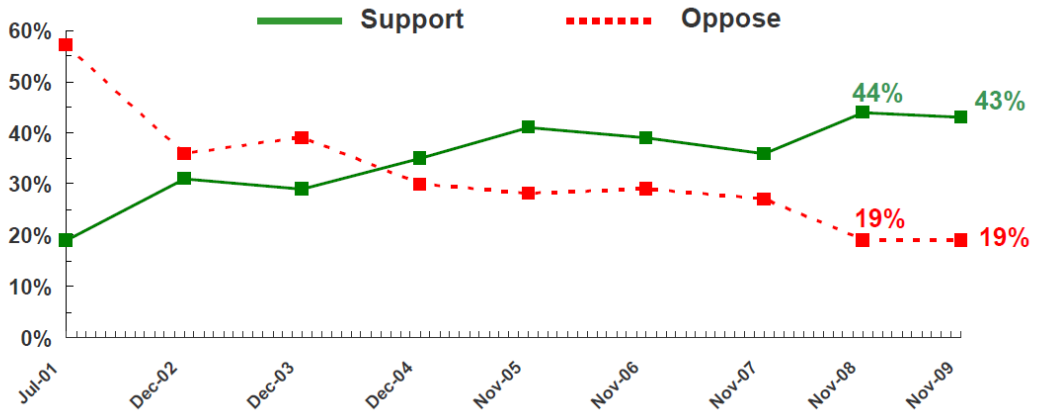


Figure 4.3: To what extent would you support or oppose the building of new nuclear power stations in Britain TO REPLACE those that are being phased out over the next few years? This would ensure that the same proportion of nuclear energy is retained. The wording in 2001 was "To what extent would you support or oppose the building of new nuclear power stations in Britain?" (Source: Ipsos-MORI; Knight 2009b).

Nuclear power is the only energy source for which public attitudes have been systematically 'tracked' over a relatively long period of time. Research by Ipsos-MORI for the Nuclear Industry Association (NIA; Knight, 2007; 2009a; 2009b) has shown that support for new-build has increased since the early 2000s and may have gathered momentum during 2008 in the wake of the UK Government energy review and its commitment to nuclear energy. Whilst in 2002 about two out of five opposed the building of new nuclear power stations in Britain to replace those that are being phased out over the next few years, in 2007 fewer than one in three did so (see figure 4.3).[3] In 2008 less than one out of five indicated to oppose new-build. In the most recent poll (Knight, 2009b) the levels of support and opposition to nuclear new built remained at the same level as in 2008. The growing support for nuclear energy in recent years was confirmed by Eurobarometer research (2008), which showed that overall support increased from 44% in winter 2005 to 50% in winter 2008. More recent research (Spence et al., 2010) suggest that, whilst preferences seem to have shifted slightly towards an expanded nuclear programme for the future, the aggregate proportion wanting to replace nuclear (at current levels or with expansion) has changed little since 2005. Unlike Knight (2009b), who found higher levels of support than opposition to nuclear new built, Spence et al. (2010) found that a similar proportion appeared to support the continuation and the discontinuation of nuclear power for generating electricity in Great Britain. When respondents were asked how they would vote in a referendum on whether to build new nuclear power stations, 46% would probably or definitely vote against, whilst 41% would probably or definitely vote in favour (Spence et al., 2010). Accenture (2008) also found that just over half of the respondents thought that the UK should increase its nuclear capacity, while just under half thought the UK should not. Opposition to nuclear new built increased

[3] The 2001 results show far higher levels of opposition to nuclear new build. However, the question was phrased slightly different in 2001, i.e., "To what extent would you support or oppose the building of new nuclear power stations in Britain?"

substantially when respondents were asked to what extent they would support or oppose the possibility of a new development within 5 miles of their own home. In this context, approximately 60% of the public oppose the building of a new nuclear power station, of which nearly 40% strongly oppose such a development in their area (ibid). With regard to more specific attitudes, the same study found that a clear majority in 2010 agreed that there are risks to people in Britain from nuclear power, although this figure had fallen since the same question was asked in 2005. Interestingly, more than half of people now agree that there are benefits to people in the UK from nuclear power, a modest rise from just under half in 2005. Consistent with these data, the proportion of the sample who agree that the benefits of nuclear power either slightly or far outweigh the risks has risen slightly from 2005 to 2010. Furthermore, people who reported being 'very concerned' about nuclear power dropped significantly between 2005 and 2010.

Overall, public perceptions of nuclear power appear to have to less opposition in recent years, most likely due to the reframing of nuclear power as a possible solution to climate change and as a reliable and secure supply of energy. The prominence of climate change and energy security has put nuclear energy firmly back on the national and international agenda. Concerns about climate change and energy security in the face of peak oil and energy imports from instable regions have become manifest in new strands of political debate that reframe nuclear power as a low carbon solution to climate change (Bickerstaff et al., 2008; Pidgeon et al., 2008ba). Bickerstaff et al (2008) were among the first to observe that from the early 2000s onwards, industry actors, some engineers and scientists, and senior politicians were increasingly referring to nuclear power in general – and nuclear 'new build' in particular – as a method of responding to climate change, using the low-carbon credentials of nuclear power to advocate government investment in the sector (at the point of production, nuclear power is essentially zero carbon). Indeed, nearly one in five of the British public see no carbon dioxide being produced during generation/ helps to combat climate change, its general lower impact on the environment/being cleaner, and ensuring reliable supply of electricity/energy as clear benefits of nuclear energy as a source of electricity (see e.g., Knight, 2009b). But while about half of the British public believe that nuclear energy will make a major contribution to a reliable and secure supply of electricity in Britain in the future, support for future contribution of nuclear to the energy mix is still lower than for renewable energy sources such as sun/solar, wind power, and hydro-electricity (Poortinga et al., 2006; Spence et al., 2010; see Figure 4.2). A Eurobarometer conducted in 2006 shows that when the public were asked what the best alternative is for reducing our dependency on imported energy sources, only 18% of the UK public mentioned "developing the use of nuclear power". Although this is among the highest in Europe, it is substantially lower than support for the development of solar (43%) and wind power (39%), and the "promotion of advanced research for new energy technologies such as hydrogen, clean coal, etc" (36%). A more recent poll by Accenture (2008) showed that where only about one third thought that an increase of nuclear power should be considered to reduce our reliance on fossil fuelled power generation, nearly nine out of ten thought that an increase of renewable power should be considered. Although the balance somewhat shifted towards nuclear when participants were asked to choose between the two options.

Despite an increasing frequency with which arguments about climate change, energy security, and nuclear power are being fused together, only very few studies have sought to focus on all of these topics simultaneously (e.g. Poortinga et al., 2006; Pidgeon et al., 2008a; Spence et al., 2010). Poortinga et al. (2006) designed a range of questions about different choices about future energy options in the context of climate change and energy security. Very broadly they present statements designed to elicit endorsement of new nuclear power

in the light of climate change, that endorse alternatives to nuclear power for tackling climate change, and statements which elicit endorsement of a mixed energy future for Britain. Pidgeon et al. (2008a) showed that, in line with the expectations, acceptance of nuclear energy increases when it is seen as contributing to climate change mitigation. Around two out of five thought that it is better to accept nuclear power than to live with the consequences of climate change. Also more than half showed a willingness to accept the building of new nuclear power stations if it would help to tackle climate change.

However, research conducted by the same team of researchers suggests that many people express only a 'reluctant' or at best ambivalent acceptance of nuclear power (Poortinga et al., 2006; Bickerstaff et al., 2008; Pidgeon et al., 2008a; Corner et al., under review). Bickerstaff et al. (2008) conducted a series of reconvened focus groups in 2002 where participants both discussed climate change and nuclear waste risks, including a deliberation about a possible risk-risk trade-off between nuclear power and climate change. Although some of the respondents became more ambivalent and less antagonistic towards nuclear power, very few were willing to make a direct risk-risk trade-off. That is, most were not willing to actively support nuclear power as a climate change mitigation policy. However, after some debate, a greater number of respondents arrived at the conclusion that we may have little choice to accept nuclear power as part of a low carbon energy mix. Bickerstaff et al. (2008) termed the public views of nuclear energy being the 'lesser of two evils' as 'reluctant acceptance'. Importantly, the 'reluctant acceptance' discourse was accompanied by a profound questioning of the narrow risk- risk trade off between nuclear power and climate change, and a view that other policy alternatives should be explored as part of the UK's long term sustainable energy strategy. In the focus groups and workshops that were conducted as part of the 2002 Energy Review also highly conditional views were expressed by the participants, with acknowledgement that nuclear power won't go away, alongside a reluctance to accept nuclear power except under very stringent conditions. That is, rejecting new buildings until waste storage issues are dealt with more effectively" (DTI, 2002, reported in Grove-White et al., 2006). Research by Pidgeon et al. (2008a) confirmed that, when given the choice, the British public overwhelmingly favour renewable sources of energy generation over both nuclear and fossil fuels. More than three quarters of the sample believed that both promoting renewable energy and reducing energy use through lifestyle changes and energy efficiency are better ways to tackle climate change; and a similar proportion agrees with the statement that "We shouldn't think of nuclear power as a solution for climate change before exploring all other energy options". However, possibly the most important finding of the survey concern the statements referring to a mixed energy future: almost half of the sample believed that we need nuclear power because renewable sources will not be sufficient, and almost two-thirds that reliability of electricity supply would need to be ensured through a mix of energy options, including nuclear power and renewable sources (Pidgeon et al., 2008a). This is in line with Accenture's poll (2008) that only one in four think that renewables alone can fill the gap in order to reduce the UK's reliance upon fossil-fuelled power generation. When the questions were replicated in the 2010 survey, only a small shift towards more support for nuclear power as a reliable low carbon source of energy was found; whilst nearly three out of six agreed that the energy mix "doesn't need to include nuclear power" (Spence et al., 2010). Also in this survey a clear preference remained for renewable sources of energy production over nuclear power (ibid). In a recent, yet unpublished, analysis of the survey data, Corner et al (under review) paint a much more detailed picture of the reluctant acceptance of nuclear power. Using three classes of measures of attitudes towards nuclear power, i.e., the unconditional acceptance of nuclear power, the conditional acceptance of nuclear power as a solution to climate change and energy security, and the reluctant acceptance of nuclear power as a 'necessary

evil', they found that concern about climate change and energy security were negatively related to the unconditional acceptance of nuclear power but unrelated to the measure of conditional acceptance of nuclear power. When nuclear power was given an explicit 'reluctant acceptance' framing, these relationships were reversed and individuals with higher levels of concern about climate change and energy security became more likely to endorse it. These results suggest that only when people are able to express their dislike of nuclear power – that is, their reluctant acceptance – concern about climate change and energy security increase support for nuclear power (Corner et al., under review).

Overall, these results suggest that attitudes have become somewhat more positive towards nuclear power over recent years, although the majority of people are still concerned about the risks. It is important to consider that responses are heavily dependent on the specific wording of the question, with higher levels of support noted when nuclear power is presented in the context of climate change or energy security.

Unlike for wind energy developments, only limited research has taken place in the UK examining the experiences of those living close to nuclear facilities. Research conducted in the late 1980s suggests that local opinion about the possible development of a nuclear power plant or a nuclear waste repository are generally more extreme or 'anti' than opinions about nuclear energy as a whole (Eiser et al., 1995). However, these adversarial attitudes only apply to the siting of new facilities in areas where they are not present yet. In a survey of four small rural communities that were selected as possible locations for a new nuclear power station in southwest England, Van der Pligt et al. (1986) found more favourable attitudes toward nuclear power in the community located near an existing nuclear power station than in the three communities that were located further away (also see Eiser et al., 1995). Not only did respondents' perceptions of the various potential costs and benefits of the building and operation of a nuclear power station differ, but also the importance respondents attached to the various consequences, in particular with regard to the perceptions of economic benefits and health and environmental risks. Similar results were found in a more recent Scottish survey of attitudes to energy issues (Scottish Executive, 2005a). People living within a 10-mile radius of a nuclear power station were more likely to be happy with the idea of living beside a nuclear power station than people living outside the 10-mile zone. However, the effects don't tend to be strong or uniform, with perceived benefits often going hand in hand with concerns about undesired impacts (Eiser et al., 1995). Indeed, a common explanation often relates to the economic benefits it brings to the local community, in particular where a community is otherwise economically marginalised (Pidgeon et al., 2008b). However, qualitative research on local communities living in very close proximity to nuclear facilities show that this can be highly qualified with an ever-present underlying unease (ibid).

A major recent mixed-methodology programme of work conducted between 2003 and 2008 aimed to get a detailed and comprehensive insight of how people live with the risks of nuclear power in communities that host or are in very close proximity to such facilities (Pidgeon et al., 2008b). This research comprised three empirical stages: narrative interviews and a Q-study, which were both conducted at Bradwell in Essex and Oldbury in South Gloucestershire, followed by a survey conducted at Oldbury and Hinkley Point in Somerset. The biographical narrative interviews show that a majority of local residents view the existing stations through a dominant frame of 'ordinariness' and are supportive of nuclear power in general (Parkhill et al. (2010). Over the years the nuclear installations have become a familiar part of everyday life and of the local place. However, despite processes of familiarisation and/or normalisation of the risks as part of their everyday life, this

ordinariness is juxtaposed with moments of extraordinariness in which residents are reminded of the potential risks of living close to a nuclear power station, leading to anxiety which ebb and flow through our interviewees' lives (Parkhill et al., 2010).

The subsequent Q-study was designed to investigate the distinctive points of views within the local communities. This exercise identified four distinct perspectives, which Venables et al. (2010) termed "beneficial and safe", "threat and distrust", "reluctant acceptance", and "there is no point of worrying", suggesting that the 'landscape of beliefs' about nuclear power in such communities is both subtle and complex, avoiding simplistic bipolar dichotomies such as 'for' or 'against'.

While Q method is extremely capable for identifying distinctive qualitative configurations of belief, it is unable to give any indication of the distribution of such beliefs. Therefore the programme conducted a major survey in 2008 of residents living near the Oldbury and Hinkley Point sites. Taken as a whole, the survey results paint a picture, broadly in line with the narrative interview findings, of a local population which is broadly accepting of nuclear power. Residents living in proximity to nuclear installation generally have somewhat more positive views and less overall concern about nuclear power, and are far more likely to think that the benefits of nuclear power outweighed its risks, when compared to a nationally representative sample obtained in 2005 (see Poortinga et al., 2006). However, majority of local residents still feel that there are risks associated with nuclear power, and many remain concerned about the issue of radioactive waste. The survey findings also suggest that there is considerable variation in opinion, which is masked when looking at the average levels of support. For example, the most popular point of view was one that expressed a conditional acceptance on nuclear energy (i.e., 'reluctant acceptance'), while between 10 and 20 percent of the respondents were found to remain strongly opposed to nuclear power as a national or local development (Pidgeon et al., 2008b).

Various previous studies have suggested that women have less favourable attitudes to nuclear power (see e.g., Davidson and Freudenburg, 1996;). Also in the studies reviewed here many such effects were found. For example, Eurobarometer (2008) research found that men are more likely to be in favour of nuclear energy and to perceive higher benefits of nuclear energy in relation to climate change and energy security. Pidgeon et al (2008b) found that respondents who indicated that the 'beneficial and safe' point of view was most like their own tended to be male, whilst those who indicated that the 'threat and distrust' vignette was closest to their own point of view tended to be women. Research conducted by Ipsos-MORI for the Nuclear Industry Association found that men are generally more in favour of nuclear new build whether for replacement or expansion, with the observed rise in support over the last number of years being mainly driven by increased support among men (Knight, 2009a;b). Also to a number of other attitude statements to nuclear power and the nuclear industry men responded consistently more favourably (ibid). However, a Scottish survey conducted in 2002 (Scottish Executive, 2005a) found that concern regarding the generation of electricity by nuclear power was broadly similar for men and women; and research by Costa-Font et a. (2008) suggests that gender is important for attitudes to nuclear but in the opposite direction. A recent survey conducted by Spence et al. (2010) suggests that women have less favourable views on nuclear energy on the basis of a wide range of attitude items (not reported). Various explanations have been given for the gender differences in environmental risk perception (e.g., Bord and O'Connor, 1997; Finucane et al., 2000; Satterfield et al., 2004; Freudenburg and Davidson, 2007), which we will not discuss in detail as that will be beyond the aims of this review. There is some conflicting evidence with regard to age differences in attitudes to nuclear power. Eurobarometer (2008) research

found no significant age differences when it come to citizens' attitudes to nuclear energy production. However, younger participants were more likely to be in favour of energy production by nuclear power stations "if there was a permanent and safe solution for the management of radioactive waste" (older respondents are more likely to think that there is no safe way of getting rid of high level radioactive waste). Interestingly younger respondents were less likely to perceive benefits of nuclear energy in relation to climate change and energy security than older respondents (ibid). Research in Scotland (Scottish Executive, 2005a) found that concern about nuclear issues increase with age from 16 to 64 years then fall for those aged 65 and above. Costa-Font et al. (2008) found that the age differences in attitudes towards energy produced by nuclear power stations are non-significant. A recent survey conducted by Spence et al. (2010) suggests that older age groups (in particular those aged 65 and over) have more positive attitudes towards nuclear energy on a wide range of items (not reported).

Various studies have shown that attitudes to nuclear power are highly polarised and politicised. The focus groups that were conducted as part of the DTI commissioned public and stakeholder consultation exercise during the UK Government's energy review in 2002 found that members of the public consulted held wide ranging views on nuclear power – from those who completely oppose its use to those who wholly supported it' (DTI 2002, reported in Grove-White et al., 2006). This exercise suggested that opposition to nuclear power is largely based on principle, and that therefore attitudes are unlikely to change. Although many participants in the focus groups were yet undecided, the nuclear waste issue was seen as a key factor, including the widely held perception that there was currently no acceptable solution to its long-term secure management. The importance of personal values is further illustrated by work of Costa-Font et al. (2008) in that people who indicated left political leanings were less likely to support nuclear power than people who indicated right political leaning (also see Eurobarometer, 2008). The same study found that self-reported and 'quiz knowledge' were associated with lower levels of support for nuclear power. It is however questionable whether these knowledge measures are a valid assessment of people's understanding of nuclear power; and such research has often be criticised by science and technology scholars (see e.g. Wynne, 1995; Irwin and Wynne, 1996; Owens and Driffil, 2008). Overall, however, the results of Costa-Font et al. (2008) show that the relationship between knowledge and attitudes is not straightforward, and that in particular attitudes to nuclear power are highly ideological and often a matter of principle, DTI, 2002).

Various studies have indicated the importance of trust in risk communication and management for the shaping of attitudes towards nuclear power (Viklund, 2003; Poortinga and Pidgeon 2003b; Bickerstaff et al., 2007; Costa-Font et al., 2008; Pidgeon et al., 2008b; Poortinga et al., 2006). These studies have almost universally found strong positive associations between trust and support for nuclear energy. Costa-Font et al. (2008) suggest that perceptions of being informed about radioactive waste and trust in sources providing information about radioactive waste management are important predictors of attitudes toward nuclear power generation. The research by Venables et al. (2009) appears to suggest that trust and distrust form an integral part of the four distinct viewpoints on nuclear power within the local communities. That is where the "beneficial and safe" group expressed trust in local operators, the "threat and distrust" group expressed widespread distrust in the government, the Environment Agency, and in particular of the nuclear industry. As trust and distrust were associated with different aspects, they concluded that there is a qualitative asymmetry between judgments of trust and distrust, with trust and distrust are separate constructs, rather than being at the opposite end of any single 'trust' continuum (Poortinga et al., 2008b). This was confirmed in the survey stage of their research by showing that trust

in the local operation of the station appears to be a critical factor in their confidence in the safety of the nuclear power plant, while distrust in Government and the nuclear industry is associated with underlying concern. According to Pidgeon et al. (2008b) trust and distrust are important mediators of perceived risks, benefits and acceptability; and that local discourses of the 'ordinariness' of power stations are all underpinned by a form of social trust (also see Parkhill et al., 2010). They argue that social trust develops through social networks (either being or knowing power station personnel) and in that way decreasing the social distance to the power station, reinforcing the construction of the power station as a familiar and ordinary presence. However, there is still a debate ongoing about the role of trust in the public perceptions of nuclear power and other risk issues. Considering the strong polarization and 'political anchoring' of the nuclear energy issue (cf. Costa-Font et al., 2008), it is likely that trust may be an expression of a more general attitude rather than a determinant of the acceptability of nuclear power (cf. Poortinga and Pidgeon, 2005).

4.4.2 Nuclear Waste

The issue of nuclear waste is inextricably linked to the generation of electricity by nuclear fission technology; and as reported earlier, radioactive waste is one of the main lingering concerns relating to the use of nuclear fission to generate electricity. Until the 1970s radioactive waste did not constitute a major political problem. Nuclear waste was either dumped at sea or stored at existing nuclear sites (CoRWM, 2006). However, public concerns about nuclear energy and its waste products changes from the late 1970s onwards, after a number of incidents (also see section 4.4.1). Drilling programme to assess the geological suitability of sites for high level waste disposal and sea dumping were suspended in the face of intense public opposition (CorWM, 2006). After more than two decades of failed attempts to find a publicly acceptable, the UK set up the independent Committee on Radioactive Waste Management (CoRWM) to review the options for the long-term storage and management of higher activity solid radioactive waste. The committee's brief was to come up with a set of recommendations that would protect the public and the environment, and be capable of inspiring public confidence (Morton et al., 2009). After extensive consultation with the public and other stakeholders, CoRWM recommended the geological disposal of radioactive wastes in deep underground permanent repositories and robust storage in the interim period (CoRWM, 2006; Morton et al., 2009). Although the recommendations were positively received by an independent evaluator (Faulkland Associates, 2006), the public appear to have reservations about any long-term disposal and storage of nuclear waste.

The long-term disposal and storage of nuclear waste is seen by the general public as the greatest disadvantage of nuclear energy as a source of electricity (McGowan and Sauter, 2005; Poortinga et al., 2006; Bickerstaff et al., 2008; Knight, 2007; 2009a;b; Accenture, 2008). Despite there being some softening on the idea that nuclear energy might contribute to a broad policy of reducing CO_2, 'for a majority in the UK negative aspects of nuclear such as waste disposal seem to outweigh this advantage' (McGowan and Sauter, 2005; also see previous section). Even local communities who have been found to be broadly accepting of nuclear power remain highly concerned about the storage and transport of radioactive waste (Pidgeon et al., 2008b).

As part of the stakeholder consultation to inform the 2003 Energy White Paper (DTI 2003), a series of focus groups were run, followed by a number of deliberative community workshops in three places across England, Scotland and Wales (DTI 2002). Although participants in the focus groups held wide-ranging views on nuclear power, there was general consensus that it should continue to play a role in energy generation, and that the safe management of radioactive waste and power generation were of paramount importance. These findings

were mirrored in the deliberative community workshops in that there is a great need for solutions to the nuclear waste problem in order to secure more public support. However, very few of the participants –apart from the occasional "technological optimist"- could see a solution to the nuclear waste problem (Stagl 2006). One of the main conclusions of the consultation exercise was that:

"(…) Waste management was a dominant issue for all shades of opinion on nuclear power, with many people unable to envisage acceptable solutions to the problem of waste disposal. In the focus groups and workshops a highly conditional view began to emerge, with acknowledgement that nuclear power won't go away alongside a reluctance to accept it except under very stringent conditions – for example, rejecting new building until waste storage issues are dealt with more effectively" (DTI, 2002).

In quantitative work conducted by the Future Foundation for Nirex in the early 2000s (Future Foundation, 2002), the general public showed great interest and concern about the issue of radioactive waste and its future management. However, it also suggested that public awareness about the issue was very low. There was widespread support for the wider dissemination of information about radioactive waste and for greater public involvement in the debate about the future management of radioactive waste. An overwhelming majority of 90% felt that the general public should be given more information about the subject. No major shifts in public awareness and attitudes were found between August 2000 when the first survey was conducted and a second survey in November 2001.

Another survey conducted in the early 2000s that covered five key risk cases in the UK (climate change, radiation from mobile phones, radioactive waste, genetically modified food and genetic testing) showed that radioactive waste is consistently the most negatively evaluated by the UK public, and as such was identified as "the most contentious risk case" of the ones that were included in the survey (Poortinga and Pidgeon, 2003a). Radioactive waste was evaluated most negatively on most items. For example, nearly three quarters of the respondents felt that radioactive waste was "a bad thing". It was also seen as having the lowest benefits and the highest risks of all five cases. More than half of the respondents said that the risks slightly or far outweigh the benefits of nuclear waste. Concern about Radioactive Waste was the highest of the five risk cases, and it was also seen as the least acceptable risk case. Nearly two-thirds of the general public expressed some level of concern about nuclear waste, while more than three out of five thought that nuclear waste is unacceptable. In addition, radioactive waste was negatively evaluated on a range of 'psychometric' characteristics, such as unknown consequences, risks to future generations, dread, being informed, control, unfair distribution, and moral concerns (ibid); With regard to public interest in the issue, more than seven out of ten said they were fairly or very interested in radioactive waste, and more than three out of four said it was an important issue to them. The report also pointed to the importance of trust with regard to the communication and management of the risks of nuclear waste. The general public expressed very low levels of trust in the government and nuclear industry, with only around one in three indicating that they trust them a little or a lot. This contrasts with trust levels of 75% in environmental groups, which are generally seen as independent from the nuclear waste industry. Even lower levels of trust were found for the regulation in radioactive waste. Only about one if five felt that current rules and regulations are sufficient to control radioactive waste, and about one in four that the British government adequately regulates radioactive waste. A great majority of about three out of four thought that "organisations separate from government/industry are needed to regulate radioactive waste". This need for a credible, independent 'watchdog' to oversee the nuclear industry and the management of radioactive

waste was also found in the survey conducted by Future Foundation (2002). The 2002 UEA/MORI risk survey further shows that for contentious risk issues, such as radioactive waste, public consultation and the involvement of local communities is crucial. A majority of about three out of four agree that local communities and the general public should be included in making decisions about nuclear waste, as well as local authorities. However, in slight contrast to these findings, only about one in three would like to be personally consulted in policy making decisions about nuclear waste.

In a more recent study regarding public attitudes to radioactive waste (Eurobarometer 2008) it was reported that "if there was a permanent and safe solution for the management of waste" more than half of the UK public would be in favour of energy production by nuclear power stations. Although only a very small percentage responded with "I do not think there is a solution", it has to be noted that this includes only spontaneous responses. That is, the 'no solution' option was not offered as an answer category. This may be crucial, as two out of three think that there is no safe way of getting rid of high level radioactive waste, when asked directly. It was further found that a large majority (94%) tended or totally agreed that "a solution for high level radioactive waste should be developed now and not left for future generations", with about two out of five agreeing that deep underground disposal represents the most appropriate solution for the long-term management of high level radioactive waste. When UK respondents were asked what would worry them most if a deep underground disposal site for radioactive waste was built near their home, 41% indicated the possible effects on the environment and health (which was among the lowest in Europe) and 34% the risk of radioactive leaks while the site is in operation (which was among the highest in Europe). Unlike Poortinga and Pidgeon (2003a) who found that only about one in three would like to be personally consulted, the Eurobarometer (2008) study found that two out of three would like to be directly consulted and to participate in the decision making process. In line with previous research, self-reported knowledge of radioactive waste was low: only one out of four felt fairly or very well informed. When respondents were asked seven true-false knowledge questions, UK participants were on average able answered 34% of these questions correctly, 45% incorrectly, and a further 21% of the questions with don't know. Similar to other research in the area, trust in information about the handling of radioactive waste is very low, with only 16% saying that they trust the national government or the nuclear industry, and 19% national agencies in charge of dealing with radioactive waste. With 33%, non-governmental organisations concerned about the environment were the most trusted sources with regard to information about the way radioactive waste is handled.

In a Scottish Survey conducted at the beginning of 2006 (Scottish Executive, 2007), about half of the respondents indicated that they are unfamiliar with the issues surrounding radioactive waste; although the Scottish public does appear to have a basic knowledge of radioactive waste and the risks associated with it. A majority of people know that nuclear power stations are the primary source of waste and understand that some forms of waste are more dangerous than others; although a significant minority mistakenly think that some other source (gas or coal fired power stations, bombs, x-rays, scanners, mobile phones or natural radioactivity) are the primary source of waste in Scotland. Despite a subjective lack of familiarity and a moderate level of knowledge, a clear majority of 70% of those surveyed think the issue of radioactive waste is important. With regard to the (devolved) responsibility of radioactive storage and disposal, only a quarter (26%) think that the Scottish Executive is responsible for creating policy to manage the safe disposal of radioactive waste in Scotland, while 41% think it is Westminster's responsibility. In line with previous research, about two out of three think that the general public should be involved in

making decisions about how to manage radioactive waste safely. However, only 4% say it is likely that they themselves will get involved; while a further 14% indicate that they are interested in getting involved but don't know how to do so. When it comes to managing waste in the interests of public safety, the public most trusts government agencies responsible for safety and the environment (such as the HSE, the Environment Agency and SEPA) and least trust bodies connected with the nuclear industry, the UK parliament and local councils. In terms of trust in information on nuclear waste, the most trusted sources are environmental groups such as Friends of the Earth and Greenpeace and industry regulators such as HSE and SEPA. Again, nuclear industry bodies, the UK parliament/government and local councils were least trusted. This pattern broadly reflects the findings of previous research asking similar questions.

As many of the questions in the 2006 Scottish Survey were drawn from two previous surveys conducted in 2002 (Scottish Executive, 2002; 2005), the changes in attitudes since the NDA (Nuclear Decommissioning Authority) and CoRWM (Committee on Radioactive Waste Management) were set up in 2005 and 2003 could be tracked. Overall, very few real differences were found in Scottish attitudes to nuclear waste between the different surveys. Self-reported familiarity, knowledge, and perceived importance of radioactive waste were roughly at the same level. Although the overall pattern of trust remained broadly the same, with still very high levels of trust in information provided by environmental groups and nuclear industry regulators, trust in information from the nuclear industry and the UK Parliament/Government appears to have increased somewhat, as well as trust in their management of radioactive waste.

Eurobarometer research also found that European and UK attitudes to nuclear waste have hardly changed between 2005 and 2008. Favourability ratings of energy production by nuclear power stations "if there was a permanent and safe solution for the management of radioactive waste" were at a similar level in 2008 as in 2005, while agreement with the statement "there is no safe way of getting rid of high level radioactive waste" has dropped slightly with six percentage points. Furthermore, the share of respondents that consider deep underground disposal the most appropriate solution for long-term management of high level radioactive waste has grown somewhat since 2005. Only very limited changes were found for trust in information about the management of radioactive waste. Europeans trusted more or less the same sources of information in 2008 as in 2005. Although, overall, Europeans have become slightly more trusting of information received from the European Union, a reverse pattern was found in the UK: in 2008 fewer people in the UK trusted information from the EU than in 2005. In line with the observed European trends with regard to public attitudes to the safe disposal of radioactive waste, Knight (2009a) reported that the number of people disagreeing with there being "a clear way forward on nuclear waste" has diminished between 2006 and 2008. However, a recent poll conducted by Ipsos-MORI in November 2008 suggests that disagreement with the statement is on the rise again (Knight, 2009b).

Overall, public attitudes to radioactive waste have been surprisingly stable in the past decades. Although attitudes to nuclear power have somewhat softened during this period, in particular when questions are framed in terms of climate change and energy security, radioactive waste remains a matter of high public concern, with very few people thinking that the issue can or will ever be resolved.

With regard to socio-demographic differences in public attitudes to nuclear waste, Scottish research (Scottish Executive, awareness of the issues and engagement is lowest among

women, those in the youngest and the oldest age groups and those on the lowest income. Eurobarometer research (2008) found similar patterns for gender and age, while also pointing to the importance of political orientation. In general, women felt less informed about nuclear waste, were less likely to trust information regarding the handling of radioactive waste, and showed lower levels of agreement with the statement that deep underground disposal is the most appropriate solution for long-term management of high level radioactive waste. Furthermore, women expressed more concern about the effects that a disposal site for radioactive waste could have on the environment and on health. A slightly more complex pattern emerged for age: while respondents' level of agreement with the statement that there is no safe way of getting rid of high level radioactive waste rises with their age, younger respondents were more likely to disagree with underground disposal of managing high level radioactive waste and to be concerned about the environmental and health impacts of the long-term storage of radioactive waste. At the same time, younger respondents were more likely to trust information about the way radioactive waste is managed from industry, national agencies dealing with radioactive waste, as well as non-governmental organisations. Political orientation was linked to attitudes to radioactive waste as one would expect: people who position themselves to the left of the political spectrum were less likely to agree with underground disposal of radioactive waste or to think that there is a safe way to get rid of radioactive waste, and are generally more concerned about the environmental and health impacts of the long-term storage of radioactive waste. With regard to trust in information, those on the left were more likely to trust non-governmental organisations, whilst those on the right were more likely to trust the nuclear industry, national government, or national agencies dealing with radioactive waste. Overall, these patters generally reflect the socio-demographic differences in attitudes to nuclear power (see e.g. Costa-Font et al., 2008)

Analogously to the issue of nuclear power, the acceptability of radioactive waste is closely related to levels of institutional trust in the management of storage of nuclear waste (Poortinga and Pidgeon, 2003a,b). They found that about 40% of the variance in that acceptability of radioactive waste can be explained by general trust in the regulation of radioactive waste and a scepticism dimension –showing the great importance of trust in institutions to deal with radioactive waste properly. Eurobarometer (2008) research found that support for energy production by nuclear power stations does not significantly improve "if there was a permanent and safe solution for the management of radioactive waste"; probably indicating that the public may not necessarily trust that there may be a solution for the storage of radioactive waste (ibid). Indeed, the same Eurobarometer shows that about two out of three think that there is no safe way of getting rid of high level radioactive waste, when asked directly. Furthermore, less than one in ten would leave the responsible authorities to decide on this matter (the lowest level of all 28 surveyed countries) showing a surprisingly low level of trust; while a large majority would like to be directly consulted and to participate in the decision-making (which is among the highest levels in Europe). Only very few indicated that they trust the National Government and "national agencies in charge of dealing with radioactive waste" to give information about the way radioactive waste is managed (Eurobarometer, 2008).

4.4.3 Nuclear Fusion

Fusion power refers to energy generated by the fusion of two light atoms into a heavier one. In theory, nuclear fusion is able to produce large amounts of low-carbon energy without producing radioactive waste products. However, nuclear fusion is currently not an economically viable source of energy, as it takes more energy to create a heavy nucleus than that the process produces. Because nuclear fusion is not an operational energy technology,

there are hardly any studies on public attitudes to nuclear fusion. Only one Eurobarometer survey asked a number of questions about the future of nuclear fusion (Eurobarometer, 2003). Most of the UK respondents responded with "don't know" to these questions, showing the unfamiliarity of the general public with this novel energy technology. More people thought that nuclear fusion is *not* safe against major nuclear accidents (29% versus 20%), would produce as much long term energy nuclear waste as today's nuclear power station (25% versus 18%), would contribute to global warming (29% versus 22%), and would use abundant fuel resources (27% versus 16%). These findings suggest that the public is quite wary about this unfamiliar technology. Accordingly, 62% indicate that much more research and development is needed to confirm its potential, whilst 34% responded with 'don't know'. As there are no specific UK studies on public attitudes to nuclear fusion, this should be an avenue for future research. Considering that the public is largely unfamiliar with this complex and currently non-operational technology, deliberative research appears to be the most appropriate approach.

4.6 Hydrogen and Fuel Cells

The role of hydrogen in the UK's future energy system is based on its role as an energy carrier, not a primary energy source. Hydrogen can be generated from various renewable and non-renewable sources with the potential for zero carbon emissions if a renewable source is used. A DTI report Meeting the energy challenge (2007), discussed the role of hydrogen in terms of 'transport, heating and possibly balancing intermittent renewables for power generation in remote situations' (p.221) whilst Eoin Lees Energy et al. (2004) identified uses of hydrogen for industrial or domestic energy supply and as portable supplies of power such as in mobile phones and laptops. Ricci et al. (2010) refers to hydrogen as a 'system innovation' as new institutional, cultural, and technological infrastructures would need to be developed. However, concerns over infrastructure, storage, and generation of hydrogen have not been seen to present insurmountable technical or economic problems (Lovins, 2005). Nevertheless, a hydrogen economy is characterised by uncertainty at government and stakeholder levels as disputes exist over the development and application of different technologies (Ricci, 2006a).

A variety of studies on public understanding of, and engagement with, hydrogen energy have been carried out during the last decade. However, like CCS, research on social acceptability is limited given the early stage of technological development with few demonstration or case-studies in existence. Ricci (2006b) discussed the complexities of ascertaining public attitudes towards an uncertain technology which is, 'remote from people's everyday experience and for which people have no immediate reference points' (p.4). Noting in 2006 that most studies had focused on transport or specific projects either planned or in existence, a position which has largely remained unchanged at the present time, Ricci (2006b) also noted the complexity, lack of certainty about infrastructure, use of specific technologies, and future scenarios meant that portraying a coherent configuration of hydrogen energy to the public was, in itself, problematic.

A review of early studies on public understanding of hydrogen was carried out by Altmann et al. (2003) who provided a comprehensive review of research on hydrogen transportation. The review looked at studies carried out in Germany (e.g. Schulte et al., 2004; LBST, 1999; Dinse, 1999, 2000 (in Schulte et al., 2004)) as well as more recent research in the UK (Mourato et al., 2004, reviewed below). Regarding the relationship between knowledge about hydrogen and levels of acceptability, Altmann et al. found that despite low levels of knowledge, support for hydrogen vehicles was high. In addition, their review suggested that hydrogen and risk were not closely associated unless people were expressly asked to assess

the risk of explosion, and recommended that, 'Questions of safety should be a priority in the development of technologies, not, however, in the public relations.' (p.3-6) going on to state that, 'intensified treatment' of risks associated with hydrogen technologies served to induce an assessment of danger (p.3-6).

Mourato et al. (2004) conducted focus groups and interviews with London taxi drivers, assessing their knowledge of, and attitudes towards, environmental issues generally and fuel cell vehicles in particular. Factors underlying drivers' preferences to pay to participate in a pilot scheme for fuel cell taxis was assessed using a 'willingness to pay' approach. Preferences were attributed mainly to personal financial benefit in the short term and, environmental considerations in the long term when purchase of a vehicle was being considered. Their findings suggested that levels of knowledge and acceptance of hydrogen transport were not related; experience of hydrogen vehicles increased acceptance; and environmental concerns were outweighed by evaluation in terms of price and performance. Increasing direct contact with hydrogen technologies was recommended to effect positive acceptance using demonstration projects and field tests. The provision of more information to fill the large knowledge gap on hydrogen was also proposed prior to the wider introduction of hydrogen vehicles.

A hydrogen transport demonstration project was carried out in London as part of the EU AcceptH2 project where hydrogen buses were trialled in five cities around the world. Surveys carried out prior to, and following, the trials included questions looking at awareness of bus trials, attitudes towards hydrogen buses, and support for the wider introduction of hydrogen buses. Results from the first survey (O'Garra et al., 2005) also looked at perceived risks associated with hydrogen transport but determined that these risks were not, 'substantial' (p.11) and did not, 'pose a serious issue in relation to hydrogen transport acceptability' (p.21, italics in original). Spontaneous associations with 'hydrogen' revealed mostly neutral responses (such as 'gas' or other scientific/factual information), with some negative associations, including 'bomb' and 'Hindenburg' and some positive associations such as 'clean' and 'environmental'. Less than half of respondents claimed to have heard of hydrogen vehicles, with just over a third supporting their introduction and two thirds saying they needed more information before they could support the introduction.

O'Garra (2005) reports on the follow-up study carried out at the end of the trial to determine the influence of the hydrogen buses on public awareness and acceptability. Neutral associations with hydrogen increased (58% to 74%), whilst positive associations decreased (22% to 6%) and there was no change in the number of negative associations. No increases in knowledge about hydrogen were found following the bus trial in London. Older people, males, and those with a university education were found to have greater knowledge of hydrogen vehicles. Lower overall awareness of the bus trial was attributed to ineffective information dissemination activities and London's large population compared to other cities in the project. Overall this survey confirmed the results of earlier studies where research indicated that the public were not overly concerned with safety aspects of hydrogen, acceptability was associated with prior knowledge of hydrogen, and those who directly experienced hydrogen buses were no more likely to support the introduction of hydrogen than those with no direct experience. In terms of engagement, public exposure to hydrogen buses and the scope of information and communication campaigns were considered as the two important factors determining the effectiveness of the bus trial.

Using two focus groups in Wales, Cherryman et al. (2008) adopted an exploratory approach to investigate public opinion of hydrogen energy in Wales. Knowledge of hydrogen included

chemical and safety aspects where responses to hydrogen brought images of the hydrogen bomb and Hindenburg to mind. Although there was some awareness of hydrogen being a clean fuel, participants were unaware of the two hydrogen projects in Wales and of the hydrogen bus trial in London. Overall, attitudes were supportive of hydrogen technology but there were two main concerns regarding safety and cost. Concerning safety, successful historical energy transitions, such as the move from town to natural gas, provided reassurance about a possible switch to hydrogen but participants recognised there might be a reluctance to change if the new technology wasn't cost effective.

Based on the results of comprehensive literature reviews (Ricci 2006a, 2006b), Ricci et al. (2008) carried out focus groups in different areas of the UK; two where an older chemical industry provided the basis for an embryonic development of a hydrogen economy (Teesside and South West Wales) and one where a hydrogen development had been more recently introduced as part of the EU hydrogen bus project (London). This research investigated public understanding of hydrogen energy as well as attempting to redress the balance between research based on quantitative data by using focus groups to gather data. Similar to earlier research, awareness of hydrogen energy technologies and applications were relatively low, and neutral views regarding the desirability of a shift to hydrogen energy were expressed. Despite the technical uncertainties of hydrogen energy technologies, public perceptions of hydrogen focused on how lifestyles and behaviour may be affected rather than on safety issues as expected. Their results highlighted issues of a social nature, such as how hydrogen would fit in with established ways of life and individuals' views of the world, that would potentially affect a transition to a hydrogen-based energy system and which had been largely overlooked by previous social research on hydrogen.

Drawing on the same focus group data as Ricci et al. (2008), Flynn et al. (2008) focused on related issues found to be important for supporting the development of hydrogen energy. Like previous studies, there was a belief that any concerns regarding risks would have been resolved prior to widespread introduction. Support for hydrogen was found to be dependent on perceptions of local (air pollution) and global environmental (energy crisis) issues. Altruistic concern for the greater good did not shape attitudes to hydrogen energy. Participants emphasised that support would be conditional on the demonstration of benefits to consumers in terms of cost and practicality.

As part of previous focus group research, Ricci et al. (2010) focused on engaging with the public regarding the future of hydrogen energy technologies, discussing possible scenarios for a future hydrogen economy, and identifying criteria and issues participants considered useful for decision-makers. Topics discussed included how hydrogen should be communicated to different publics and people's views on involving the public in decisions about hydrogen energy. Ricci et al. (2010) found that, generally, there were few a priori opinions about hydrogen as an energy carrier and awareness of potential hydrogen technologies and future applications was low. Concerns about risk varied widely across groups ranging from the identification of technological risks by those with an interest in the technology or specialist knowledge of the chemical industry, to comparisons with existing fuels by those with less familiarity. In contrast to previous research, public acceptability of hydrogen was found to be conditional on knowing the 'bigger picture' of any development. Attitudes and behaviour towards hydrogen technologies were dependent upon knowing the trade-offs between global and local benefits, cost, and safety. Strong distrust and lack of confidence in sources of information were found to shape public beliefs about hydrogen (an argument introduced in Bellaby (2010a) and developed in Bellaby (2010b)). In particular, the groups expressed unease at having to make sense of conflicting information coming from

experts. Crucially, Ricci et al. (2010) point out that engagement must connect with issues that people see as relevant, rather than simply framing hydrogen energy through the use of technological and economic assessments, echoing concerns raised by Flynn et al. (2009) regarding upstream public engagement with hydrogen technologies.

A similar study was carried out by Bellaby and Upham (2007) in areas where there were no existing or planned hydrogen developments. Qualitative and quantitative methods of engagement were used to determine public understanding of hydrogen energy infrastructure (generation, storage, distribution) with a focus on transport applications. The questionnaire study described existing knowledge of hydrogen as moderate and variable with those in full-time employment appearing to have more hydrogen-related knowledge than part-time employees or retired people. Additionally, younger men with a higher level of education tended to know more about hydrogen. More detail on beliefs and opinions about hydrogen came from focus groups where a specially commissioned DVD detailing hydrogen energy and transport applications was shown. The generation of hydrogen from renewable sources was supported and contrasted with opposition to hydrogen generated using fossil fuel and nuclear sources. Although the groups had difficulty imagining an infrastructure for hydrogen, support for its development was dependent on the resolution of issues relating to safety, costs and benefits, and efficiency. Participants remained positive towards hydrogen use in transport, valuing lower noise levels and the absence of air pollutants and carbon emissions. Inconveniences such as the shorter range of hydrogen vehicles and the longer fill-up times were not considered major detractants as it was anticipated that this would improve over time.

King et al. (2009) looked into attitudes to climate change and transport behaviour to explore the attitude-behaviour gap between concern for climate change and behaviour change. The research aimed to identify barriers and incentives and the role of information on behaviour change. A deliberative approach was chosen where members of the public met in groups during a series of five meetings over the course of ten months. Within the wider context of transport behaviour, hydrogen was known only to a minority where it arose in the context of the range of alternative, cleaner fuels. Along with other alternative fuels, such as LPG and biofuels, a lack of confidence in its effectiveness and availability was found.

Sherry-Brennan et al. (2010) carried out case-study research on an existing community-owned wind-hydrogen project in Shetland. Public understanding of hydrogen was explored through the use of a large-scale survey. Similar to previous research, perceptions of hydrogen were predominantly scientific or technical and did not focus on aspects of risk or safety. Although hydrogen energy was relatively unfamiliar, the specific circumstances of the case provided a connection between the technology and the community. Contextual factors such as the economic and social sustainability of the island were used as part of the process of understanding and the resulting generally positive evaluation of hydrogen energy.

Very little research has focused specifically on fuel cells even though they are considered technically effective but prohibitively expensive for mass consumption (Bellaby et al., 2006). In the context of household heating systems hydrogen fuel cells would form part of a combined heat and power system (CHP). Haddock Research (2008a) carried out a nationally representative UK survey comparing different types of heating systems. Although the CHP boiler, with 'reasonable' cost, was found to be appealing to UK homeowners for installation when the old boiler needed replacing, intentions to install a system using hydrogen fuel cells was low (15% expressed an intent to a system using hydrogen fuel cells). Concern for climate change was found to be the best predictor for identifying who would be enthusiastic about

CHP boilers. An open ended question was used by participants to express concerns about the safety and cost of the boiler, as well as queries over the continued use of fossil fuels to generate hydrogen.

In summary, much of the research on public understanding of, and attitudes toward, hydrogen energy has drawn similar conclusions; namely that overall knowledge of hydrogen energy, production processes, storage, and infrastructure is low yet general support for hydrogen technologies remains positive. Nevertheless, support is conditional upon concerns about safety, personal and global costs and benefits, and technological efficacy being met. The current literature reveals an emphasis on hydrogen use in transportation and related infrastructure rather than on hydrogen electricity production. There is, therefore, a research gap for public understanding and engagement with hydrogen in stationary and mobile applications such as home boilers or portable electronic devices such as mobile phones and laptops.

4.7 Electricity and Gas Networks

UK energy policy makes clear that significant updates to existing supply infrastructure will be necessary to enable expected increases in the penetration of low carbon energy. This is especially clear with relation to the electricity grid, the centralised, complex infrastructure that connects UK power stations to centres of demand. For example, the UK Renewable Energy Strategy (DECC, 2009b) indicated that OFGEM would be working to incentivise grid companies to invest £4.7 billion in the period to 2020 to enable the connection low carbon energy generation to the grid. An additional feature of current energy policy is the potential to create novel offshore transmission networks to enable rapid increases in offshore wind energy to take place. These policies favour technical, political and economic dimensions of change to grid infrastructures, yet public acceptance may also play an important role in the pace and feasibility of technical change, suggesting the importance of understanding public engagement with grid technologies.

Relatively few studies have been conducted to date in the UK on public attitudes to energy supply infrastructures such as gas or electricity networks. This is surprising, given the physical scope and significance of these socio-technical systems in the wider energy system, and given frequent references in the media to the necessity to 'keep the lights on'.

With respect to gas networks, this review found no studies that had specifically investigated public attitudes to gas network technologies. Some research was identified that probed more general issues concerning the availability and responsibility for gas supply to the UK as a whole – the issue of energy security. Ipsos-MORI (2010) survey research suggested that public concern is high about the increasing need to import gas from abroad: approximately 70% of the public is very or fairly concerned. This concern seems to increase with age, being greater than average among the over 45s, and among the ABC1C2 social groups. There is also more concern in Scotland in comparison to Wales. However, the wording of the question posed to the public ("*As North Sea Gas supplies start to run out, Britain will need to buy more gas from other countries. How concerned are you, if at all, that more gas will be coming from abroad in the next 10-15 years?*") suggests a strong energy security framing (see Lockwood, 2009, *section 4.2.1*), which may have influenced public responses. Future research could establish the validity of this assumption. A majority of respondents (57%) assumed that the Government was responsible for ensuring energy supplies to Britain, both in terms of gas and electricity (MORI, 2010). The most popular alternative is the energy suppliers, mentioned by 13% for gas and 12% for electricity, and significantly more likely to

be mentioned in Scotland in both cases. The pattern of responses is very similar for gas and electricity. In both cases, 10% of the public report not knowing who is in charge.

Whilst more research has been conducted on public attitudes towards electricity supply networks, this research literature is still rather small. Research has indicated that, whilst blackouts were considered unacceptably 'out of place' in a developed country such as the UK, threatening vulnerable social groups such as the elderly and invoking memories of the 1970s, public attitudes were not exclusively negative towards power outages that were short in duration. People welcomed blackouts as opportunities to escape from restrictive social norms, particularly in urban areas, legitimizing social interaction and cooperation with strangers (Devine-Wright and Devine-Wright, 2007).

Devine-Wright and Devine-Wright (2009) used an innovative qualitative methodology involving focus groups, drawing tasks and free association tasks to explore public beliefs about electricity supply. The findings suggest that members of the public view A-frame high voltage transmission pylons as visually iconic of the network as a whole. There are ambivalent attitudes towards large-scale network infrastructure, with the size of pylons perceived to be impressive engineering feats yet monstrous, being imposed upon landscapes and communities and associated with health risks such as leukaemia. Using a free association task to reveal associations with the 'National Grid', analysis indicated highly variable public beliefs, from little or no associations at all, to beliefs anchored in familiar technology networks (e.g. railways or broadband internet), to sophisticated understandings of grid connections within the UK and between the UK and other countries. Ensuing discussions revealed some tension in the meaning of 'national', with Scottish participants believing that demand for electricity in 'the South' (i.e. in the South-East of England/London) unfairly necessitated the imposition of electricity infrastructure upon Scottish rural communities, without local benefit. Furthermore, the organisations operating the network were unfamiliar to participants and poorly trusted. This relative invisibility and mistrust is important, as it is likely to influence future public responses to engagement initiatives undertaken by network operators with individuals and communities directly affected by reinforcement proposals (Devine-Wright and Devine-Wright, 2009).

A subsequent study (Devine-Wright, Devine-Wright and Sherry-Brennan, 2010) used a survey methodology to investigate the beliefs held about electricity supply, drawing on a nationally representative study of UK adults and using a mix of both open-ended and closed questions (n = 1041). The study probed beliefs about how electricity reaches the home, responsibility for electricity supply, associations with the words 'National Grid', as well as beliefs about the planning of new infrastructure. Findings suggest that public beliefs about how electricity reaches the home focus predominantly on technologies rather than organisations, specifically in terms of familiar, visible components such as cables or wires, rather than more systemic concepts such as networks. The most common responses to this question were words such as 'cables', 'wires', 'a lead' and 'electric cables', which suggests that thinking about electricity supply is primarily anchored in the day-to-day use of electrical devices such as TVs and stereos, which connect to more distant components of the electricity network via cables or wires. The familiarity of the electricity cable provides a frame of reference that is easy for individuals to access and recall and can be readily associated with the process of electricity supply. Along with less common responses such as 'substations' (11.4%) and 'pylons' (7.4%), the results indicate that single components of power networks were more frequently mentioned than more systemic concepts such as a 'grid/transmission system' (12.5%). Moreover, only 26.8% (n = 259) of respondents

mentioned a combination of interconnected components, and 17.8% of participants responded 'do not know' to this question.

In terms of who was perceived to be responsible for ensuring electricity supply to homes, most participants mentioned a single organisation (73%); other responses included 'do not know' (20%), while instances where several organizations were mentioned were few (6.5%). Single organisation responses consisted of a variety of organisational types, including private companies (including electricity suppliers and providers, and power companies or generators); electricity boards (central, regional, local); government (central or local) and OFGEM. Private sector companies accounted for 86% of those who cited a single organisation as being responsible for making sure electricity reaches their home, often referring to an un-named or named supply organisation. Relatively few individuals mentioned network operators, and of these, transmission businesses were more frequently cited (e.g. 19% for 'National Grid') than distribution network companies (5.1%). Of interest was how electricity boards, and local or national government, were cited by larger numbers of respondents in comparison to distribution network operators. Finally, only 0.4% mentioned OFGEM, the energy regulator.

Free association responses with the 'National Grid' were categorised according to whether or not they reflected associations with the National Grid as a company or organisation, as a technical object or system, or drew on visual or other aspects of understanding. Associations with the National Grid as a technical system dominated the results (82%), followed by 'do not know' responses that accounted for 11.5% of responses; only 2.3% mentioned the National Grid as a company or organisation. The relative frequencies of the results of all thematic associations with 'National Grid' confirms the results of the previous research (Devine-Wright and Devine-Wright, 2009) that the grid is typically represented as a technical system on a nationwide scale and suggests that the transmission network operator, National Grid plc, is relatively less well known or visible to members of the public.

Participants were asked to estimate the degree of involvement of various actors in decision-making about new power lines. The findings indicate that National Grid plc, electricity supply companies, government ministers and Ofgem were perceived to be more involved in planning decisions than environmental groups and local residents. The relatively high number of 'do not know' responses for Ofgem (27.7%) suggests uncertainty and perhaps unfamiliarity with this organisation's role in planning new power lines. Participants were asked to rate their degree of agreement with the statement 'New powerlines should always be built underground, regardless of the extra cost'. Levels of agreement (63.4% slightly, somewhat or strongly agree) were far higher in comparison to levels of disagreement (18.4% slightly, somewhat or strongly disagree).

In conclusion, the research found electricity supply to be represented predominantly in terms of technologies rather than organisations, and even then to be predominantly in terms of specific, familiar and visible components, such as cables or wires, rather than more systemic concepts. Both transmission and distribution network operators were largely invisible to members of the public, who were more likely to cite un-named organisations and even electricity boards, rather than specific network operators. Surprisingly few respondents spontaneously mentioned National Grid as a network organisation, even when asked to spontaneously mention associations with the words 'National Grid'. These findings have implications for the extensive network reinforcement being planned to adapt the energy system to low carbon energy sources. A failure by network operators to undertake more extensive public engagement, along with policy makers affording genuine opportunities for

citizens to input into planning processes, could lead to strong public opposition and significant delays in new infrastructure siting. In effect, the relative invisibility of network organisations to the public, coupled with low expectations of residents' control over planning decisions heightens the risk of escalating levels of public opposition to new line proposals.

4.8 Summary

This chapter has reviewed attitudes to various forms of energy supply, storage and distribution. In terms of general conclusions, it should firstly be observed that the results of attitude studies are sensitive to research methods, which in turn vary with research objectives. This implies a need for caution when generalising. The issue of consistency and inconsistency, in different forms, has concerned psychology for at least the last couple of decades (Azjen, 2005). Attitudes and perceptions are to some extent changeable and contingent: they should not be approached from a naïvely positivist perspective, as if wholly independent of context and elicitation methods. Neither, though, are attitudes simply a function of these factors; most theorists hold that people do have a preference for being consistent over time and in their attitudes and behaviour (ibid). Attitudes can be investigated and documented empirically, quantitatively and qualitatively, on small scales and large scales. One simply needs to be aware of the influences that are operative in any particular study and of the need to interpret the results accordingly.

One key influence on attitudes in this context might be described as the level of personal engagement. There is a relatively coherent pattern of attitudes to in principle energy supply options in the UK and indeed in Europe. Well-known renewables, particularly wind and solar, are highly rated by the public in the abstract and in principle. Although public attitudes to lesser known renewables, such as biomass, tend not to be as favourable as attitudes to wind and solar energy, they are still more positive than attitudes to fossil fuels and nuclear power. However, this support is neither unqualified nor necessarily translated into acceptance of renewable energy developments by local communities.

Where siting objections do occur, there is a need for a more nuanced understanding of the different reasons for local opposition to specific renewable energy developments that goes beyond the rather simplistic notion of "Not In My Backyard". Communities are often sensitive to the impacts of renewable energy development on landscape quality and to what is perceived as the 'industrialisation of the countryside' by unaccountable actors. There is a growing and variously theorised literature on renewable energy siting controversy, with, for example, concepts of place attachment and identity (Devine-Wright, 2009) and technological symbolism (McLachlan, 2010b) being used to help explain objection. Offshore wind energy is often thought to have the benefit of being out of 'sight out of mind' and therefore expected to attract less opposition than onshore developments. However, studies suggest that both offshore wind and other marine technologies have also been found to elicit both local support and opposition – e.g. (McLachlan, 2008; West et al., 2010). Similarly, the low public profile of the National Grid and electrical operators (Devine-Wright and Devine-Wright, 2009) may well become an issue as grid upgrading becomes necessary and firms that are currently out of sight and out of mind come to wider attention.

Community renewables have been both suggested and critiqued as an instrumental way of improving levels of local support for renewable energy and more normatively as offering local empowerment, learning opportunities and building civic capacity – e.g. (Devine-Wright, 2005b; Walker and Cass, 2007; Walker et al., 2007). The term 'community renewables' covers a wide range of projects and activities, and may relate to both the process of

developing the project and/or the distribution of its benefits (Walker, 2007). Small-scale renewable energy systems, also known as micro-generation, hold great potential for decarbonising household energy use, but require different policy approaches to large-scale infrastructure projects. Although small-scale renewable energy systems are generally not held up by lengthy planning procedures as is often the case with large-scale energy infrastructure projects, they need the active involvement of householders to make investments. Currently, there is a major gap in the understanding of attitudes to small-scale renewables as well as of the decision-making processes that are involved in purchasing these technologies. It is necessary to understand how general (in principle) positive attitudes towards micro-generation can be translated into active involvement and in which internal and external factors inform the decision-making process of households purchasing renewable technologies. It is particularly important to explore which policy measures could be most effective in promoting micro-renewables among different 'publics' or populations. It should also be noted that studies of public responses to small and large-scale renewables have generally focussed on developments that experienced difficulties in gaining planning permission. Positive experiences of renewable energy projects and development processes should also be investigated so that both support and opposition are more fully understood.

5 Energy Demand

Summary: Public attitudes to energy demand issues

- Attitudes towards energy-efficiency (involving one-off purchases of appliances or products) are generally more positive than towards energy conservation (ongoing curtailment of energy consumption and behavioural restriction)
- Energy efficiency and conservation also have different psychological properties, and tend to be understood using different theoretical perspectives
- In general, the UK public considers reducing household energy use as a virtuous thing to do, but show less support for lifestyle change measures than for technological measures
- Public attitudes to energy saving light bulbs are positive, and their use of is now widespread
- Most people claim they buy energy-efficient appliances, although this seems to be more common for 'white goods' (e.g., fridges, washing machines) than for 'brown goods' (e.g., TVs)
- Barriers to buying energy-efficient appliances primarily relate to trade-offs with utility of the product and, in some cases, increased cost
- Attitudes to insulation and double glazing are also very positive; loft insulation and double-glazing have been installed by most people, while wall insulation and other energy efficient installations are less common due to lack of motivation, awareness or affordability. Improving energy efficiency of homes is less important than other home improvements.
- Public attitudes to buying a low emission vehicle are less positive. Few own, or would own, low-emission vehicles, although most agree environment-friendly car drivers should pay less
- Energy use is driven by economic (especially income), structural (e.g., transport systems), and social factors, and by unconscious habit; environmental values tend to have little influence, while social values such as convenience, comfort, freedom, and status are far more salient
- Energy is 'invisible'; households often have little awareness of their energy use. The 'hidden' cultural drivers and meanings of energy use make energy behaviours difficult to change
- Most feel an obligation to save energy, but few are making significant lifestyle changes; turning off unused lights and appliances are commonplace, but washing and heating behaviours are more resistant to change (due to primacy of comfort and cleanliness)
- Financial considerations are the key motivator for domestic energy saving behaviours
- Public attitudes to buying local and seasonal produce are positive; there is little understanding of the link between food production/consumption and climate change, but the idea of a low-impact (e.g., vegan) diet is unpopular
- Attitudes to waste avoidance are very positive; and recycling and reuse are widespread
- There is considerable resistance to changing travel habits, particularly changing mode, due to perceived inconvenience, unavailability, or cost of alternatives, and strong cultural associations with driving and flying
- Motivations for changing travel behaviour are usually tangible benefits such as health (from walking/cycling), saving money or convenience
- Informational tools (e.g., carbon calculators, smart meters) can make energy more personally relevant and visible. However, information alone is usually insufficient to encourage energy conservation; economic, social and structural approaches are also required

5.1 Introduction

5.1.1 Policy context

Although UK energy policy focuses more on supply-side than demand-side measures[4], low-carbon lifestyles are nevertheless promoted by government through informational

[4] This is despite evidence that demand-side measures are more important for achieving energy and climate targets (Bows et al., 2009; Grubler and Riahi, 2010).

approaches and incentives to encourage uptake of low-carbon services (HM Government, 2009a). Recent years have seen investment by DEFRA in a programme of research on fostering pro-environmental behaviour change across consumption clusters of food and drink, personal travel, homes and household products, and tourism. Central to this programme has been the development of a segmentation model, which classifies the English public into seven groups (from 'Positive Greens' to 'Honestly Disengaged') according to their environmental beliefs and perceived willingness and ability to take pro-environmental (particularly low-carbon) action; and the identification of behavioural goals within the consumption clusters (e.g., install insulation products; buy energy-efficient products; see DEFRA, 2008). The approach to encouraging sustainable lifestyle change amongst these diverse groups is based on the social marketing-inspired '4Es' model – Engage, Enable, Encourage, and Exemplify. DEFRA's (2008) research highlights that different attitudinal segments not only hold very different views about environmental issues and changing their behaviour, but also require different approaches to engaging them in lower-carbon lifestyles. Although this recent work offers a more nuanced perspective on lifestyle change than traditional government-led behaviour change interventions relying on information provision and economic incentives (Ockwell et al., 2009), the public is still narrowly defined as 'consumers' and given a relatively passive role in a potential low-carbon energy transition (Höppner & Whitmarsh, 2010; Nye et al., 2010; see also section 3.4.4).

5.1.2 Energy efficiency versus energy conservation

Public attitudes to energy conservation and efficiency can be interpreted from various theoretical perspectives. Wilson and Dowlatabadi (2007) discuss a number of social science traditions that have explored the drivers of individual energy-relevant behaviours and decision making, including conventional and behavioural economics, technology adoption theory, social and environmental psychology, and sociology. These approaches differ fundamentally in their theoretical and methodological foundations. Some are founded on informed rationality or psychological variables, while others emphasize physical or contextual factors from individual to social scales. It is beyond this review to describe the theoretical framework and their differences in detail. Instead, the review will primarily focus on recent empirical evidence that has been collected in the UK. Where work has been conducted from a specific theoretical framework, this will be mentioned in the text. Here it has to be noted that the most empirical evidence is collected from a social or environmental psychology perspective and to a lesser extent from a technology diffusion or sociology perspective (Wilson and Dowlatabadi, 2007). This means that the review will mainly focus on these disciplines, reflecting the degree to which empirical data has been collected within this field of research. In this review we will distinguish between public attitudes to energy efficiency (investments that lower energy use without sacrificing normal and desired activities or energy services) and curtailment measures (saving energy by cutting down on normal and desired activities or energy services; cf., Gardner and Stern, 2008).

Energy efficiency and curtailment measures not only have different conservation potential, but they also have different psychological characteristics (Gardner and Stern 2002; Poortinga et al., 2003). Whereas many energy efficiency measures need a one-off upfront financial investment (e.g., home insulation), curtailment measures often involve a change or 'restriction' of behaviour that needs to be upheld in order to keep saving energy (e.g., not flying). Research on the topic suggests that the two types of measures need different approaches. Whilst curtailment requires changes in people's day-to-day energy-relevant behaviours, there is only a small window of opportunity to influence individuals' decision to purchase energy-efficient products. Both types of measures can be taken to reduce domestic energy use and energy use for travel and transport. Barr et al. (2005) found a clear

conceptual difference between purchase-related behaviours (including energy-efficient light bulbs and appliances) and so-called habits, which included the energy curtailment behaviours of reducing heat in unused rooms, reducing hot water temperature, putting on more clothes instead of more heating, turning lights off in unused rooms, and fully loading the washing machine. Research by Whitmarsh and O'Neill (2010) shows that people perceive energy-efficiency measures and energy conservation as separate categories of 'behaviour': in a principal components analysis with a wide range of environmental significant behaviours, all one-off domestic energy conservation actions loaded highly on a single factor as did a number of water and energy-related curtailment behaviours. They also found that these different types of behaviour were associated with different attitudinal and structural factors. Although both one-off domestic energy conservation actions and regular water and domestic energy conservation were influenced by the perceived personal importance of climate change, a pro-environmental self-identity is only a predictor of regular curtailment behaviours and not energy-efficiency.

5.2 Energy-Efficiency Measures

5.2.1 Introduction

Within the UK, a clear majority (70%) consider reducing household energy use as a virtuous thing to do for the environment (Green Barometer, 2007), although policy measures aimed at reducing household energy use are generally unpopular: few think that measures, such as 'green' taxes (34%), road pricing (30%), and carbon rationing (28%) are socially acceptable. Similarly, enthusiasm of individuals for changing their lifestyles appears to be somewhat muted. According to a recent survey on public attitudes and behaviours towards the environment (Defra, 2009), nearly half of the respondents are happy with what they do at the moment in terms of their current lifestyle and the environment, a similar proportion would like to do "a bit more", and only about one in ten would like to do "a lot more" to help the environment. The reason is that most respondents already think that their current lifestyle is environmentally friendly: nearly half (47%) reported that they do "quite a few things" that are environmentally friendly, and an additional 24% that they are "environmentally friendly in most things" they do.

Technological measures are generally thought to be more acceptable to the public than those that require behavioural change (Poortinga et al., 2003). There are many different types of technological or energy-efficiency measures, including buying energy-efficient appliances, improving the energy efficiency of homes (e.g., wall and loft insulation), and energy-efficient/low emission vehicles. Public attitudes to these energy efficiency measures are generally positive. For example, research by Warwickshire County Council (Warwickshire Observatory, 2008) has shown that many are willing to buy 'A' rated electrical appliances (88%), get a more fuel efficient/low emission car when their car is due for replacement (78%), or to install/increase the amount of insulation in their home (75%). However, other research shows that people are not always able or willing to make the additional energy-efficiency investments. A recent representative British survey (Spence et al., 2010) found that while 65% of people tend to agree or strongly agree that they are prepared to greatly reduce their energy use to help tackle climate change, less than half of respondents (44%) are prepared to pay significantly more money for energy-efficient products. Furthermore, while many householders overestimate the potential for energy savings in curtailment, most home energy specialists think that investing in energy efficiency is generally more effective (Gardner and Stern, 2008) - although it should be noted that curtailment and efficiency should not represent an "either-or" choice. In motor vehicle and some in-home energy uses, some curtailment actions can provide significant immediate savings and should not be

overlooked (ibid). Public attitudes to energy saving through curtailment are discussed in section 5.3. In the current section public attitudes to energy-efficient appliances, energy saving light bulbs, energy efficiency of homes (i.e., insulation and double glazing), and energy efficiency in travel and transport are discussed in more detail. There are great differences in public attitudes and willingness to 'purchase' these technologies, not least because they need different levels of initial investments.

5.2.2 Energy-saving light bulbs

Public attitudes to energy saving light bulbs are generally very positive. The purchase and use of energy saving light bulbs is one of the most popular environmental behaviours after recycling. For example, the use of energy-efficient light bulbs is one of the behaviours that Scottish consumers undertake most often for the environment (Scottish Government, 2009): around nine out of ten respondents in the survey said they feel it is important to use energy-efficient light bulbs, and around four out of five saying that they use them at least 'most of the time'. Although the Scottish Environmental Attitudes and Behaviour Survey (SEABS) found no consistent pattern of variation according to environmental engagement in the perceived importance of using energy saving light bulbs where possible, those most environmentally-concerned were consistently more likely to use energy saving light bulbs and to engage in a range of other environmental behaviours. The willingness to purchase energy-saving light bulbs out of concern for the environment has increased substantially over the last number of years. A series of national surveys on public attitudes towards climate change and the impacts of transport (see DfT, 2010) have shown that the willingness to use energy saving light bulbs in the next 12 months due to concerns about climate change has risen from 66% in 2006 to 80% in 2009. This was only second after the most popular 'environmental behaviour' of recycling household rubbish.

Research conducted by the Energy Saving Trust and DEFRA (Defra, 2009) estimated that, on average, UK households have 19 light bulbs in their home, with 30% having 1-10, 43% 11-20, and 29% 21 or more. Of these, a majority were energy saving light bulbs (60%). The average number of energy saving light bulbs per home was estimated to be 12 (ibid). All respondents who had at least one non-energy saving light bulb were subsequently asked what was stopping them from fitting more. A substantial minority of 42% said that energy saving light bulbs did not fit their light fitting, with an additional 14% saying that the quality of the light is poor. Although, about one in four (23%) said that they would substitute the non-energy saving light bulbs when they blow, suggesting that the proportion of energy saving light bulbs in people's homes will increase steadily in the future replacing conventional light bulbs when the reach the end of their lives (ibid). When comparing the findings of this study with earlier research (EST, 2008; 2007), it appears that the number of energy saving light bulbs has increased substantially from 7 in 2007 and 2008 to 12 in 2009, while the overall number of light bulbs per home has remained fairly constant over the same period.

5.2.3 Energy-efficient appliances

Energy efficiency investments can, from a (behavioural) economics perspective, be interpreted as an individual's willingness to exchange present consumption for future consumption, for example by spending more up front on an energy-efficient appliance with lower energy use (Wilson and Dowlatabadi, 2007). As in so much carbon-related behaviour, the costs are upfront but the benefits delayed (hence discounting rates are critical). While this is the case for all energy efficiency purchases, including energy saving light bulbs, the level of investment is greater for energy-efficient appliances and home efficiency measures (e.g., insulation and double glazing). It is then perhaps not surprising that buying more

energy efficient products is a less popular environmental behaviour than buying/using energy saving light bulbs (see e.g., DfT, 2010).

Energy-efficient appliances can make a substantial contribution to lowering household energy use over its lifetime, in particular considering that major household appliances are only bought on an irregular basis. The recent EST/DEFRA survey (2009) found that about two-thirds of the interviewed individuals had not bought a single household appliance in the last year. Household appliances that use electricity continuously, such as a fridge, freezer or fridge-freezer, have the biggest energy saving potential. However, these were bought the least often (ibid). Many respondents claim that they are already buying energy-efficient appliances and intend to continue to do so (60%). A clear majority of the people who had bough at least one appliance in the last year (70%) said that they had looked for the Energy Saving Recommended logo in the majority of purchases (DEFRA, 2007b); and a similar proportion (72%) said that the appliance they actually bought had the Energy Saving Recommended logo on it. The proportion of respondents that are looking for the Energy Saving Recommended logo and had actually bought an appliance with the logo on it had increased substantially since 2007 (EST, 2007), suggesting that the logo is helping people to make more energy conscious decisions when replacing or buying new household appliances. Similarly, there seems to be fairly widespread recognition of the 'A to G' energy efficiency rating scale logo (Figure 5.1 - which appears on appliances and now is also used for homes; see section 5.2.4); Haddock Research (2008f) found the logo is recognised by 72% of English adults and that 47% claim it has had an impact on their behaviour. Awareness and impact positively correlated with income and environmental values. However, SEABS (Scottish Government, 2009) found that at least half of respondents who had bought electrical appliances in the last two years did not know or could not remember the energy efficiency rating - although the figure varied widely depending on the specific type of appliance bought. Thus, whereas a great majority of respondents said they did not know the energy efficiency rating of their new television (82%), this number was substantially lower for people their new fridge/freezer/fridge freezer and washing machine (54% and 53% respectively). These figures suggest that people are more likely to take the energy efficiency ratings of 'white goods' into account than of 'brown goods'. There was some variation in recollection according to the degree of engagement with the environment, with significantly more 'deep greens' being able to recall the rating of their fridge or freezer, washing machines and dish washers (ibid).

The BarEnergy project (Emmert et al., 2010) identified a range of barriers to the purchase of energy-efficient household appliances. The most popular responses related to the issue of 'utility' of the products, which for many were non-negotiable. Focus groups participants argued that the higher costs of energy-efficient appliances are a main barrier; although some were willing to pay extra for more durable appliances. Overall, however, there was a good level of knowledge about energy efficiency ratings of electrical appliances; some were aware of the longer-term savings that could be achieved by purchasing higher rated appliances; and accordingly many focus group participants said that they had made purchasing decisions according to a product's energy rating (Emmert et al., 2010).

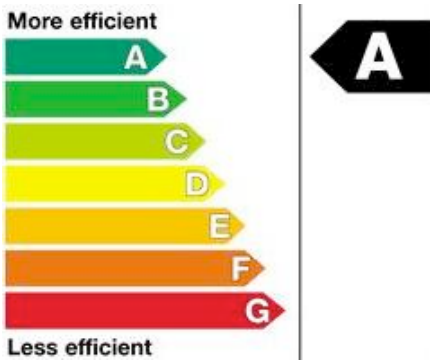


Figure 5.1 – A to G Energy Efficiency Rating Logo

Roy et al. (2007) and Caird et al. (2008) looked at consumers' reasons for adoption and non-adoption of energy-efficiency measures, including condensing heating boiler, thermostatic radiator valves (TRVs), compact fluorescent lamps (CFLs) and light emitting diode (LED lighting, and their experiences with these technologies (also see section 4.2.5) They concluded that green consumers typically adopt these energies to save energy, money, and/or the environment. With regard to the TRVs, a number of people reported that the fuel savings are not worth the investment and that it is too much trouble installing them, while condensing boilers were seen by most as too expensive and that therefore the fuel savings are not worth the costs of the investment. Condensing boilers' reputation for unreliability was also seen by many as a barrier to adoption.

5.2.4 Energy efficiency of homes

Home insulation and the installation of double glazing can also be considered energy efficiency measures, as they constitute investments that lower energy use without sacrificing energy services (cf., Gardner and Stern, 2002), i.e., the heating of the home to a desired temperature. According to EST (2010b) cavity wall and wall and loft insulation are basic energy efficiency measures that usually 'only' cost a few hundred pounds or less to install and therefore are highly cost effective – paying for themselves in only a few years. Attitudes to insulation and double glazing are generally very positive (Defra, 2009), with many people seeing an energy-efficient home to be worth more when sold because it saves on heating bills (EST, 2010c) and a large minority of respondents (42%) indicating that they are willing to pay more for a refurbishment if it also makes their house more energy-efficient. The majority of respondents indicated that they had already installed double glazing and loft insulation (55% and 82%, respectively; Defra, 2009). In addition, a large proportion of those who had not installed double glazing and loft insulation said that they were contemplating installing them in the future. About half of those able to install cavity wall insulation or draught exclusion had already done so (this excluded all renters and those who are not responsible for physical upkeep of their home as well as those households where such insulation was not possible). Only around one in ten of those who had a house with at least one solid wall claimed to have installed solid wall insulation – suggesting that there is little public awareness of solid wall insulation and that it may be confused for cavity wall insulation (Defra, 2009).

There are various reasons for people to not install insulation or double glazing, even if in the long term these may result in substantial energy savings. As pointed out by Gardner and Stern (2008), and similarly but on a greater scale to the point above in the context of appliances, energy efficiency measures often require a substantial investment upfront. Many households may lack the funds and/or access to credit to make these investments

possible. Furthermore, renters can in most cases not be in a position to install insulation or double glazing and are dependent on the willingness of the landlord to make these investments. Indeed when asking in general terms about home insulation, about 37% said that they would like to install insulation but cannot afford to even if it will save them money in the long term. Overall, the key barriers to the uptake of basic insulation among households that have not done so yet are: (a) a lack of awareness/knowledge, (b) a lack of motivation, and (c) a (perceived) lack of affordability (Defra, 2009; EST, 2010b,c). Lack of awareness is clearly an obstacle for the installation of basic insulation measures, with many people having never thought about installing them (Defra, 2009) or not knowing how to go about having such work done (EST, 2010c). About one in ten do not even know if they already have wall insulation or not. Although many people perceive financial barriers to installing cavity wall insulation, this may be due to an overestimation of the installation costs and an underestimation of the time required (Defra, 2009; EST, 2009). It is therefore suggested that access to reliable information and advice is essential for the uptake of basic insulation measures. According to EST (2010b), people are often pleasantly surprised when informed of the true costs and likely benefits, and the speed and simplicity of the installation process. A lack of motivation is also considered a major barrier to the take-up of basic insulation measures. Many consumers say that they just do not get around to putting in more cavity wall or loft insulation because they see it as a hassle organising it or that they are simply not interested (EST, 2010b). At the same time, many say that they know where to go for reliable advice to improve the energy efficiency of their house and do not perceived major barriers to installing cavity wall insulation (ibid).

Research by Roy et al. (2007) and Caird et al (2008) identified a range of barriers to the adoption of new or extra loft insulation as perceived by consumers, most of which are very practical. The installation often requires the cleaning of cluttered lofts and/or the boarding, and is likely to mean a reduction in storage space and the potential for a loft conversion (Roy et al., 2007). Furthermore, there are some consumers who believe that the installation of insulations is not worthwhile. Roy et al. (2007) suggest that the 'unobservable' nature of loft insulation may contribute to the belief that loft insulation is not effective.

The BarEnergy project (Emmert et al., 2010) identified a range of barriers to energy efficiency refurbishment. In line with the research conducted by the Energy Saving Trust (2010a;b), focus groups discussions suggest that consumers are often unaware of the possibilities of making existing houses more energy-efficient. Although focus group participants indicated that there is a lot of information available about energy efficiency, they struggled to understand all of the issues. Furthermore the motivation to take action was principally guided by a cost-benefit calculation. Individuals said they were more likely to install energy efficiency measures if they were able to discern what the benefits would be in financial terms. Perhaps counter-intuitively, focus groups conducted in the UK identified the provision of free measures through government and energy suppliers as a social barrier to make investments themselves. That is, consumers expressed a diminished willingness to pay for measures that are provided for free to others. Individual-psychological barriers identified in the BarEnery project included the low priority people give to energy issues, and the invisibility of energy. When people refurbish their houses they invariably want to see the results of their investments, and are therefore more likely to invest in – for example – a designer kitchen than an energy-efficient heating system. Whereas a new kitchen or bathroom suite is highly visible, energy efficiency measures are often not (Emmert et al., 2010). Again, the invisibility of energy use provides a challenge to would-be intervenors working within a social psychological framework (see section 3.4).

With regard to the question as to whether consumers are willing to invest in home efficiency measures, Skelton et al (2009) conducted a number of focus groups, in-depth interviews, and an online survey among homeowners. As shown in other research, most people think that climate change is caused by energy use and say that they do a few small things (39%) or quite a number of things (26%) to help reduce their energy use. Using a conjoint analysis technique, Skelton et al (2009) found that the most important element in homeowners' decisions to invest in energy efficiency measures is the price, followed by the specific technology that is used to save energy. The payment method (type of loan), incentive given (e.g., tax rebate), and monthly repayment were less important attributes of the packages. Additional qualitative work showed that the payback time is another important aspect of the uptake of energy efficiency measures, with householders automatically discarding options that have long payback periods. With regard to the uptake of low and high cost home efficiency measures, many of the low to medium cost measures, including energy saving light bulbs, double glazing, loft insulation, and draught proofing of windows and doors, had already been installed by householders themselves or were present when they moved there; fewer people had considered purchasing 'mid range' condensing boilers or cavity wall insulation; and most householders had never considered more costly measures, such as internal/external wall insulation, triple glazing or microgeneration (biomass, wind, ground source heat pump; also see section 4.2.5). Interestingly, although about one in three indicated that they had considered micro solar water heating or solar electricity, virtually no-one had actually installed microgeneration. (See e.g., Defra/EST 2009: of the 1,335 respondents, 4 had installed solar photovoltaics, 19 solar thermal, 2 wind turbines, and 8 ground source heat pumps.) In line with other research, Skelton et al (2009) identified the (perceived) purchase costs as the main barrier to installing key energy efficiency measures, and to a lesser extent uncertainty over the amount of energy saving and payback time, the 'hassle factor', and a lack of knowledge. Potential motivators that would make people want to incorporate energy efficiency measures in their home were government grants and incentives (mentioned by about two out of three), followed by increased comfort of the home and assurances about the installation costs and payback time. The research further highlighted the importance of 'trigger points', such as renovation work, adding extensions, and moving house, when people are more likely to consider installing additional energy efficiency measures.

Qualitative group discussions organised on behalf of the Department of Energy and Climate Change (COI, 2010) largely mirrored the findings of the other quantitative and qualitative work discussed here. The results show that homeowners see the planning process as a major barrier to home improvements. The time taken to research home improvement options, making decisions, and arranging the work was often considered more stressful than the hassle and disruption that the work itself would bring. Moreover, many had negative experiences with DIY and felt they had learned to be risk averse of using professionals. Home insulation was not top of mind among those who took part in the research and were generally not aware of the benefits or the planning process. Even among homeowners who claimed to be very engaged with home energy efficiency there was a lack of awareness about the potential benefits. Despite this lack of awareness, many expressed a great deal of interest in home energy efficiency and how it could benefit them. The research showed that the majority of homeowners taking part in the research grossly overestimated the initial costs of home insulation; and also overestimated the scale and complexity of the work. The research further showed that 'the home' plays a very important and emotive role in homeowners' lives, and that 'warmth' was the term most commonly used by householders to express what they try to achieve when investing in their homes. Furthermore, they claimed that they were prepared to invest a great deal of time and money into home

improvements (COI, 2010). Based on the findings of the study, the authors suggested that home insulation should be repositioned as a normalised behaviour as part of 'need to do' home improvement work, as well as something that 'keeps the warmth in' alongside the more familiar positioning of double glazing ('keeping the cold out'). Homeowners that took part in the discussions indicated that such a repositioning would give home insulation a sense of necessity that it currently lacks. Research by Caird et al. (2008) supports this conclusion. They found that, alongside saving energy, reducing fuel bills, and concern for the environment, loft insulation was installed because of a desire for a warmer home.

Although a lot of research is conducted on general public attitudes to energy use and efficiency, less is known about people's experiences with sustainable technologies in the home. Pickvance (2009) found that residents of two sustainable housing developments were generally satisfied with the features and costs of their housing or had 'no strong feelings'. In both developments residents were most satisfied with heat insulation and double/triple glazing, and slightly less positive about the heating system. People were less satisfied with other housing features that did not directly relate to the energy efficiency of the home (e.g., size and construction).

Another issue that needs further investigation is the effectiveness of energy-efficiency strategies to reduce household energy. In many cases the installation of energy-saving technologies does not lead to the theoretically achievable energy savings as a result of so-called 'rebound' or 'take back' effects from the increased consumption of such goods (Roy et al., 2007). For example, about 60% of users said that their wood stove heated one or more rooms to a higher temperature (ibid). This 'expansion of living space' means that the savings from greater energy-efficiency is partly or completely cancelled out. According to Boardman (2004), consumers choose a mixture of higher living standards and energy conservation when installing energy-efficiency measures.

Rebound effects and inappropriate or sub-optimal use of energy technologies are still poorly understood. Future research should therefore not only investigate the aspects of public attitudes that are important for the adoption of energy efficiency products and systems, but also the behavioural implications of these technologies in order to assess their effectiveness in reducing carbon emissions.

One way of encouraging householders to take into account the energy efficiency of homes is by providing information about the energy performance of buildings. Since 2007, every house being sold in England and Wales with three or more bedrooms needed a Home Information Pack (HIP) which included a home energy rating. Although from May 2010 there is no longer a requirement in England and Wales for a HIP, all homes in the UK still need an Energy Performance Certificate (EPC) when sold, built or rented. The certificate provides energy efficiency ratings on a scale from A to G, and also includes recommendations for improvement.

Qualitative work on the public understanding of sustainable energy consumption in the home (Defra/Brook Lyndhurst, 2007) found that on the whole EPCs were not well received, for a variety of reasons. Participants saw EPCs as an infringement of their civil liberties, and also resented the additional costs which they feared would affect the housing market and the ability to sell their homes. Individuals resented the mandatory nature of the EPC, and saw that as an example of government intrusion into their lives. Many participants saw the EPC as a means of taxation. The only group who were broadly positive to the introduction of EPCs were the 'Currently Constrained', plus a few 'Greens' (see DEFRA, 2007b). This may be

because it was one of the few ways that landlords and builders could be forced to make pro-environmental choices.

Banks (2008) conducted, as part of an extensive investigation of the implementation of EPCs in the domestic sector, structured interviews with key stakeholders, including householders. The findings reflect those found in the research by Defra/Brook Lyndhurst (2007). Banks (2008) found that householders were unanimous that they would not use the information in the EPC prior to sale, and would not implement the recommendations in the EPC. Many sellers expressed the view that the energy performance of a house does not affect its value, that the installation of energy efficiency measures is something that should be left to the new occupant, and that some of the recommendations are inappropriate. These findings suggest that very few sellers will implement EPC recommendation prior to sale. Banks (2008) concludes that the EPC may be accepted by the seller as a necessary requirement, but is seen as something without clear use. Also among buyers there was little interest in the EPC, as they claimed that energy performance of the home has no major influence on their decision making.

Overall, none of those consulted in Banks' (2008) research had a positive attitude to the EPC or HIP, and could at best be interpreted as a resigned acceptance of the need for it as part of new regulation. It has to be noted that misgivings about the Home Information Pack tainted public attitudes to the EPC (Banks, 2008) and that it is difficult to isolate people's feelings about EPCs from their aggravation at being forced into action through regulation. It may be that now the HIP is no longer obligatory in England and Wales, public attitudes to the EPC have become more positive. Furthermore, it has to be considered that the research by Defra/Brook Lyndhurst (2007) and Banks (2008) was undertaken before the recent rises in energy prices. Whereas Defra/Brook Lyndhurst (2007) and Banks (2008) found that most participants did not think that the EPC would influence their decision to buy or rent a house, more recent research by the Energy Saving Trust found that about one in three (one in four in Wales) agreed that their decision on which house to buy or rent would be influenced by information on the EPC (EST, 2010c; EST Wales, 2009). Furthermore, a substantial minority (44%) reported that they would ask an estate agent or seller questions about the EPC, and even more than half (53%) would try to pay less for a home with a poor EPC (EST, 2010c). This reflects the earlier reported findings that many people think that an energy-efficient home to be worth more when sold because it saves on heating bills (ibid).

5.2.5 Energy efficiency in travel and transport

Little UK research has been conducted on the topic of public attitudes to energy-efficient and/or low emission vehicles. Although there have been continuous improvements in vehicle efficiency over the years, most of the (potential) energy savings have been offset by increases in vehicle weight and use. There are very few known examples of energy-efficient and/or low emission cars that many consumers would consider an alternative for their current less efficient one; and only few know which cars have the lowest emissions (EST, 2010c). Indeed, buying a low emission vehicle, such as a hybrid, electric, biofuel, or less than a1.4l engine, is among the least common pro-environmental behaviours in the UK (Whitmarsh and O'Neill, 2010). Less than 1% of vehicles on the road are alternative fuel/engine vehicles (i.e., electric, hybrid, biofuel, LPG; Defra, 2009). The EST/DEFRA survey (2009) shows that a substantial proportion of current drivers has either never thought about switching to or never heard of an electric/hybrid or LPG car (27%) or said they probably will not or do not want to switch (53%). Only 15% said they were thinking about switching to an electric, hybrid or LPG car. Slightly more car drivers said that they were thinking about buying a more fuel efficient, smaller, or diesel car (27%), while 26% said they had already

done so (ibid). Research by the Energy Saving Trust (EST, 2010c) shows that about two-thirds of the adult UK population would like a car with low carbon emissions if they could afford one and about three out of four would consider fuel efficiency an important factor when buying their next car, only around one in four would consider an electric car the next time they buy a new car. Furthermore, just under half of the respondents didn't know whether they could use an electric car where they live. Although more agreed that the image of electric cars had improved, few thought it can now perform as well as a conventional car for many types of travel (ibid).

Research by the Department for Transport (DfT, 2010) shows that many consumers expect the government to take the lead on energy efficiency in travel and transport. More than eight in ten adults agreed that the Government should do more to persuade people to buy more fuel efficient cars, although the proportion supporting this has reduced somewhat from 87% in 2006 to 81% in 2009. The British Social Attitudes Survey also shows that a clear majority agree with the statement that environment-friendly car drivers should pay less (Park et al., 2008).

5.3 Energy consumption and conservation

5.3.1 Introduction

In this section we review the literature pertaining to the UK public's energy use and responses to curtailment (i.e., conservation) measures. This literature is large, so again we focus on recent and notable studies, primarily from the UK. We include both direct energy conservation associated with domestic and transport activities (sections 5.3.4 and 5.3.6), but also indirect energy use from shopping, eating and waste behaviours (section 5.3.5). We also cover public responses to energy conservation measures and policies in section 5.3.7.

5.3.2 Energy consumption

Energy use is primarily driven by economic (income, cost, etc.), structural (location, home ownership, household size, etc.), and social factors (status, meaning, identity, etc.) and by everyday (consumption) practices and habit; environmental values tend to have relatively little influence. This finding resonates with a range of theoretical perspectives including the expectancy-value, habit, social practice and identity-based theories of behaviour reviewed in section 3. Income is a key driver of energy use, with higher earners tending to use more energy at home (Brandon and Lewis, 1999; cf. Poortinga et al., 2004) and to drive and fly more (Emmert et al., 2010). Consistent with this, we see energy consumption rising in recent years in line with household income; in particular, transport energy demand has doubled since 1970 (Figure 5.2). However, there is an interesting asymmetry in this respect; as household income falls (e.g., following retirement), energy use - at least for travel - tends to remain at its existing level for some time (Goodwin et al., 2004). This highlights the role of habit and social practices in maintaining energy-using behaviours, and points to the importance of seeing energy use as not merely an economic behaviour[5]. Growth in energy use is also linked to increased number of appliances in homes, which further serve to 'lock in' patterns of energy consumption behaviour (Mansouri et al., 1996). As indicated earlier, this highlights the importance of influencing energy efficiency behaviours as well as conservation behaviours.

[5] The economics and other social science literatures on energy consumption are still, however, largely separate (e.g., van den Bergh, 2008).

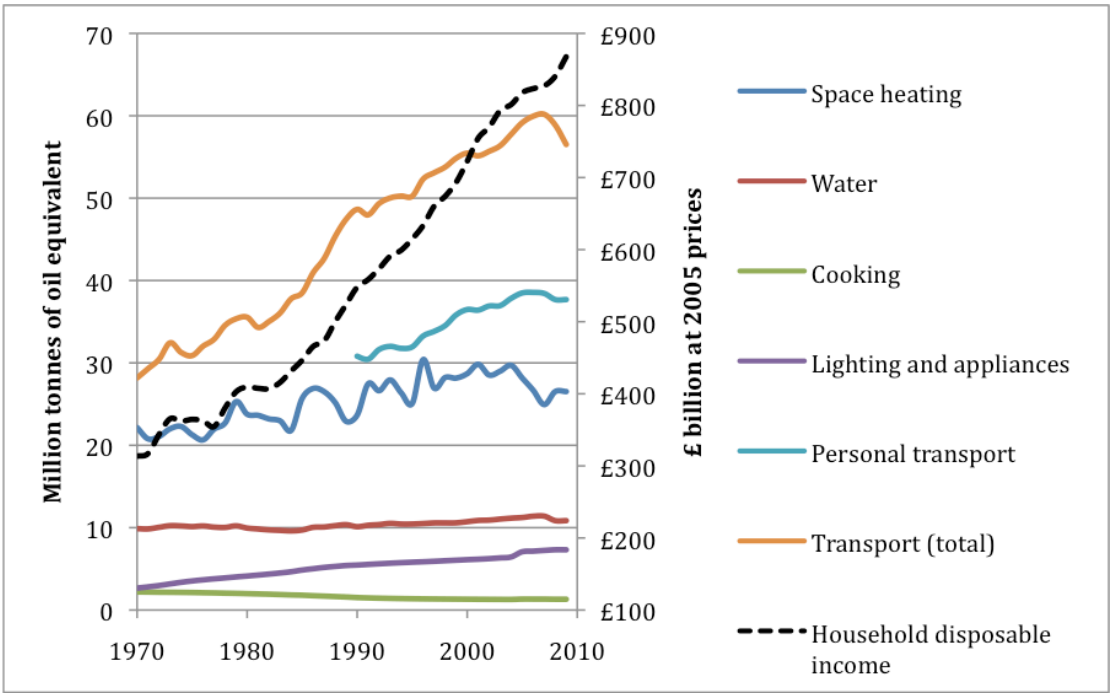


Figure 5.2. Rising UK energy consumption and income (based on DECC, 2010b)

It would be misleading to assume that all, or indeed the bulk of, everyday energy use behaviour is financially driven, or even necessarily rational. Research shows very strongly that energy use and travel behaviours can, and often do, move quickly from considered deliberations over perceived personal costs and benefits to the more habitual sphere (Bamberg and Schmidt, 2003; Gardner and Abraham, 2008). Habits can be low-carbon (e.g., cycling to work every day) or can impede low-carbon lifestyle change. For example, survey work has found that 'habit' is the most common reason given for not switching off lights and appliances (Emmert et al., 2010). This has implications for behaviour change strategies, as we discuss later. Similarly, qualitative research highlights that energy use is taken-for-granted and households often have little awareness of their daily or monthly energy use (Defra/ Brook Lyndhurst, 2007). The 2008 SEABS survey, for example, found one-third were unable to estimate their energy use, while most felt they could estimate their monthly bills to the nearest £20 (Scottish Government, 2009).

Research also points to the importance of identity, lifestyles, social practices and norms in driving everyday, 'unthinking' energy use. For instance, comfort has been shown to be a key consideration for domestic heating (Gatersleben and Vlek, 1998; Harrington et al., 2005; COI, 2010); while decisions about lighting and home appliance use are bound up with social identities and lifestyles and related to assumptions about quality of life and prosperity (Poortinga et al., 2004; Layton et al., 1993). Concerns underpinning energy choices may also include re-sale value of one's property, aesthetic qualities of energy equipment, self-image, status or personal comfort (Layton et al., 1993). Such diverse concerns can result in energy consumption behaviour that is seemingly inconsistent or 'irrational' - i.e. someone might save electricity by cooking two meals at once, but keep the heating on 'for the cat' or open windows to 'air the house' (Layton et al., 1993). Social identity and values are also strong influences on travel behaviour and aspirations; qualitative research with 11-18 year-olds by Line et al. (2010) revealed that values of comfort, freedom, pleasure and social status determined the prevalent desire amongst young people to learn to drive and own a car. Other research indicates that car driving is seen as 'normal', 'necessary', an important

dimension of 'quality of life' (Chatterton et al., 2009; Black et al., 2001; Exley and Christie, 2002; Urry, 1999) and (particularly when used for leisure trips) is chosen because it is considered relaxing and enjoyable (Anable and Gatersleben, 2005).

Sociological studies of consumption similarly emphasise the inconspicuous nature of energy use. Consumption, according to this literature, is driven by: "wider cultural trends towards consumerism, insatiable wants transformed into 'needs,' shifting conventions of normality, increasing individualisation and the use of consumption to define the self, and (un)sustainable socio-technical systems of provision or supply" (Nye et al., 2010, p.702). This highlights the difficulty of changing consumption patterns in the face of socio-technical systems that 'lock in' consumers to various consumption practices (Geels, 2005) and points to the role of consumption in maintaining social conventions, lifestyles and identities (Shove, 2003; Hobson, 2002). Whilst electricity itself arguably has little symbolic value, its use is implicit in many of the material goods that are used to construct meanings and identities. For example, some families (including those in 'fuel poverty') like to project the image of an inviting and cosy home through maintaining a warm and well-lit house (Shove, 2003; Harrington et al., 2005). These 'hidden' drivers and meanings of energy use make it difficult for social actors to reflexively change energy systems or practices (Nye, 1998).

Energy use in transport is similarly driven by habit, social identity and practices, and economic considerations. Travel behaviour is an outcome of a complex set of psychological, social, economic, and infrastructural factors. Personal preferences for comfort, convenience, autonomy and so on, clearly play a role in transport choices (e.g., Whitmarsh, et al., 2009), as do less conscious determinants, such as social identity, symbolism and status associated with vehicle choice and use (Anable and Gatersleben, 2005; Steg, et al., 2001). Income and pricing of transport options are also important (e.g., Goodwin, et al., 2004), as are infrastructure and availability of alternatives (Köhler, 2006; Panter et al., 2008); those living in rural areas are most likely to drive because there are few alternatives available (DEFRA, 2002). Consequently, there are various barriers to changing lifestyles that prevent awareness of transport problems (see below) manifesting in behaviour change. Institutions and infrastructures serve to lock in carbon-intensive lifestyles, including car dependency. On the social and cultural side, norms and conventions serve to reinforce the value of automobility (Urry, 1999). At the same time, the built environment has developed around – and perpetuated – car dependence, contributing to widespread perceptions of limited (or unattractive) alternatives to driving (Lorenzoni, et al., 2007; Lyons, et al., 2008). The term 'behavioural lock-in' has also been coined (by Sanne, 2002) to describe the role of habits in restricting lifestyle change. Travel behaviour is often habitual, and as such difficult to change: individuals with strong car use habits do not consciously deliberate over travel choices or pay attention to information about alternative modes (Verplanken, et al., 1997).

5.3.3 Low-carbon and differential energy tariffs

Despite increasing choice in low-carbon electricity suppliers and the introduction of the Green Energy Supply Certification Scheme in 2010 to increase consumer confidence, to date there has been very low (estimated at 0.3%; Diaz-Rainey & Ashton, 2008) uptake of renewable energy tariffs by households. Awareness of green energy schemes is also relatively low: when shown a list of green energy suppliers' names or logos (e.g., British Gas' Energy for Tomorrow, Ecotricity), 63% of the English public said they were not aware of any of the companies/schemes and 83% had never used them (Haddock Research and Branding, 2008e).

Most suppliers charge a modest (5-10%) premium for a green energy tariff (Lipp, 2001). Spence et al (2010) found that just over half the British public were willing to pay a small premium for their electricity if it came primarily from renewables: 36% (rising to 45% in Wales) said £0, 34% said £2- £8 extra per month, and 31% said £10 and over. However, only 29% said they would pay a premium for their electricity to come primarily from nuclear power. Willingness to pay for renewable energy appears to have increased over the last decade; Batley et al (2001) reported only 34% in Leicester were willing to pay more (by, on average, 17%) for electricity generated from renewable sources, and also found that income was a significant factor for willingness to pay. US research on determinants of green energy consumption similarly shows it is positively associated with environmental values, household income and having few people in the household (Clark et al., 2003). The reasons for the disparity between willingness to pay for, and uptake of, green electricity – beside inevitable over-claiming of WTP and research effects (e.g., social desirability bias; see section 3) – include cost of tariffs, limited information on green energy, effort involved in switching supplier (switching 'inertia') and low levels of public trust about claimed environmental benefits of green energy schemes (Diaz-Rainey & Ashton, 2008).

Research has also examined public responses to differential tariffs, which can help spread demand and – through more conscious decision-making about when to use energy – reduce overall demand. In qualitative research (Defra/Brook Lyndhurst, 2007), many participants thought these tariffs were a good idea due to cost savings, although awareness of these schemes was low and some disliked the idea of changing their patterns of energy use.

5.3.4 Domestic energy conservation

Attitudes are broadly, though not unequivocally, positive towards energy curtailment behaviours. Given the important social and cultural meaning of 'home' (as safe, comfortable, self-expressive, etc.), the public in some cases see domestic energy saving as threatening (Linguistic Landscapes, 2009). Some begrudge being admonished for using energy for entertainment or comfort purposes or feel energy saving devices, such as smart meters, can be intrusive in this private domain (Defra/Brook Lyndhurst, 2007; Emmert et al., 2010). Control over home temperatures is important to many; and some (21%) claim they do not like to wear layers indoors (Defra, 2009). (Here, it is worth reflecting that these 'attitudes' may be stronger expressions of socially-constructed norms and meanings - e.g. wearing layers, parental standards - than individual 'choice'). Others may feel the effort involved in conserving energy is too great, be reluctant because they perceive others are not cutting down on energy, or be unaware of how to alter heating equipment or appliances to lower energy settings (Defra/Brook Lyndhurst, 2007; Defra, 2009; Emmert et al., 2010). On the other hand, many feel a strong moral and social obligation to save energy; and parents will often encourage their children to turn off lights and appliances (Emmert et al., 2010). The 2009 Defra UK survey found 81% agreed 'It really bothers me when I see people wasting energy or food'.

Willingness to change energy habits does appear to be increasing. EST (2010) survey data indicates the proportion of the UK public stating they are doing 'lots of things' or 'quite a number of things' to reduce their energy use and emissions increased from 19% to 38% between 2008 and 2009. More, however, say they are doing small things (32%), while one in ten say they are unwilling or unable to reduce their energy use (EST, 2010b). The proportion taking action in Wales is lower with only 27% claiming to be doing 'quite a number' or 'lots' of things to reduce their energy use; most of the remainder say they are thinking about or doing small things (54%; EST Wales, 2009). Consistent with this, a recent UK survey by Spence et al. (2010) found that 65% of people say they are prepared to greatly reduce their

energy use to help tackle climate change. It is noteworthy that this proportion claiming to be 'willing' to take significant action is much higher than the proportion making significant behavioural changes, according to the EST (2010) data described above.

It is important to point out that the surveys reviewed in this section measure self-reports of conservation behaviours, which may not provide an accurate reflection of actual behaviour (e.g., Defra/Brook Lyndhurst, 2007). Nevertheless, at the very least they do provide insights into changing attitudes and social norms in respect of conservation behaviours

Some energy curtailment behaviours now appear to be widespread, although there are interesting variations by type of behaviour and by region:

Lighting and appliances: According to a 2009 EST survey (2010), two-thirds (67%) of the UK public claimed to turn off unused lights, and 49% said they turn off appliances instead of using standby – a rise in each case of around 7% since 2007 (EST, 2010b). Alternative measures suggest these behaviours are not always enacted; half the population at least *sometimes* leave lights, heating or appliances on when not in use (Defra, 2009) and a minority (21%) say they are actually using less energy than 12 months ago (Scottish Government, 2009). Most people (84%) of households now say they only fill their kettle up with as much water as they need (Defra, 2009). The EST Wales (2009) survey similarly found that 75% turn off unused lights; but a much higher 70% claim to avoid using standby. In Scotland, 94% say they turn off lights in rooms that aren't being used, 83% avoid filling the kettle with more water than they are going to use, and 91% avoid using tumble driers in summer (Scottish Government, 2009).

Washing: The EST survey (2010) found only 29% wash their clothes at 30 degrees; according to Defra (2009), though, far more – 76% – wash them at 40 degrees. Most people (74%) only put on the washing machine with a full load (Defra, 2009). In Wales, 29% do washing at lower temperatures (EST Wales, 2009). EST surveys suggest poor awareness (9% unprompted) of the link between domestic water use and carbon emissions, despite two-thirds claiming to cut down on water use (EST, 2010b; cf. Defra, 2009). There appears to be scope to increase water conservation through metering since most (67%, rising to 95% in Scotland) do not have a water meter. However, at least in Scotland, public opinion is split on whether they would be prepared to install a meter (Scottish Government, 2009).

Heating and cooling: Two-thirds of the UK public (65%) say they have turned down their thermostat by 1 degree or more (Defra, 2009; cf. Emmert et al., 2010). In Wales, by contrast, only 30% turn down their thermostat by 1 degree or more to save energy (EST Wales, 2009). In Scotland, 73% turn off the heating when they go out for a few hours in winter (Scottish Government, 2009). Currently, there appears to be relatively little demand for domestic air conditioning in the UK (though little research has examined this). Haddock Research and Branding's (2008a) English survey found only 20% (rising to 31% in London) "(would) like to use air conditioning in the summer".

It would appear that actions to save electricity for lighting are more popular than heat- and washing- related energy saving actions. This conclusion is borne out by qualitative research on energy use, which has found that, in contrast to other areas of domestic energy use, for heating "comfort and warmth took precedence over financial considerations" (Emmert et al., 2010, p.32). Cleanliness is also an important value in driving domestic energy (and water) demand (Shove, 2003); for example, 48% of English people believe that washing at 30 degrees does not wash clothes properly (Haddock Research and Branding, 2008a). To our

knowledge, willingness to save energy associated with cooking behaviours has not been covered in UK research (though see Emmert et al., 2010 for some European work on this).

Consistent with the importance of economic drivers of energy consumption, financial considerations are a key motivator for energy saving behaviours (Brandon and Lewis, 1999; DEFRA, 2002, 2010; Defra/Brook Lyndhurst, 2007, 2009; Reeves, 2010; cf. Ek and Soderholm, 2010). In an English survey in 2003, Whitmarsh (2008), found that turning off unused lights is most often motivated by a desire to save money. In a 2008 Scottish survey, most (67%) of those claiming to use less energy than a year ago said this to save money, while few saved gas or electricity for environmental reasons (13% and 16%, respectively; Scottish Government, 2009). More recent EST research (2010) similarly finds that the current economic recession is influencing consumers' willingness to save energy with 65% saying they are more interested in energy saving for this reason. Financial motivations are more important than environmental ones, even for those living in eco-friendly social housing (e.g., BedZed; see Reeves, 2010).

Unsurprisingly, at least in light of the so-called 'value-action gap' (e.g., Blake 1999; Kollmuss & Agyeman 2002 – as discussed in the Theory section at 3.2.3 above) environmental concerns are less significant predictors of energy conservation behaviour (Whitmarsh, 2009a). Consumers are unlikely to characterise energy use as a moral/ environmental issue (see also Black et al., 1985; Kurz et al., 2005; Poortinga et al., 2004). EST (2010) found that only 49% now say they feel a growing pressure to change their lifestyle to reduce their impact on climate change, compared to a peak of 75% in 2006. (This corresponds with a decline in public concern about climate change noted by Spence et al., 2010 and others, which may be due to recent cold weather, the 'climategate' controversy, and more pressing economic concerns). This differs according to environmental values, of course, with those classified as 'deep greens' or 'positive greens' more likely to be motivated by environmental concern (Scottish Government, 2009; Defra, 2009). Those in higher social grades and women also tend to be more motivated by environmental concern to reduce energy consumption (Defra, 2002).

Although motivations for energy conservation have been found to different according to values and demographic variables, there are no clear divisions between 'energy conservers' and 'non-energy-conservers' along demographic lines. For example, those aged 18-24 are least likely to regularly cut down household electricity/gas (35%), but most likely to use alternatives to driving (47%; DEFRA, 2002). This is likely to be because many conservation behaviours are undertaken at the household, rather than individual, level, which obscures individual-level differences.

5.3.5 Shopping, eating and waste behaviours

Druckman and Jackson (2010) estimate that over three-quarters of UK emissions come from household consumption, including direct and *indirect* emissions. Indirect, or 'embedded', emissions are those associated with the production, transport and disposal of goods. Given the considerable environmental impact of embedded energy, we include here discussion on public attitudes to consumption and waste.

There appears to be support amongst the UK public for buying local and seasonal produce, with 73% in the UK (65% in Wales) claiming to make an effort to buy things from local retailers and suppliers, and 60% (54% in Wales and 52% in N. Ireland) saying they buy fresh food that has been grown when it is in season (Defra, 2009). Three in ten (29%) say they grow their own fruit and vegetables (Defra, 2009). One-third in Scotland, say they buy as

much local produce as they can, though only 9% visit farmers markets (Scottish Government, 2009). For those who do not currently buy seasonal food, the largest proportion (38%) say they would if it was the same price or cheaper than alternatives (Defra, 2009). More generally, 50% of the English public say they buy 'environmentally-friendly products' (Whitmarsh et al., 2010a).

In respect of diet, 59% in the UK (dropping to 48% in Wales) say they are willing to change their diet to reduce their environmental impact (Defra, 2009). However, it would seem that this willingness depends on the type of change required. For example, a 2008 English survey found that only 9% claimed to 'always' avoid eating meat and 57% said they 'never' do (Whitmarsh et al., 2010a). Qualitative work commissioned by Defra (Defra/Opinion Leader, 2007) found that food purchase decisions involve a complex interaction of factors such as convenience, cost, health, habit, offers, taste and availability; but sustainable food production and consumption is rarely considered. For environmental, social and health reasons, many (particularly those in rural areas) support eating local and seasonal food and agree on the need to avoid food waste. However, most find the suggestion of adopting a low-impact (e.g., low meat and dairy) diet unacceptable. However, the proportion acknowledging the link between food production and climate change is not high (57%); and 65% (rising to 73% in Wales) know nothing at all about adopting a 'low impact diet' (Defra, 2009). In general, public understanding and social acceptability of a low-carbon diet, appears to be relatively under-researched despite this potentially offering considerable emissions savings.

Avoiding waste is widely and increasingly accepted as a social and moral obligation across the UK. In 2009, 71% in the UK (80% in England) agreed that ''Waste not want not' sums up my general approach to life' and 88% agreed 'people have a duty to recycle' (Defra, 2009). Consistent with this, most people do not like to waste food, 60% agreeing that it 'bothers them' to throw away uneaten food. In terms of waste behaviours, recycling is now very widespread - 91% of the UK public claim to recycle (up from 70% in 2007; Defra, 2009). Defra (2009) also find that reuse is becoming more common with 83% taking their own bags when shopping and 75% claiming to reuse "items like empty bottles, tubs, jars, envelopes or paper" (though reuse of other items, e.g., batteries and gift wrap is much lower: Scottish Executive, 2008). However, only 30% avoid buying products with too much packaging (Defra, 2009; see also Haddock Research and Branding, 2008a). Most (87%) say they 'waste less food', an increase from 64% in England in 2007 (Defra, 2009).

Influences on waste behaviours have been the subject of considerable empirical research, and include individual, social and structural factors (e.g., Schultz et al., 1995). When asked for the reasons why they recycle, most people cite the environment (Whitmarsh, 2009a). However, while recycling behaviour is often positively associated with environmental values, is it also influence by house size (Barr et al., 2003); availability of recycling facilities (Gonzalez-Torre and Adenso-Diaz, 2005; Barr et al., 2003; Derksen and Gartrell, 1993); and availability of information about what/when/how to recycle (Barr et al., 2003). Determinants of eco-friendly consumption include socio-economic factors, such as gender, education and income, with green consumption positively associated with higher education and income, and being female (e.g., Brecard et al., 2009) as well as environmental values (Whitmarsh and O'Neill, 2010). Status also appears to be an important driver of purchasing eco-friendly products (Griskevicius et al., 2010), with shopping for material objects (unlike energy or water use) a conspicuous form of consumption and more likely to be an expression of identity (Belk, 1988; Dittmar, 1992). Habit is also an important determinant of shopping,

including eco-shopping, behaviour and of waste behaviours (Honkenen et al., 2005; Holland et al., 2006).

5.3.6 Travel behaviours

Although the vast majority of the public agree that action should be taken to tackle climate change and transport problems, most see the government rather than individuals as responsible for taking action (Whitmarsh, 2009b; Whitmarsh, et al., 2009; Xenias and Whitmarsh, 2010; Bellaby et al., submitted). Consistent with this, there is more support for new technologies or policies to encourage behaviour change (e.g., improved public transport) – termed 'pull measures' (Eriksson et al., 2008) – than 'push measures', such as increased taxes or tolls which might restrict individual freedom (Poortinga, et al., 2006; Anable et al., 2006; King et al., 2009; Haddock Research and Branding, 2008c). Most oppose increased road or fuel taxes (64% and 71%, respectively; Haddock Research and Branding, 2008c). There is more support for restricting expansion of airports (47%) than for raising taxes on flying (32%; Haddock Research and Branding, 2008c). Most also do not support congestion charging; for example 55% oppose it in Scotland (Scottish Government, 2009) and 43% in England (Haddock Research and Branding, 2008c). However, attitudes have become more positive in London since the introduction of the congestion charge, suggesting experience of a successful scheme can change opinion (Downing & Ballantyne 2007; Richards, 2006). Similarly, King et al's (2009) qualitative research found that willingness to change travel behaviour became more positive after deliberation and particularly following consideration of personal benefits (health, financial, time) accruing from combining trips, eco-driving or using more local facilities.

In general, there is resistance to changing travel habits, a finding which is consistent across countries (e.g., US: O'Connor, et al., 2002). When asked about personal lifestyle changes to reduce their environmental impact, most people state they are recycling and conserving energy use in the home, but a minority say they have changed their travel behaviour (DEFRA, 2002; Whitmarsh, 2009a). This is despite widespread acknowledgement that individuals 'have a responsibility to do more than switching off unnecessary lights and equipment, and recycling as much as you can' (92% agreement; Warwickshire Observatory, 2008). In the UK, only 21% (rising to 24% in Wales) car share, while the same proportion state they would not want to. Many (60%) claim to have switched to 'walking or cycling instead of driving for short, regular journeys', while only one-quarter have switched to public transport for regular journeys (Defra, 2009). In England, 6% 'always' use alternatives to travel (e.g., shopping online) while 39% never do (Whitmarsh et al., 2010a). A notable 50% say they 'would only travel by bus if I had no other choice'; furthermore, only 23% agree that 'for the sake of the environment car users should pay higher taxes' (Defra, 2009). Research on attitudes to and adoption of eco-driving suggest this is more acceptable than reducing car use with 77% claiming to drive in a 'fuel-efficient way' (Defra, 2009). In Wales, 55% of drivers stated they would drive more efficiently if they had more information on how it would save them money (EST Wales, 2009).

Resistance to cutting down on flying is at least as prevalent as resistance to using alternatives to driving. In the UK, 41% have taken a holiday/leisure flight in the last 12 months (work trips are less common at 17%, according to Scottish data; Scottish Government, 2009), of which over one quarter (27%) were internal UK flights (Defra, 2009) and most others were within Europe (Haddock Research and Branding, 2008b). A minority of Britons (24%) say they have reduced the number of flights they are taking, while more (35%) would not want to and many others (23%) have not thought of it (Defra, 2009). Haddock

Research and Branding (2008b) similarly found over 80% of the English public would not replace flying with video- or tele- conferencing.

Resistance to changing travel behaviour is not primarily due to lack of awareness of problems associated with transport, since there is high public awareness of and concern about transport-related, such as air pollution and congestion levels (Lethbridge, 2001; DEFRA, 2007b; Bellaby et al., submitted). A majority of the public also appears to acknowledge the link between transport and climate change (DEFRA, 2002; King, et al., 2009) particularly when shown a list of possible causes (e.g., Whitmarsh, et al., 2010a). However, unprompted awareness of the links appears to be lower (Whitmarsh, 2009b), as is awareness of the relative contribution of different transport modes to causing climate change (DfT, 2009). For example, there is more recognition that car travel contributes to climate change than air travel (Anable et al., 2006). Furthermore, the Scottish public more commonly identify waste behaviours than travel behaviours as the most effective ways of tackling climate change (Scottish Government, 2009).

Although there is more awareness of the role of transport than of domestic energy use in contributing to climate change, when presented with a list of energy-reduction actions the public is more willing to reduce domestic consumption than to drive or fly less. Indeed, one Welsh study (Bibbings, 2004) even found motorists were *more* aware than non-motorists of the role of driving in contributing to climate change (though they may be less worried about it; Bellaby et al., submitted); while an English study (Barr et al., 2010) found that those who are most environmentally conscious tend to fly the most (though see Haddock Research and Branding, 2008b, for divergent results). Clearly, this demonstrates that there is a gap between awareness and concern on the one hand, and behaviour on the other (the 'value-action gap'; Blake, 1999). This gap is often most apparent amongst well-off, environmentally-aware sections of society, which has led the notion of a 'sustainable lifestyle' to become bound up in identity politics and to claims that middle-class proponents of green lifestyles are 'hypocrites' (Barr, 2010).

Common reasons for not changing travel habits include perceived inconvenience, unavailability or unattractiveness of public transport (Scottish Government, 2009), and safety concerns about alternatives, such as cycling (Emmert et al., 2010; Black et al., 2001; Davies et al., 1997). There is more willingness to consider making adjustments to trip patterns than changing mode of transport used (King et al., 2009). In contrast to domestic energy use, few people feel socially obliged to reduce car use (Emmert et al., 2010; King et al., 2009; Anable, 2005). Similar to heating behaviours, though, there are clear cultural and social associations with travel behaviours; in particular, many enjoy the flexibility, autonomy, comfort, and privacy of travelling by car which are not offered by car-sharing or public transport (Emmert et al., 2010; King et al., 2009; Bellaby et al., submitted). Defra's (2009) evaluation of the Environmental Action Fund projects found that changing travel behaviours was considered the hardest of all possible lifestyle changes by participants.

When asked why they had not taken alternative modes of travel (e.g., rail) to an internal flight, most Scots claimed flying was quicker, or most convenient (74%), or cheaper than alternative options (27%; Scottish Government, 2009). Qualitative research also suggests willingness to consider cutting down on flying is reduced because politicians and celebrities are seen to fly frequently (King et al., 2009), pointing to the social dimensions of environmental problems (Sustainable Consumption Roundtable, 2006) as well as the (socially-constructed) meanings of social practices. Many also value the social and cultural

capital afforded by tourist travel, as well as the opportunity to have a break from domestic commitments including energy-saving habits (Barr et al., 2010).

Amongst those who have changed their travel habits to use alternatives to driving, the most commonly reported motivations include tangible benefits such as health (from walking/cycling), saving money or convenience (e.g., lack of parking facilities), while environmental considerations may be a secondary factor (Whitmarsh, 2009a; Bellaby et al., submitted). In respect of determinants of low-carbon travel behaviour, location, income and (to a lesser extent) values are important. Those living in urban areas are more likely than rural dwellers to use alternatives to driving, and to feel more socially obliged to do so (Emmert et al., 2010). Lower income groups and those with left-wing political preferences are also more likely to use alternatives to driving (Emmert et al., 2010; Exley and Christie, 2002). Those with strong pro-environmental values are more willing to consider changing travel habits, and this seems to be linked to a greater perceived responsibility for taking action to address environmental impacts of behaviour including climate change (King et al., 2009; Anable, 2005).

As with driving, flying behaviour is strongly correlated with income: amongst those with household incomes of less than £20,000, two-fifths never fly, compared to just 2% of those with £60,000+ incomes (Haddock Research and Branding, 2008b). Nevertheless, only 44% agree that 'people who fly should bear the cost of the environmental damage that air travel causes' (Defra, 2009). The public's low willingness to reduce flying seems to be accompanied by an acknowledgement that they may have to change in future: research with residents in Warwickshire found that while 53% were currently willing to 'set a limit on how much travel for pleasure you will do by aeroplane', 94% believed they would change in the next five years (Warwickshire Observatory, 2008).

5.3.7 Energy conservation interventions and policies

5.3.7.1 Introduction

Low-carbon lifestyles are nevertheless promoted by government through informational approaches (e.g., the 'Act on CO2' campaign, smart metering) and incentives to encourage uptake of low-carbon services (e.g., public transport; HM Government, 2009a, Ockwell et al., 2009). Local government, government agencies, the private-sector and non-governmental organisations are also important in promoting energy-efficiency and conservation behaviours. Ariel's 'Turn to 30' initiative, Energy Saving Trust campaigns and resources, and Global Action Plan's Ecoteams approach are amongst the many examples of UK low-carbon lifestyle change initiatives using information-based, economic, social and structural approaches (for a range of case studies see Whitmarsh et al., 2010b and EST, 2010b).

A number of reviews exist on how to encourage energy conservation behaviours (e.g., Abrahamse et al., 2005; Linden et al., 2006; Anable, 2005). Furthermore, the BarEnergy report (Emmert et al., 2010) maps out many of the informational, social economic and structural measures to overcome barriers to energy saving behaviour. Here, we focus on evidence of the efficacy of recent and ongoing interventions in the UK to encourage energy conservation.

5.3.7.2 Information-based approaches to encouraging energy conservation

Since much energy consumption is inconspicuous, habitual and routine, information campaigns to foster energy-saving habits will tend to have little effect (Verplanken et al., 1997, 1998; Abrahamse et al., 2005). Nevertheless, more targeted information-based

interventions can encourage individuals to consider their energy use and deliberate over alternatives (Verplanken and Wood, 2006; Defra/Brook Lyndhurst, 2009; EST, 2010b). For example, home energy audits can highlight areas where energy could be saved (Defra/Brook Lyndhurst, 2007). Giving individuals a hypothetical carbon budget can provide an opportunity for them to examine their choices and differentiate activities according to their personal and social importance and the availability of alternatives (Capstick and Lewis, 2010). More generally, information to encourage energy saving will be more effective if framed around more tangible benefits (e.g., health benefits of walking/cycling, financial savings; Emmert et al., 2010; Ek and Soderholm, 2010) and intrinsic goals (e.g., social relationships; Crompton, 2010), and if offering practical, tailored advice (Defra/Brook Lyndhurst, 2009).

While awareness of carbon terminology is rising amongst the public (Defra, 2009), there remains a tendency to consider carbon in abstract terms or associated with other people's or institutions' (e.g., industrial) activities rather than one's own actions or lifestyle choices (Whitmarsh et al., 2010a). Consistent with this, there is low awareness of the relative contribution of different activities to causing climate change (Whitmarsh et al., 2010a; Attari et al., 2010), confusion associated with emissions-related terminology (e.g., carbon dioxide, carbon, carbon equivalent) and difficulty visualizing quantification of emissions (Anable et al., 2006, DfT, 2007; Upham et al., 2010b), along with general low salience of climate change, energy and sustainability in individuals' day-to-day choices and actions (e.g., Macnaghten and Jacobs, 1997, Whitmarsh, 2009a). The EST Wales (2009) survey reported that a sizeable minority (19%) find their energy bills very hard to understand, and do not understand the link between usage and amount charged on their energy bills. Informational tools, such as carbon calculators, carbon labelling, tailored energy bills, and real-time energy displays, are increasingly being used to help make energy more personally relevant and visible.

Smart meters: Electricity and gas smart meters are due to be rolled out across the country by 2020 (DECC, 2009c). The term 'smart meters' encompass a range of technologies, but broadly refer to real-time or near real-time sensors (and often displays) which provide users/providers with more information and potentially control (Darby, 2010). Assessments of energy smart meters show they can help 'rematerialise' energy (Burgess and Nye, 2008) and lead to energy savings of 5-15% (Darby, 2006; see also Faruqui et al., 2010, for a US review). There appears to be widespread public support for smart meters (e.g., Defra/Brook Lyndhurst, 2007): in Wales, 96% of people would use a smart meter to help reduce their heating bills (EST Wales, 2009). In terms of particular designs, there is a clear preference for informational feedback in monetary terms, which is more meaningful than carbon or energy units (e.g., Kw/h) saved, and for more simple designs (EST, 2009). Trials have also found that advice and demonstration when the device is installed is important; after this, the vast majority find them easy to use (EST, 2009, 2010). However, as Hargreaves (2010) shows, this type of information provision may be counter-productive if it results in individuals feeling guilty about consumption which they feel unable to reduce, or otherwise disempowered, disinterested or cynical about such attempts by government to 'educate' the public by locating responsibility for climate action with individuals.

Carbon labelling: Although carbon labelling is not mandatory, several major firms (e.g., Pepsico, Tesco) are working with the Carbon Trust to develop and trial carbon labels for certain products. Recognition of the label is not yet widespread: in 2008, Haddock Research (2008f) found the logo was recognised by 9% of English adults, while only 2% claim that it has had an impact on their behaviour. Awareness and impact is highest amongst older and

more environmentally conscious individuals. Upham et al (2010b) found that public support of carbon labelling of products is moderated by scepticism about the motives of companies involved. Finally, Beattie et al. (2009) have examined attitudes towards low-carbon products and carbon labelling. Psychological experiments of consumers' visual attention indicate that carbon labels are rarely the first part of a product that is looked at; the carbon footprint icon was the focus of first fixation of participants in only 7% of all cases (rising to 10% for energy-saving light bulbs, since they are more readily associated with being 'green', compared to products like orange juice or detergent). Furthermore, Beattie et al.'s study (2009) is a rare example of environmental research that examines both implicit and explicit attitudes (see section 3.2.1). They find that implicit and explicit attitudes to low-carbon products are generally very positive and highly correlated, but a subset of around 12% of the sample express divergent implicit and explicit attitudes. This group can be classified as 'green fakers' (i.e., their implicit attitude is much less positive than their self-reported, explicit attitude). The research also finds that under time pressure, implicit attitude is a better predictor of consumer product selection.

Carbon calculators: initial assessments of these tools show they can increase interest in reducing carbon emissions, although not necessarily produce actual behaviour change (Chatterton et al., 2009). This serves to highlight that the two goals of education and behaviour change are distinct (albeit potentially overlapping). There appears to be particular value in the provision of comparative information, so that individuals understand the relative contribution of different activities and how their lifestyles compare to others locally, nationally and globally (DfT, 2007). In this sense, relevant information is individually and socially contextualized. Carbon calculators will not necessarily motivate behaviour change where individuals are not motivated to change or perceive barriers to doing so. In some cases, these tools only serve to highlight the lack of individual control over potentially major carbon saving actions (e.g., lack of insulation in rented accommodation), and the minimal effect of other, directly controllable, choices (e.g., using energy-efficient light bulbs) (DfT, 2007). Currently, use of carbon calculators is low: in 2009, 7% in the UK said they used a carbon calculator (dropping to 3% in Wales) (Defra, 2009) although this proportion rose to 10% by 2010 (TNS, 2009). Also, note that both use and effects of carbon calculators drop off over time. Usage of other online information resources, such as travel planning tools, is similarly very low (King et al., 2009).

Advanced energy billing: DECC is about to launch a pilot to evaluate the impact of providing social comparison data (e.g., average consumption by households in the local area or by equivalent household size) on energy bills. While such norm-based messaging can influence energy behaviour (e.g., Rabinovich et al., 2010; Brandon and Lewis, 1999; cf. Siero et al., 1996) - often without recipients being aware of this effect (Nolan et al., 2008) - caution should be exercised when using comparative information since it can lead to a 'boomerang' effect, whereby those who consume less than the norm will tend to *increase* their energy use; while whose who do not identify with the comparator group will tend to ignore such information or react by acting differently to the implied norm (Rabinovich et al., 2010).

5.3.7.3 Economic, social and structural approaches to encouraging energy conservation

Inevitably, information alone will have limited impact on encouraging energy conservation. There also needs to be some motivation for changing behaviour. This may be intrinsic (e.g., environmental values, satisfaction or frugality; DeYoung, 1996) or extrinsic (e.g., financial gain). Economic measures are commonly applied to change behaviour, and the public often state they will change, or have changed, their energy use because of financial reasons (e.g., Defra/Brook Lyndhurst, 2009). The Durham road pricing scheme, for example, resulted in a

90% reduction of car use in the city centre (Dobson, 2003). However, where economic measures are inappropriately applied, they can lead to public protests, as in the case of the fuel duty protests in the UK in 2001. Participants in the BarEnergy project similarly expressed frustration at measures to discourage car use (e.g., car free zones, congestion charging) without improvements in alternative modes (Emmert et al., 2010). Greater success has been seen for transport demand management policies that are at once equitably enforced and provide viable alternatives to car use. Revenues from the London Congestion Charge have been used to enhance public transport within the city, thus providing attractive alternatives to car use. The scheme has largely been seen as a success, having reduced congestion without negatively affecting business, and (since its introduction) receiving support from much of the public (Richards, 2006). It is clear that fairness is a key characteristic of acceptable transport policies (King, et al., 2009).

Public attitudes to carbon policies (e.g., personal carbon allowances, carbon taxation, emissions trading) also indicate a critical role for perceived fairness and institutional trust (Jagers et al., 2010; Bird and Lockwood, 2009; Defra/Brook Lyndhurst, 2009). This work highlights the need to explore public acceptance of carbon management proposals in relation to broader social context and energy polices (e.g., investment in large-scale renewables; Wallace et al., 2010; Pidgeon et al., 2008a).

In general, attitudes towards carbon offsetting are more positive than negative, but there is nevertheless some ambivalence about the concept (Whitmarsh, 2008). Haddock Research and Branding (2008d) found that 43% in England agreed carbon offset schemes are a 'good idea', compared to only 16% who disagreed; but only 18% agreed such schemes work well, with most (59%) having no opinion on this. Indeed, many in the UK know little or nothing about offsetting: Defra (2009) found 61% know nothing about carbon offsetting, and a further 25% know 'just a little'. Again underlining that pro-environmental attitudes often do not lead to pro-environmental behaviours, it is notable that only 5% have ever paid into an offset scheme (0% in Wales and Scotland). The motivation for offsetting is mostly because it is believed to help the environment. Willingness to offset is higher for domestic than travel behaviours (Defra, 2009). However, amongst offsetters and non-offsetters alike there are concerns that offsetting discourages people from reducing their carbon footprint, or that carbon offset schemes are not effective in mitigating climate change (Whitmarsh, 2008).

Environmental concern may be enough to encourage some individuals to change their energy or travel habits, although often this will not occur until they are reconsidering energy/travel options for some other reason (e.g., due to moving house, or changing job). Verplanken et al (2008) for example found that environmentally conscious people are more likely to travel to work using slow or public modes if they have recently relocated, compared to environmentally conscious people who have not moved (and therefore may have strong driving habits). Often, the encouragement to change behaviour comes from external incentives, penalties or restrictions – for example, a free one-month bus pass, parking restrictions, or closure of a highway (Bamberg, 2006; Fujii, et al., 2001). Provision of free bus tickets with a targeted bus marketing campaign was found to be effective in one study in Leeds (Beale and Bonsall, 2007). In general, such interventions to encourage behaviour change tend to work best when targeted to moments in time when individuals are reconsidering their transport choices, and therefore 'unfreezing' their habits ('habit discontinuity'), such as when relocating or changing job (Verplanken and Wood, 2006). These psychological concepts also resonate with more sociological approaches based on disruption – albeit that practice theory begins with the assumption that change is the norm: practices being emergent (e.g., Giddens 1984).

Consistent with the literature on social learning and social identity (see section 3), lifestyle choices are influenced and constrained by membership of social groups (e.g., family) and communities, as well as by social systems of provision. This highlights the importance of examining carbon management decisions at the level of social groups, as well as by individuals. Group-based deliberation has been shown to lead to greater, more durable changes in behaviour than individual deliberation (e.g., Lewin, 1947), but critically this depends on the content of discussion which is strongly influenced by group members' values and social context (Duke and Morton, 2010). A supportive social context will have a greater potential to embed low-carbon choices and habits, over and above individual household members' support for low-carbon alternatives. Furthermore, learning about energy-efficient behaviours from trusted sources, such as friends and neighbours, is more likely to persuade individuals to adopt them (EST, 2010b). Global Action Plan's 'Ecoteams', 'Open Homes' demonstration events, and the 'Student Switch-Off' programme are good examples of social approaches to encouraging low-carbon lifestyles (see Whitmarsh et al., 2010b).

5.4 Summary

In this section, we have reviewed primarily UK literature on public attitudes to energy efficiency (investments that lower energy use without changing energy consumption habits) and curtailment measures (saving energy by cutting down on energy use; Gardner and Stern, 2008). These not only have different conservation potential (the former being greater than the latter), but they also have different psychological and social characteristics and require different approaches. Whilst curtailment requires changes in people's day-to-day energy-relevant behaviours, there is only a small window of opportunity to influence individuals' decision to purchase energy-efficient products. We have here reviewed psychological and sociological perspectives on energy efficient, consumption and conservation behaviours and emphasised the multiple individual, social and structural influences that interact with them.

6 Energy Systems, Scenarios and Research

Summary: Energy Systems, Scenarios and Research

- There is little work on public attitudes to energy systems, scenarios and energy research, perhaps partly due to the interdisciplinary demands, but also due to a lack of related programmatic funding and referee challenges.
- The Big Energy Shift for DECC/OST found that people are supportive of changes in energy supply and consumption, providing their quality of life remains the same and that they are helped to change.
- The Energy Research Dialogue for RCUK made recommendations on how to engage the public in energy research strategy development.
- Work in Manchester with the GRIP energy-emissions model found that focus groups had little trouble envisaging their role in a national 42% CO2, made up of reduced gas consumption, changes to the electrical grid mix and domestic power and heat generation.
- Forthcoming UKERC-funded work at Cardiff University will explore public opinion of energy scenarios.

6.1 Introduction

Work on public attitudes to energy technologies and infrastructure has very often focused on single technologies or developments and has very rarely explored public attitudes to energy policy, systems or scenarios. Yet in many cases, responses to a specific technology or development cannot be fully understood without taking into account public attitudes to other technologies and/or environmental concerns. A notable illustration of this is the way in which, in recent years, nuclear power has been reframed in terms of its potential contribution to climate change mitigation and energy security (Bickerstaff et al., 2008). Thus while higher proportions of the British public are now prepared to accept nuclear power if they believe it contributes to climate change mitigation, this acceptance is conditional on further factors (Pidgeon et al., 2008a). Specifically, the UK public views nuclear power as just one part of a wider strategy for achieving significant cuts in CO_2 emissions (ibid). In the following sections we review the very few UK research initiatives that have attempted to engage the public in considering wider energy policy and scenarios.

6.2 Energy Systems and Scenarios

EU climate policy requires renewable energy generation to more than double by 2020. Moreover, the EU will also need to replace half of its (ageing) power stations by 2020, even assuming energy efficiency improvements are made across the economy (Market Observatory for Energy, 2008). Even with this major increase in renewable energy generation, plus new nuclear power plants, it is unlikely that Europe can avoid building at least some new power plants that use either coal or gas in the next ten years, which in turn implies a role for CCS. Indeed, although energy scenarios from a variety of sources and political positions envisage differing supply mixes and levels of energy efficiency, coal and gas remain prominent in all for decades to come (Luukanen et al., 2009). Nonetheless, despite the likely on-going use of fossil gas, coal and of course oil, the relative mix of energy supply and demand options remains contestable and subject to public acceptance. This section considers the literature on public engagement in energy scenarios and systems.

Of all the aspects reviewed, public engagement in – and attitudes to – UK energy systems and scenarios is probably the lightest literature. This may reflect the state of interdisciplinarity in UK energy research, which is high in aspiration but somewhat lower in

practice (Wang 2010). Researchers involved will have their own thoughts on why this is so, but experience suggests that UK grant application review processes still pose significant challenges for social scientists involved in relatively applied and inter-disciplinary proposals, particularly with respect to their own research council, ESRC. Another reason may be the very limited range of tools available to help with energy scenario development suitable for public engagement. Quantitative energy scenarios are often technically demanding and obscure to non-specialists – though they need not be (Mackay 2008). We were able to find only three sets of UK public engagement projects relating directly to energy systems or scenarios research, though other research has engaged stakeholders in energy scenario assessment – e.g. (Mander et al. 2008). Moreover, the only project below to involve the public in what energy or emissions modellers would recognise as quantitative scenarios are those involving the GRIP software tool (Carney and Shackley 2009). It should be noted that there is some non-UK literature available – for example, work for CSIRO in Australia held three deliberative panels on energy futures, each with 20 people (Littleboy et al. 2005). The panels varied in their conclusions but three approaches were ultimately preferred: Broad Scale Reform (a shift to renewable and decentralised generation), Centralised Energy Generation (CCS, natural gas and nuclear) and Orderly Reform (a wide mix of technologies). There was some shift from renewable energy to large-scale centralised 'solutions' (defined as above) where there was perception of high cost and inability to meet demand peaks; and a shift towards Orderly Reform involving transition technologies (principally CCS) when there was a concern with the short-term viability of renewables but a long-term desire for their widespread use (ibid).

6.2.1 The Big Energy Shift

'The Big Energy Shift' was an Office of Science and Technology (OST) Science Wise initiative in public dialogue, run during the summer of 2009 by IPSOS-MORI on behalf of the Department of Energy and Climate Change (DECC), with citizen participants drawn from Northern Ireland, England and Wales. Thirty house owners in both rural and urban areas were involved, had access to energy experts and were led through a variety of exercises, some structured and some more free-ranging (Ipsos-MORI 2009) (http://www.bigenergyshift.org.uk/). The emphasis was more on the energy system than scenarios. The initiative used a range of engagement methods to educate, discuss energy interventions and to investigate: what makes individuals shift from (a) no action, to action; and (b) shift from piecemeal to household action; what makes householders shift from household action to community level or collective action; and what makes people get involved in mass action, at a national or cultural level. The project found, somewhat familiarly, that people are supportive of changes in energy supply and consumption, providing their quality of life remains the same and providing that Government and business take the lead on creating the conditions that will allow individuals to make changes. Those conditions include making well-designed, low-cost energy-saving and microgen technology packages affordable, with public estates (schools, NHS buildings etc) leading by example, coupled with a strong and sustained government narrative (message) on the importance of emissions reduction/energy shift, to be backed by, in time, penalties for non-compliance (ibid).

Perhaps the most interesting and innovative aspect of the exercise was its investigation of the advantages and disadvantages of alternative communication/policy 'worlds', in which participants discussed the merits of three different communications/policy approaches to facilitating a lower carbon future. These alternatives were grounded in the findings of the preceding parts of the exercise:

- World One: overt central messaging by Government with urgent overtones and national energy security emphasised ('Your country needs you');
- World Two: a lighter tone focused on information provision and emphasising the positive aesthetic and consumer appeal of low carbon (Ideal home show; low carbon chic);
- World Three: a moral tone and message re wasting energy, in which business and Government might also be held to account (name and shame; waste is wrong) (Ipsos-MORI 2009).

An ideal communications/policy scenario would be one that combined positive elements of the above, while rejecting those considered adverse. Thus participants judged the need to avoid 'scaring' people without telling them what they can personally do and without providing facilitating conditions. On the positive side, they said that they wanted to see the following policies, in this order:

- Educate and inform people about the need for the Big Energy Shift;
- SMART goals for the country: the Government needs to establish a strong argument for urgent action, without being alarmist;
- Emphasise that everyone has a part to play, and that no action is too insignificant;
- Make a symbolic gesture, such as introducing smart meters as soon as possible;
- Offer independent and informed advice to people looking to make improvements to their homes;
- Grants and loans balanced to ensure that the 'worst offending' properties are dealt with, but also that people who want to make an effort are rewarded;
- Public estates leading the way in efficiency;
- Ensure that there is an adequate supply of new energy technologies to meet the anticipated level of need;
- Introduce phased legislation to ensure minimum energy-related standards (Ipsos-MORI 2009).

The *Big Energy Shift* project was evaluated to find out to what extent it had met DECC's objectives and the Sciencewise-ERC principles of good practice in public dialogue (Rathouse and Devine-Wright, 2010). The evaluation used a mixture of desk research, observation, questionnaires, and interviews from householders, policy makers, external stakeholders, the DECC project manager, and delivery team (ibid).

The evaluation concluded that, overall, the dialogue had worked well. Specific results included:

- The dialogue had positive impacts on attitudes such as willingness to accept a wind turbine in participants' neighbourhoods and the responsibility attributed to individuals and communities. Participants attributed such changes to site visits as well as to discussions.
- Participants' trust that the dialogue would make a difference was boosted through the presence of government ministers at events and exceptional communication after events.
- However, during the householder events some discussions were more inclusive than others and the final event, designed as a dialogue between householders and stakeholders, did not work as intended (ibid).

The reviewers drew from The *Big Energy Shift* four main lessons for future public dialogue projects:

1. To ensure that the full range of views is heard and recorded, it is important to use techniques for making discussions inclusive and for recording them systematically.

2. Householder engagement can be maintained throughout longer than standard public dialogue projects, if well structured and facilitated.
3. An effective model for direct dialogue between stakeholders and householders seems to involve informal discussions with a small number of stakeholders at householder events, rather than more formal meetings with larger numbers of stakeholders.
4. Reports setting out a clear agenda for action help ensure that dialogue findings are translated into policy (ibid).

6.2.2 Citizen views of city-level energy scenarios

In as yet unfinished/unpublished work involving a total of some 40 members of the public in four separate groups, each convened for one day over May-September 2010 (about 10 people per group), Upham and Carney investigated citizen views of macro and micro generation technologies in the context of long term government targets for emissions reduction (Carney and Upham forthcoming). All participants were home-owners from Manchester, with one group being landlords. Each group followed the same research design, being provided with initial information on macro and micro lower carbon energy technology options; a pre- and post-group questionnaire designed to identify technology ranking and any opinion change; and group discussion of how to reach a 42% CO_2 reduction target by 2020 and a 90% reduction target by 2050, using the technologies, in ways that the group considered feasible, assisted by a domestic household version of GRIP emission scenario software that shows the emissions consequences of different energy technology choices with respect to a recent baseline for (in this case) Manchester (Carney and Shackley 2009). The household version of GRIP differed from the original version by excluding transport: the focus was on provision of heat and power to and by the domestic house.

The combination of a ranking exercise informed by information sheets, plus use of a domestically-focussed version of GRIP, proved useful in both helping the lay-public understand the emissions implications of micro-generation technologies and energy efficiency and in generating qualitative and quantitative information on perceptions, attitudes and judgements. The level of engagement with the material and software was generally high, though a small minority of participants did struggle with the pace of information provision.

Energy efficiency options were generally ranked as the first priority, above energy generation options. This intuitive and reasoned response accords with technical modelling of domestic emissions reduction potential (HM Government 2009), illustrating the capacity of a non-specialist audience to comprehend and reasonably respond to key issues, given appropriate information and support. The relatively high ranking of solar options parallels previous national findings: solar is perceived as a benign, clean technology. Other technologies are more critically appraised in terms of their cost and supply potential, with all considered to require government support and regulation for higher up-take. Biomass heating suffers from an association with polluting activity, though, as would be expected, those who had practical experience of a modern biomass boiler took a more favourable view. Concerns about the noise of air heat pumps looks to be a potentially problematic issue for their installation in quiet environments. Micro-CHP seemed poorly understood, while district CHP had industrial associations. Retrofit was widely seen as more problematic and costly than new build in terms of installing microgen.

In terms of increasing the use of both macro energy technologies, government intervention was considered critical, though overtones of compulsion would need to be avoided.

Participants had little trouble envisaging a national 42% CO_2 emissions reduction by 2020 over a 2006 baseline, substantially made up of reduced gas consumption, changes to the electrical grid mix and on-site (on home) power and heat generation. This perhaps suggests that it is the pace of change that is likely to be most challenging in terms of public perceptions, rather than the technological change per se. Envisaging a 90% reduction for 2050 was found much more difficult, as this requires zero emissions from natural gas and hence more substantial changes that there was not time to explore.

6.2.3 UKERC Public Attitudes to Energy Scenarios Research

UKERC has recently funded a two-year project at Cardiff University, which will investigate public perception of whole energy system transformation to inform the policy-making process and provide research evidence for future energy scenarios. Using three main work packages, the interdisciplinary research team will investigate where the public agrees or contests the underlying reasons for proposed change using in-depth qualitative and generalisable quantitative research methods. This research will focus on key dimensions or trade-offs in the energy system as well as relating it back to everyday life.

6.3 Energy Research

6.3.1 Energy Research Dialogue

Global expenditure on 'clean energy' research, development and deployment (RD&D) is substantial. Including stimulus spending, total International Energy Agency member country spending on 'clean energy' RD&D in 2009 was about USD 23 billion; USD 16 billion excluding stimulus spending (IEA, 2010). These totals do not include spending amounts in other major economies such as China, Russia, Brazil and India (ibid). The Research Councils UK energy programme itself currently has an investment programme of some £530 million, building on an investment of £360 million over the past 5 years (http://www.rcukenergy.org.uk).

To inform this investment, the energy research dialogue carried out in 2007 by Ipsos MORI on behalf of the Research Councils (Ipsos-MORI 2007) involved close to 90 members of the public, selected to be broadly representative of the UK population. This is to our knowledge the only in-depth public consultation on energy systems research to be held in the UK to date. (In fact, as we point out in Upham et al. 2009, there is little research on public engagement in environmental research, per se). The final report (ibid) outlines the public dialogue process and the findings from the workshops in terms of the public's priorities for evaluating energy research (http://tiny.cc/pXVQQ). The purpose of the exercise was to bring public opinion into the major spending reviews being undertaken by the Research Councils to decide future energy research investment. The exercise provided information on public attitudes to both the energy system and to energy systems research.

There were three stages to the exercise. First, three one-day regional workshops were based around both small group and plenary group exercises. Second, participants were given optional 'homework' tasks to complete, to provide personal perspectives on the issues and enable them to deepen their understanding (if they so chose). Finally, a Summit event was held over a full weekend, at which 30 participants from across the regional events were joined by a team of energy researchers and Ipsos MORI facilitators. Initial exercises included elicitation of top of mind associations with energy, the criteria by which people judge energy issues and the priorities that people assign to different energy objectives. These and other exercises culminated in participants allocating notional proportions of the energy research budget to particular research topics/technologies (Ipsos-MORI 2007).

Findings included:

- Limited knowledge of the nature of energy research and researchers.
- The centrality of attitude to climate change in relation to attitudes to energy research.
- There was controversy related to the roles of biofuels, nuclear (fusion and fission –for different reasons) solar, wind and measures to instigate social/behavioural change.
- A high level of support and consensus over energy efficient buildings, hydrogen fuel cells/economy and tidal power.
- Little interest or outright rejection of conventional energy sources, carbon capture and fuel poverty as research topics (except as a hygiene measure).
- Questions and concern over the apparent level of state funding for energy research as a proportion of national spending.
- Participants seemed to shift from favouring social and behavioural solutions towards technology-driven ones as the dialogue process progressed.
- Confidence in the motives of scientists is high but there is suspicion over the role and motives of private enterprise in funding science.
- Seven evaluative criteria that emerged are: Ethics and equality; Economics; Quick Fix; Sustainability; Legacy; Environment; Efficiency.
- In terms of weighting, environmental impact, legacy and sustainability are strong criteria, underpinned by sound economics. Ethics and equality were secondary.
- Budgeting exercises revealed a 'principled but pragmatic', utilitarian approach to public evaluation of energy research options (Ipsos-MORI 2007).

In terms of understanding the above, Ipsos-MORI hypothesise that public opinion is related to a variable sense of a) Urgency and b) Agency with respect to the UK's future energy challenges; that is, support for energy research is strongest when the problem is perceived as urgent, and choices over particular directions for research are influenced by perceptions of both the degree of urgency and our capacity to make a difference (ibid). In terms of representing the public's voice in energy research decisions, among Ipsos-MORI's 13 suggestions are the following (both paraphrasing and quotation):

- Construction of archetypal public response patterns or counterarguments to enable the RCUK to incorporate the public's voice into their decision-making process.
- Construction of 'rich pictures' of a range of hypothetical members of the public (i.e. based on narratives and character vignettes). These would bring the findings to life and provide a challenge and critical thinking function to RCUK funding debates.
- Public criteria could be adopted as part of the formal submissions, evaluation and validation process for all new energy research projects under the auspices of the RCUK.
- In order for the RCUK to effectively communicate energy research funding choices to the wider public, it is important not only to outline the potential results of the research, but also the framework underlying that decision.
- This could be done in the form of a 'fund management portfolio' publication, with accompanying annual energy "shareholders" meetings to invite the public to talk to the RCUK and question them on their stewardship of the "fund".
- RCUK to provide the public with more opportunities for direct interaction with the energy research community to build trust and reduce suspicion.
- Provide an overarching narrative about the way the Research Councils see science and technology working to achieve energy goals (incremental or radical, technological or social).
- Provide more information/justification for social and behavioural energy research programmes – to counter scepticism of behaviour change work.

- Communicate the findings more widely through the research community to enable them to incorporate these into their submissions for funding, thereby increasing the public accountability aspect of these submissions (Ipsos-MORI 2007).

6.3.2 EPSRC Partnerships for Public Engagement

For a number of years, EPSRC has run a *Partnerships for Public Engagement* (PPE) scheme to explain, demonstrate and articulate the results of EPSRC research to the general public. Examples of recent energy-related projects are referred to below. While an evaluation of the PPE scheme concluded that it was the only scheme of substantial size that offers funding for a wide range of engagement activities to people in subject areas other than the life sciences, and that it was successful in motivating EPSRC funded researchers to become active in public engagement activities, there was some concern that many of the projects funded were education-based rather than public engagement in a more dialogic sense (Graphic Science, 2008).

From April 2011, EPSRC will no longer offer dedicated support for public engagement, preferring to embed this in its research and training investments via RCUK's *Pathways to Impact* approach[67]. This requires all applicants to consider and cost public and stakeholder engagement activity as part of all grant applications. It is too early to determine how this will affect the nature or extent of public engagement, but it would seem inevitable that there will be fewer, larger-scale engagement activities. Examples of recent energy-related projects funded under PPE include: a CCS demonstrator for Scottish schools; appointment of a public engagement specialist to co-ordinate the collaboration of solar PV stakeholders (again in Scotland); work on carbon neutral schools in Leicester, and so on[8]. These are costly activities (up to £300k, in these examples) and it is unlikely that similar activities would be costed into standard grant applications.

6.4 Summary

In this section we have reviewed the limited literature which exists on public attitudes to energy systems and scenarios and public engagement with energy research. The lack of research in this area may be due to the interdisciplinary demands, lack of related programmatic funding and referee challenges. Forthcoming UKERC-funded work at Cardiff University, however, will explore public response to a range of energy scenarios. From the previous work which has been done on this topic, it seems – consistent with research discussed in previous chapters – that the public supports changes in energy supply and consumption, providing their quality of life remains the same and that they are helped to change. This work has also provided recommendations on how to engage the public in energy research strategy development.

[6] http://www.epsrc.ac.uk/newsevents/news/2010/Pages/publicengagementagenda.aspx
[7] http://impacts.rcuk.ac.uk/default.htm
[8] http://gow.epsrc.ac.uk/ViewPSP.aspx?PSPId=821

7 Cross-Cutting Themes and Lessons for Engagement

Summary: Cross-Cutting Themes and Lessons for Engagement

- We have identified a number of inter-linked themes which are relevant to several (and in some cases, all) energy topics in this review:
  a. attitudes are determined by context and are contingent;
  b. attitudes are influenced by how proposals and questions are framed;
  c. there are advantages and limitations of different attitudinal and behavioural measures, and deliberation is required in eliciting attitudes to novel, unfamiliar or technical issues;
  d. methods, theories, engagement approaches, and attitudes vary across spatial scales;
  e. timing (in respect of current events, R&D cycles, and policy implementation) is a critical consideration for measuring attitudes and planning engagement activities;
  f. public attitudes are heterogeneous, and there are multiple roles which individuals can play in relation to energy issues and research governance;
  g. energy use and technologies are socially embedded and often taken-for-granted;
  h. public engagement with energy is fundamentally influenced by social trust and institutional relationships; and
  i. research on public attitudes to low-carbon energy draws on a range of theories and perspectives, but often theories developed in relation to one energy topic is not transferred to another.
- Each of the above themes draws together issues that should be considered when thinking about or planning public engagement in energy research. These include:
  a. the need to define engagement objectives (e.g., correcting misperceptions, changing attitudes to science or energy issues, viewing the public as resource of inspiration, oversight and legitimacy);
  b. the need to define engagement forms (information provision, education, and consultation and deliberation) and the limits and challenges associated with each;
  c. the need to define 'successful' engagement (e.g., makes a difference; is transparent; has integrity; is tailored to circumstances; involves the right number and right types of people; treats participants with respect; gives priority to participants' discussions; is reviewed and evaluated to improve practice; participants are kept informed); and
  d. the need to learn from related engagement activity, such as public engagement with climate change.

7.1 Introduction

In this section we draw together themes and lessons that have emerged from the empirical evidence of public attitudes to and engagement with energy supply and demand reviewed in sections 4 to 6. In doing so, we also provide links back to the theoretical literatures reviewed in section 3, and foreshadow our conclusions and recommendations in section 8.

7.2 Cross-cutting themes

The following themes are relevant to several (sometimes all) of the energy topics discussed in this report. The themes are closely related and sometimes inter-linked:

7.2.1 Attitudes or engagement?

In this review, we have not only focussed on 'attitudes' in the conventional social psychological sense of an individual's evaluation of, or orientation towards an issue/object. Rather we have included literature on public 'engagement' with energy issues, technologies, developments and research. Engagement includes attitudes, understanding, meanings,

behaviour and practices at individual, community and cultural levels, and also refers to discrete engagement interventions. We have expanded the scope beyond one disciplinary perspective (psychology) because of the important contributions made by other disciplines, such as sociology and political science, to understanding how publics conceive of, evaluate, and interact with low-carbon energy. Since low-carbon energy attitudes are best understood within their context (see below), these attitudes are in a sense *indicators* of other social, institutional and psychological processes. Furthermore, we have emphasised that engagement (and attitudes) has an emotional, as well as a reasoned/cognitive, content. Emotions are critical for how we evaluate the significance of a risk, place or practice, and as such should be included in investigation of public interaction with low-carbon energy, along with what the public does and does not know about particular technologies or proposals.

We have also pointed out that some perspectives, such as the social practices paradigm, do not consider attitudes a relevant unit of inquiry for understanding action or social change. According to the practices perspective, the individual is relegated to a marginal position in the analysis; and with them, out goes the motivational apparatus which is commonly held to shape intentions, and so drive behaviour. Thus human conduct does not arise from the motivational force of an individual's intrinsic motivations, but through the ongoing interaction between agency (mediated by lifestyles) on the one hand, and structure (as rules and resources) on the other. Thus, since 'attitudes' are psychological constructs; other disciplines which are pertinent to low-carbon behaviours and public engagement make little or no reference to attitudes, highlighting the need to attend to terminology and not to close off routes to other (non-psychological) lines of enquiry.

7.2.2 Contingency, context and framing

Across energy issues, we have shown that attitudes vary according to social, economic and policy context. Equally, we have shown that proposals for energy developments and policies often receive *qualified* support, which is contingent on how they are justified or what other proposals are being considered (e.g., whole or partial solution). For example, personal carbon trading may be accepted only if renewables and efficiency are invested in; and hydropower developments are seen as acceptable providing local areas do not have to be flooded.

This contingency can arise as a result of the way in which proposals are framed. Public attitudes to energy options will be influenced by factors such as choice of language, the justification or argument used, current political or social events, and information which is omitted. This has profound implications for how attitudes are elicited, and reminds us that research is never neutral or 'objective'; rather, the choice of methods and measures critically determines attitudinal responses. For example, wind energy is seen as more acceptable with an energy security frame; and acceptance of nuclear energy increases when it is seen as contributing to climate change mitigation.

7.2.3 Measurement

A more general point which flows from the recognition of framing effects, relates to measurement of attitudes and behaviour. We have noted, for example, the limitations of self-reports of conservation behaviours due to social desirability bias or inaccurate recall; yet, this method is by far the most common since alternatives (such as meter readings, weighing waste, etc.) are more costly and intrusive. Given the importance of context and contingency in attitude construction (see above), the scale at which attitudes are measured is also critical; compared to national surveys, case studies at the local level can provide

deeper insights into the way attitudes are embedded in a particular social and historical context. This point is expanded on below.

There is also a self-fulfilling ontological/theoretical dimension: survey questions place importance on 'attitudes' as constructed and tapped through survey questions. Self report then is accorded an importance it may not merit, and attitudes appear to have a validity they may not support (the danger of reification). One response is to note that implicit or automatic attitudes (Maio et al., 2007) may be more reliable. But beyond this, other disciplinary approaches would actively prefer data from (non-human) sources – e.g., actual meter usage, time use data, or market (e.g., sales) data. Thus practice theory or STS would look beyond 'attitudes' to measure other dimensions which contribute to 'behaviour'.

Furthermore, there are unique challenges in eliciting attitudes to novel, unfamiliar or technical issues. In these cases, participants need to be informed about the issue in question, and the challenge is then for researchers to provide information which is balanced and informative rather than partisan or persuasive. Deliberative research, then, involves attitude construction, but also often attitude change. For example, attitudes to changing travel habits changed as a result of group discussions on the topic; indeed, participants may change their behaviour as a result of participating in research which raises awareness and perceived responsibility about environmental or social issues. Participants in social research – and particularly deliberative social research – are no longer the same 'public' as they were prior to participating; they are now informed public and in some cases may even become 'lay experts'.

7.2.4 Scale

Our report has covered a wide range of topics which span multiple scales at which energy and social systems exist, including: domestic/residential (e.g., domestic energy use; microgeneration); community (e.g., community energy projects; siting controversies); regional/national (e.g., national grid; energy policy); and global (e.g., climate change). Methods and theories differ across these spatial contexts (see also Figure 7.2); at national level, quantitative attitude surveys are often employed, while local-level case studies may use more qualitative methods. Each approach offers different but often complementary insights, and has its own strengths and limitations; for example a representative survey can provide a useful indication of the valence and strength of public opinion, and may be able to capture the contingency of support (as shown in large-scale surveys including a framing manipulation), but is less well-suited to providing deeper insights into attitudinal construction and the social embeddedness of energy technologies and behaviours (see also below). Engagement approaches should also be tailored to the appropriate scale; national or global issues may warrant use of internet participation tools, while local level engagement can be conducted face-to-face (see also Dietz and Stern, 2008).

Furthermore, attitudes can vary across these scales. Public views about domestic- or community- level energy issues (e.g., smart meters, local nuclear power station) may differ greatly from opinions about domestic energy or nuclear power in the abstract or at national level. The relevance of local-level issues is likely to be far greater than national or global issues, but assessment of each may also depend on different, contextual factors. This disparity in attitudes according to spatial sale and context may appear inconsistent or 'irrational', but as we have shown labels such as 'NIMBYism' are problematic because they ignore the social and psychological complexity surrounding assessments of different energy issues and particular proposals.

7.2.5 Timing

Attitude measurement and engagement are not only influenced by spatial scale; the temporal dimension is also important. In respect of attitude elicitation, the timing of surveys or interviews relative to current weather, media coverage, energy prices, or other events can fundamentally influence opinions elicited. This has been observed in relation to fluctuating attitudes to energy and environmental issues (see also Upham et al., 2009). Profound changes in attitudes have also been seen following introduction of proposed policies or developments, such as congestion charging.

Timing is also a critical consideration for engagement interventions relative to technology development and roll-out. This includes the distinction between 'upstream' versus 'downstream' public engagement, as well as attitude construction and instability, which are particularly critical for understanding novel and emerging technologies.

7.2.6 Multiple publics, multiple roles

Throughout the report, we have highlighted the heterogeneity of the public and the multiple roles which individuals can play in relation to energy issues and research governance. Consistent with the STS literature on public engagement, we have identified vastly different attitudinal and lifestyle groups – or 'publics' – who respond differently to different energy issues. Some consistency in attitudes across energy topics can be observed according to socio-demographic variables, location or environmental or political values. In a generalised example, energy efficiency and conservation behaviours are more acceptable to those with higher environmental values and women. However, often public responses to energy supply and demand issues cannot be predicted according to membership of these traditional categories or segments. For example, while women are more motivated by environmental concern to reduce their energy consumption, men are more accepting of local wind energy development. As discussed above, attitudes are dynamic and contingent, and consequently may be more determined by contextual factors (e.g., place attachment, trust in regulators) than by individual characteristics. The same can be said for behaviour: the 'value-action gap' is now widely recognised within research on environmentally-significant behaviour, and is due to the multiple influences on behaviour (not only environmental values) and the barriers to pro-environmental lifestyles. Crucially, energy use and the meaning of energy technologies and developments are often not conceptualised as environmentally-significant (and, indeed, may not be thought about at all; see below); rather the meanings attached to energy services and technologies are related to social practice, roles and identities. This poses problems for segmentation models based on environmental values, as well as for framing public engagement/action around 'low-carbon attitudes'.

Related to this, the public may adopt different roles in respect of a low-carbon transition. While traditional governance of energy and research is dominated by experts and policy-makers, there is increasing realisation that public engagement offers many benefits. These can include improved quality of decision-making, enhanced legitimacy and trust, buy-in and social learning. In respect of an energy transition, the public may then be seen as more than merely consumers of low-carbon products and services; they may be low-carbon energy producers (through microgeneration), members of low-carbon communities (e.g., wind farm cooperatives), low-carbon citizens (voting, lobbying or protesting for structural change in energy systems), low-carbon employees (engaging in organisational transformation), or even low-carbon 'citizen scientists' (through participation in research governance and development of particular energy expertise).

Yet in reality, the roles most people relate to are not defined in relation to carbon, but to social identities, such as family, friends, interest groups, jobs and communities. This has important implications for public engagement: not only should engagement reflect the multiple potential roles for the public in a low-carbon energy transition, but also the actual, lived, everyday roles which individuals adopt while they use energy and engage with technologies, research and developments. In addition, this helps explain the reasons for opposition to energy developments, technologies and policies, which may have little to do with energy per se and far more to do with threatened identities or lack of trust in those proposing the change (see below). Recent work has underscored the problems with many of the presumptions made by 'experts' about public engagement and the role of the public in changing energy systems (e.g., Aitken, 2010; Walker and Cass, 2007).

7.2.7 Social embeddedness of energy and technologies

In respect of energy demand, our analysis highlights the invisibility of energy in everyday choices and the routine, habitual and culturally-meaningful nature of many energy-consuming practices. This intangibility and symbolism of energy poses problems for changing patterns of demand, since the environmental impacts of behaviour are often unknown, but also proposed measures to curb demand may threaten cherished practices and beliefs. In respect of energy supply, storage and distribution, we have also highlighted the socially-embedded nature of technology and the importance of place to individuals and communities, which may only become apparent when change is proposed. A social lens can also help identify trends in attitudes and practices and where different social norms may conflict. For example, avoidance of waste is widely accepted as a 'good thing'; yet comfort, convenience and cleanliness are now pervasive cultural values which reinforce rising energy consumption and aspirational high-consuming lifestyles.

7.2.8 Trust and institutional relationships

Public engagement with energy is fundamentally influenced by social and institutional relationships. Not only do social practices and representations give meaning to the way we use energy, but the public's relationship with industry, regulators, government, community, interest groups, and others in society are important influences on response to low-carbon energy proposals. Given the inherent uncertainty and risk associated with many energy technologies and developments, individuals draw on their own experiences and others' assessments of the technologies and those involved with managing and regulating them. For example, local support for a proposed CCS demonstration plant will be determined by a community's experience of the competence and trustworthiness of the energy industry. Similarly, public acceptability of demand-side measures, such as government adverts on individuals' reduction of carbon footprints, is informed by whether individuals feel others are making efforts to change their behaviour. Perceived fairness and social trust are key ingredients of acceptable energy policies. Different types and levels of trust may be more or less relevant to different energy issues; for example, trust in a particular firm may be more relevant that a general or abstract 'trust in industry' for local energy developments; whereas proposed change and decisions at the level of whole energy or social systems (e.g., UK-wide road tolls; increased government investment in renewables versus nuclear fusion) may be more influenced by trust in government or society as a whole.

The outcome of public engagement interventions is also coloured by whether participants trust those organising the process to act fairly; this includes having adequate representation and involvement of different groups, and using the findings of the process to inform decisions.

7.2.9 Disciplinarity and interdisciplinarity

In this report, we have drawn on a range of academic and non-academic sources and diverse theoretical perspectives. Psychological, sociological and interdisciplinary perspectives offer different (sometimes, though not always, complementary) insights on attitudes, including how they are developed or 'constructed'. As mentioned above, different disciplinary approaches can identify different questions: 'attitudes' can presume a psychological lens, which can diminish the importance of 'structural factors' in behaviour, and altogether miss the emergent and interlocking nature of the elements implicated in a particular practice (note, for instance, the interaction of lifestyles and systems of provision in developing socio-technical regimes).

It is also notable that theoretical perspectives are often not transferred across the supply-demand border (see also Figure 7.2); for example, place identity approaches in supply-based development are not used in demand-side issues, but identity of 'home' (as safe, warm, comfortable, etc.) could be understood as a form of place identity (i.e., with symbolic meanings).

7.2 Lessons for public engagement

Each of the above themes draws together issues that should be considered when thinking about or planning public engagement in energy research. Although we have briefly addressed these in relation to these cross-cutting themes, here we explicitly draw out lessons for public engagement. We include reference to engagement in climate change-related activity in so far as this has a relatively direct relationship to energy (hence we include, for example, material on DEFRA's Act On CO_2 campaign but do not cover engagement in coastal flooding research and practice in detail).

At the start of this review, we highlighted an important distinction between engagement as 'state' and 'process'. As a 'state', we have described the various ways in which publics evaluate and interact with energy and technologies. As a 'process', engagement refers to discrete interventions by research bodies, policy-makers, industry or non-governmental organisations to communicate and interact with the public, usually (though not always) as a two-way, dialogic process. Of course, the two meanings of engagement (state versus process) overlap, and trying to cultivate a public which is more 'engaged' (e.g., with low-carbon energy) may well be an aim for a particular engagement exercise. In this section, though, we emphasise the need to be clear about the objectives, forms, assessment of, and learning about, 'engagement as process'.

7.2.1 The need to define objectives of 'engagement as process'

Before discussing, in subsequent sections, the generic and specific forms that engagement might take, it is first necessary to consider why engagement may be undertaken. As outlined in section 1, current energy and environmental targets and proposals imply significant change to UK energy systems to decarbonise while still ensuring sustainable, affordable supply. This change has major ramifications for the public, who will be *asked* to accept new energy infrastructure and technologies, and change patterns of demand. The public can also provide *answers* about the social robustness of technologies and policies. Understanding public attitudes to these changes, and the ways in which energy and technologies are understood and used, is thus vital, as is assessing the potential for the public to be actively involved in research and policy decision-making. This understanding is all the more important given recent media coverage of climate science which some fear have undermined public confidence in science and eroded trust in scientists.

Public engagement in research and policy has been approached with a variety of motivations, but these can largely be grouped in three categories. Bauer (2009) alludes to these while identifying three main scientific attitudes to lay 'common sense', as compared to systematically-derived, 'scientific knowledge'. The first approach is in the tradition of debunking, implicit in attempts to engage the public in order to dispel ignorance and misunderstanding. A second approach to public understanding of science views the public as the target of interventions that attempt to raise scientific literacy, mobilise favourable attitudes to scientific and technological innovation, change behaviour, and so on (ibid). A third approach recognises that the public's common sense (we could add here attitudes) is and are a resource of inspiration, oversight and legitimacy that may temper and moderate scientific and technological innovations that have uncertain and potentially risky outcomes (ibid).

The first approach parallels that of the traditional 'knowledge deficit model', upon which the initial Public Understanding of Science movement was based, with the public viewed as largely ignorant of the ways of science. With the right information and education, the public would understand and accept the 'right' thing to do (as identified by experts). This approach has been widely critiqued for failing to allow for different ways of interpreting and assessing expert information, and for treating divergent views as the product of ignorance (Irwin and Wynne, 1996). In response, theorists working from the perspective of science and technologies studies (STS), paralleling Bauer's third approach (Bauer, 2009), have tended to argue for the acknowledgement of plural 'knowledges' and understandings as legitimate. Indeed Yearley (1995) argued for STS specialists playing a more active role in policy-making, given their understanding of the role of expertise in policy. This is particularly the case in environmental policy-making, for the following reasons: the environment is a source of much disagreement between experts and lay people alike; (environmentalists tend to rely more on scientific evidence for their claims than an appeal to ethics alone; and scientific advance is involved in many environmental debates (Yearley, 1995). There has also been much discussion in both academic and policy circles relating to a crisis of trust in the role of expertise in decision-making. Collins and Evans (2003, 2002) term this the 'Problem of Legitimacy'. This lack of trust or legitimacy has led to many calls for an increase in 'participation', 'consultation' and 'engagement' (Collins and Evans, 2002, 2003, Stilgoe et al., 2006, Wynne, 1996, Irwin, 1995).

It is likely that all three of the approaches identified by Bauer (2009) informed the UK Research Councils' commissioning of a review of public attitudes to low-carbon energy (and, indeed, the earlier review on public attitudes to environmental change; see Upham et al., 2009). Yet each approach (or motivation) has different implications for the ways in which public attitudes to energy are understood and responded to. This variety potentially problematises the current behaviour change agenda that is popular within UK environment and sustainability policy, as well as the framing of public engagement with science as primarily a one-way communication process. Nonetheless, it is possible to match the alternative motives and purposes for engagement to its different forms, which we consider next.

7.2.2 The need to define forms of 'engagement as process'

In a 2005 review of UK public engagement in energy research for RCUK, Chilvers et al (2005) identified three forms:

- Integrative / analytic-deliberative engagement, which integrate discussion and dialogue with science and/or policy analysis, though this was more often with stakeholders than with the public;
- Public engagement and dialogue, in which deliberative processes and the public are central to the research process;
- Stakeholder engagement and dialogue, involving networking and communication processes such as conferences, seminars and workshops (Chilvers et al. 2005).

In the context of energy infrastructure siting, Haggett (2009) expands on Chilvers' distinction between engagement as (a) information provision, (b) education and (c) consultation and deliberation (Haggett 2009). This continuum parallels Arnstein's original 'ladder of participation' (Arnstein 1969), with one-way information provision at one pole and two-way negotiation at the other. Haggett (ibid) discusses the limits to engagement in an energy context, which, while referring to siting engagement, are just as relevant to deliberative research engagement. These issues include:

- The potential for manipulation, control, confusion and exclusion (Richardson 1996);
- Differential access and influence, through factors such as language, education, social position, ethnicity and gender (Tewdwr-Jones and Thomas 1998);
- Differing perceptions and interests within a community (Walker and Devine-Wright 2008);
- Narrow scoping of what the planning system considers to be materially relevant and subsequent public disillusionment (Tewdwr-Jones and Thomas 1998).

Also see (Rowe and Frewer 2005) on an engagement typology and (Burall and Shahrokh 2010) for a review of UK science engagement projects.

7.2.3 The need to define a 'successful' engagement process

Given the above limitations of, and constraints on, public engagement, what constitutes 'good' public engagement? Having discussed rationales for engagement, this sub-section provides an overview of principles and issues relating to deliberative public engagement, as a specific form of engagement practised in the UK. This form will be appropriate for engagement in the more contested and/or uncertain aspects of environmental change. The overview is normative and includes principles and criteria for 'good' engagement, particularly that which is deliberative.

In a guide to public engagement, the National Consumer Council (NCC, 2008) offer nine principles for guiding deliberative engagement, which they and Involve (a UK not for profit organisation) consider to be valuable in: "helping to create better public services, promote social cohesion and foster a thriving democracy" (ibid, p.1). In terms of definitions, the NCC (2008) define an engagement process as deliberative if it (a) involves discussion between participants; (b) involves a range (diversity) of people and information sources; (c) has a clear task or purpose relating to, for example, a policy or project question or topic. The NCC identifies three main types of deliberative public engagement currently used in the UK: deliberative research, which builds on market research techniques (e.g., national citizens' summits and policy consultations); deliberative dialogue, which builds on dialogue and consensus-building techniques, to develop an agreed view or set of recommendations (e.g., national dialogues on science and technology); and deliberative decision-making, which builds on partnership methodologies to enable participants and decision-makers to decide jointly on priorities and programmes (e.g., participatory budgeting exercises) (NCC, 2008, p.3).

The principles NCC think should be applied when practising deliberative public engagement are that the process (i) makes a difference; (ii) is transparent; (iii) has integrity; (iv) is tailored to circumstances; (v) involves the right number and right types of people; (vi) treats participants with respect; (vii) gives priority to participants' discussions; (viii) is reviewed and evaluated to improve practice; (ix) participants are kept informed (NCC, 2008, p.6).

Other guides to public engagement also exist, and there is not space here to review them all. Notable examples include ESRC forthcoming 'Impact' guidance and the Guiding Principles for public dialogue on science and technology, set out by Sciencewise-ERC[9].

7.2.4 The need to learn from related engagement activity

In this sub-section, we briefly consider initiatives intended to change attitudes and increase understanding about climate change and energy use as a driver of this. We consider whether these have had positive, negative or no success in promoting learning, engagement and behaviour change. These interventions can be categorised as one-way information provision (e.g., information campaigns, news and entertainment media; see 7.2.4.1) and more dialogic or two-way engagement (e.g., deliberative workshops; see 7.2.4.2). We have considered energy-specific engagement in sections 4-6.

7.2.4.1 Information campaigns and mass media

Since the early 1990s, there have been several government information campaigns intended to educate the public about climate change and to encourage personal energy conservation. These include the *Helping the earth begins at home* media campaign, the EST's *Energy Efficiency - It's Clever Stuff* and, more recently, *Save Energy, Money, Environment* campaigns, and the three-year high-profile *Are you doing your bit? (AYDYB?)* campaign, launched in 1998. Research indicates that these information campaigns have been largely ineffective in promoting understanding or changing behaviour. Although government evaluations suggest these campaigns have achieved 'brand recognition' amongst certain target groups (Select Committee on Environmental Audit, 1998), independent studies suggest this information has been unsuccessful in dispelling misperceptions or changing behaviour (Hinchliffe 1996; Lofstedt 1996; Diffney et al. 2009).

Act on CO_2 is the latest UK government public information campaign launched in 2008 at a cost of over £5m, to communicate climate change and encourage low-carbon behaviour change and is organised jointly by DEFRA (now DECC) and the DfT. Haddock Research's (2008f) survey found that the 'Act on CO2' logo is recognised by 31% of English adults, with 8% claiming that it has had an impact on their behaviour. The official campaign evaluation (TNS 2009) involving face-to-face interviews with the public throughout the campaign duration (September to December) found high public recognition of the campaign (up to 75% for the home energy component), reasonable recall of information about specific actions (up to 54% for home energy, e.g., using low-energy light-bulbs) and higher recall for the reasons (saving energy and money). In respect of interest and attitudes towards energy saving activities, the campaigns achieved 55% (home energy), 54% (eco-driving) and 44% (car purchasing) respectively among all respondents/drivers/prospective purchasers (those likely to purchase in the next 12 months), slightly higher than the average for government campaigns (42%). Most participants claimed to have taken some action as a result of seeing

[9] "The Government's Approach to Public Dialogue" available at: www.sciencewise-erc.org.uk/cms/assets/Uploads/TrackedDocuments/Guiding-Principles/Sciencewise-ERC-Guiding-Principles.pdf

the campaign, most commonly this is low-investment behaviours such as turning off lights (53%) and checking/inflating tyres (51%). Higher impact from the home energy component is in part attributed to greater advertising, including on TV (TNS 2009). Similarly, evaluation of the Scottish Executive's environmental information *Do A Little, Change A Lot* campaign launched in 2001 shows recognition of the TV advertisements to be much higher than for posters, newspaper advertisements or articles in newspapers (Scottish Executive, 2005b).

The literature on communicating climate change (and other issues) gives clear indications of how to effectively communicate climate change (see Upham et al., 2009 for details). These include: the need to explicitly address misperceptions; the need to provide clear tailored advice and motivating, salient messages (e.g., health benefits of cycling); building motivating narratives and collective visions; tailoring messages to audience contexts, identities, values and knowledge rather than using blanket messages and approaches; using trusted sources of information (e.g., scientists, the BBC, and friends/family); and being very cautious in using fear to communicate and persuade, as this can be ineffective or even counterproductive.

7.4.2 Deliberative approaches to climate change engagement

A number of studies have examined the potential for more interactive, two-way approaches to public engagement with climate change and associated risks (particularly flooding, though we do need consider engagement in flood planning in detail). In general, these highlight the significant benefits associated with incorporating public values and knowledge along with science into climate change assessment and decision-making processes because it improves their quality, legitimacy and capacity (Nicholson-Cole and Whitmarsh, 2008; Kasemir et al. 2003; Dietz and Stern 2008). As a 'real-world' example of this, DEFRA's public engagement activities (including citizens' summit) to inform development of the Climate Change Bill increased citizens' understanding about climate change and the need for action, and enabled them to express their views on climate change policy; however, deliberation was limited by the exclusion of opposing arguments (Warburton 2008).

Researchers have also developed and tested innovative deliberative approaches for climate change assessment and policy-making. Tompkins et al (2008) describe two case studies of UK coastal planning which involved deliberative scenario-based stakeholder engagement and allowed the necessary trade-offs associated with long term coastal planning to be explored. Lorenzoni and Hulme (2009) and researchers in the EU-funded ULYSSES project (Stoll-Kleemann et al. 2001; Kasemir et al. 2003) similarly used deliberative workshops to provide opportunities for the public to assess climate change through interaction with expert information, including scenarios and models. In general, participants felt that no single scenario was realistic, and argued for a combination of scenarios to encapsulate future societal and environmental change; they also tended to question the validity of the assumptions and rationale underlying the socio-economic scenarios or sought more locally-specific information; information was interpreted according to prior beliefs/values; scenarios generated debate and reflection but little attitude change and resistance to changing behaviour due to cognitive dissonance theory. In addition, several researchers (Nicholson-Cole 2005; Tonn et al. 2006; Lorenzoni and Hulme 2009) observe that individuals relate more easily to an 'immediate' 20 years into the future rather than 50 or more, which represents a challenge to public engagement with climate change in general and to using scenarios in particular because climate change impacts are hard to discern on a 20 year timescale.

7.3 Putting it together

Here, we provide a summary of the links between theoretical and empirical literatures, reviewed in sections 3 and 4-6, respectively (Table 7.2). This highlights that (a) much of the

work to date has been atheoretical, and (b) theoretical perspectives are often applied to a limited number of topics, or even in an ad hoc way. Together, this suggests the potential to further theory-driven research on energy topics, and potentially advance theoretical integration across topics.

Table 7.2 Links between theoretical and empirical literatures

		Attitude theories	Risk perception literature	Behaviour change models	Place attachment/ identity	Social practices & transitions	Governance	Science & Technology Studies	Atheoretical
Supply	Large-scale wind energy	■			■		■		■
	Biofuels and bioenergy	■	■		■		■	■	■
	Tidal and wave energy				■			■	■
	Geothermal energy								■
	Large-scale hydroelectric		■		■				■
	Energy from waste								■
	Microgeneration			■				■	■
	Fossil fuels		■						■
	Carbon capture & storage	■	■				■		
	Nuclear fission		■		■				■
	Nuclear fusion								■
	Nuclear waste		■					■	■
	Hydrogen & fuel cells	■	■					■	
	Electricity & gas networks	■							■
Demand	Energy-efficient domestic appliances/equipment	■		■					■
	Energy-efficient homes	■		■		■			■
	Energy-efficient transport								■
	Energy consumption	■				■			■
	Low-carbon/differential energy tariffs	■		■					■
	Domestic energy conservation	■		■		■			■
	Shopping, eating & waste behaviours	■		■		■			■
	Travel behaviours	■		■		■			■
	Energy conservation interventions/policies	■		■		■			■
	Energy systems & scenarios								■
	Energy research	■							■

8 Conclusions and Recommendations

Summary: Conclusions and Recommendations

- In this chapter, we summarise the key findings from the review
- We also provide a summary of the amount of research we have found for each energy topic and identify clear areas where research has tended to focus, and other areas where there is less literature. We also identify specific gaps in the literature for future research to explore
- Finally, we present recommendations for the RCUK Energy Programme, and categorise these into: (a) dissemination and education; and (b) strategic definition of research direction, governance, and structure

8.1 Concluding Summary

8.1.1 Introduction

Current energy and environmental targets and proposals imply significant change to UK energy systems to decarbonise while still ensuring sustainable, affordable supply. This change has major ramifications for the public, who will be asked to accept new energy infrastructure and technologies, and change patterns of demand. Understanding public attitudes to these changes, and the ways in which energy and technologies are understood and used, is thus vital, as is assessing the potential for the public to be actively involved in research and policy decision-making. This understanding is all the more important given recent media coverage of climate science which some fear have undermined public confidence in science and eroded trust in scientists.

This study on public attitudes to, and engagement with, low-carbon energy draws together the results of UK-relevant social research and evidence, as of October 2010, in order to inform the Energy Programme at both strategic and operational levels. Our sources were identified through a systematic search of bibliographic databases and a formal call for evidence issued to practitioners and academics in order to identify non-academic ('grey') sources and forthcoming academic publications.

The report provides an introduction to some of the most relevant social science theory and concepts relating to public engagement (chapter 3), before reviewing findings on attitudes and engagement relating to energy supply, storage and distribution technologies (chapter 4); energy demand attitudes and engagement (chapter 5); and energy systems and research engagement (chapter 6). We also discussed cross-cutting themes, knowledge gaps and recommendations for public engagement in the RCUK Energy Programme.

8.1.2 Conceptual framework

Philosophically, we have assumed a broad approach to the underlying reasons for public engagement in research. These may include dispelling ignorance and misunderstanding; raising scientific literacy, increasing trust in scientists, mobilising favourable attitudes to scientific and technological innovation, changing behaviour, and using public perceptions as a *resource* of inspiration, oversight and legitimacy that may temper and moderate scientific and technological innovations that have uncertain and potentially risky outcomes. There may also be a normative rationale for engagement, which assumes the public have a right to influence decisions about public-funded research and technologies or policies that may affect them. In selecting and summarising theory and evidence relating to public engagement with low-carbon energy, the report gives equal weight to these very different

rationales. We define the 'public' as citizens and consumers; however, we do not consider that the public is homogenous, but argue instead that there are multiple 'publics' reflecting diverse interests, experiences, beliefs and values, and who engage with energy in diverse ways and adopt a variety of social roles and identities in respect of energy issues.

Attitudes are hypothetical constructs which refer to an individual's evaluation of something, and comprise knowledge, emotion, and behavioural intentions. Attitudes are not static or de-contextualised; rather, they are dynamic, influenced by a range of factors, often ambivalent or uncertain, and frequently not predictive of behaviour. Attitudes are changed through persuasion and experience, but also as a result of behaviour change. The social, economic, political and technological context of individuals shape and constrain attitudes and behavioural responses to low-carbon energy (and associated risks). The 'practices' approach from the sociology of consumption provides a useful explanatory account of this form of influence: in terms of explaining behaviour, habits and routines may be at least as important as attitudes.

The concept of NIMBYism is problematic and overlooks the way individuals form strong attachments to place and how symbolic attributes of certain locations can form part of an individual's identity. Threatened place identity/attachment, rather than irrationality or ignorance, is often at the root of 'place-protective' opposition to large-scale low-carbon technologies, e.g. wind farms.

Socio-technical transitions involve multiple societal actors and processes; the public may play a more or less active role in a low-carbon energy transition. Technology, research and risk governance have generally been restricted to experts and policy makers, but there are substantive, normative and instrumental rationales for involving the lay public (i.e., public engagement can improve decision-making quality by including diverse knowledge; allow explicit representation of social values in decisions about socio-technical change; and potentially foster trust, ownership and learning). Science and Technology Studies approaches stress the need to allow space for the multiple interpretations of energy technologies (rather than seeing divergence as necessarily a sign of ignorance or misconception) and the institutions in which they are embedded. Technologies are unlikely to be universally seen positively or negatively and members of the public may bring their own experience and knowledge to bear on their assessment of the desirability of particular technologies.

8.1.3 Energy supply, storage and distribution

The large majority of UK citizens believe that we need to reduce our reliance on fossil fuels and dependence on gas imports is widely seen as undesirable. While nuclear power is only reluctantly accepted, in principle attitudes to renewables are generally positive, though differentiated and nuanced. The little work on CCS suggests that it, too, is likely to be reluctantly approved of, specifically as a bridge to a renewable future. Knowledge of hydrogen and fuel cells is low but attitudes are generally positive, conditional upon safety, efficiency and cost criteria being met. Upfront capital cost has been a major obstacle to uptake of micro-generation. As the upfront cost of domestic energy measures may need to be kept below £4,000 for most people, linkage to other domestic upgrading (extensions, re-roofing etc) is advisable. Electrical grid operators are not well-known to the public, who associate National Grid with pylons and cables. This may have implications for the public engagement that will be needed for infrastructure renewal. The explanatory value of the NIMBY concept has been extensively critiqued: proximity per se explains little and objections can be as much about procedural justice as about technology-specific impacts.

8.1.4 Energy demand

Attitudes towards energy-efficiency (involving one-off purchases of appliances or products) are generally more positive than towards energy conservation (ongoing curtailment of energy consumption and behavioural restriction). Energy efficiency and conservation also have different psychological properties, and tend to be understood using different theoretical perspectives. In general, the UK public considers reducing household energy use as a virtuous thing to do, but show less support for lifestyle change measures than for technological measures. Public attitudes to energy saving light bulbs are positive, and their use of is now widespread. Most people claim they buy energy-efficient appliances, although this seems to be more common for 'white goods' (e.g., fridges, washing machines) than for 'brown goods' (e.g., TVs). Barriers to buying energy-efficient appliances primarily relate to trade-offs with utility of the product and, in some cases, increased cost. Attitudes to insulation and double glazing are also very positive; loft insulation and double-glazing have been installed by most people, while wall insulation and other energy efficient installations are less common due to lack of motivation, awareness or affordability. Improving energy efficiency of homes is less important than other home improvements. Public attitudes to buying a low emission vehicle are less positive. Few own, or would own, low-emission vehicles, although most agree environment-friendly car drivers should pay less.

Energy use is driven by economic (especially income), structural (e.g., transport systems), and social factors, and by unconscious habit; environmental values tend to have little influence, while social values such as convenience, comfort, freedom, and status are far more salient. Energy is 'invisible'; households often have little awareness of their energy use. The 'hidden' cultural drivers and meanings of energy use make energy behaviours difficult to change. Most feel an obligation to save energy, but few are making significant lifestyle changes; turning off unused lights and appliances are commonplace, but washing and heating behaviours are more resistant to change (due to primacy of comfort and cleanliness). Financial considerations are the key motivator for domestic energy saving behaviours. Public attitudes to buying local and seasonal produce are positive; there is little understanding of the link between food production/consumption and climate change, but the idea of a low-impact (e.g., vegan) diet is unpopular. Attitudes to waste avoidance are very positive; and recycling and reuse are widespread. There is considerable resistance to changing travel habits, particularly changing mode, due to perceived inconvenience, unavailability, or cost of alternatives, and strong cultural associations with driving and flying. Motivations for changing travel behaviour are usually tangible benefits such as health (from walking/cycling), saving money or convenience. Informational tools (e.g., carbon calculators, smart meters) can make energy more personally relevant and visible. However, information alone is usually insufficient to encourage energy conservation; economic, social and structural approaches are also required.

8.1.5 Energy systems, scenarios and research

There is little work on public attitudes to energy systems, scenarios and energy research, perhaps partly due to the interdisciplinary demands, but also due to a lack of related programmatic funding and referee challenges. The Big Energy Shift for DECC/OST found that people are supportive of changes in energy supply and consumption, providing their quality of life remains the same and that they are helped to change. The Energy Research Dialogue for RCUK made recommendations on how to engage the public in energy research strategy development. Work in Manchester with the GRIP energy-emissions model found that focus groups had little trouble envisaging their role in a national 42% CO2, made up of reduced gas consumption, changes to the electrical grid mix and domestic power and heat generation.

Forthcoming UKERC-funded work at Cardiff University will explore public opinion of energy scenarios.

8.1.6 Cross-cutting themes and lesson for public engagement

We identified a number of inter-linked themes which are relevant to several (and in some cases, all) energy topics in this review:

a. attitudes are determined by context and are contingent;
b. attitudes are influenced by how proposals and questions are framed;
c. there are advantages and limitations of different attitudinal and behavioural measures, and deliberation is required in eliciting attitudes to novel, unfamiliar or technical issues;
d. methods, theories, engagement approaches, and attitudes vary across spatial scales;
e. timing (in respect of current events, R&D cycles, and policy implementation) is a critical consideration for measuring attitudes and planning engagement activities;
f. public attitudes are heterogeneous, and there are multiple roles which individuals can play in relation to energy issues and research governance;
g. energy use and technologies are socially embedded and often taken-for-granted;
h. public engagement with energy is fundamentally influenced by social trust and institutional relationships; and
i. research on public attitudes to low-carbon energy draws on a range of theories and perspectives, but often theories developed in relation to one energy topic is not transferred to another.

Each of the above themes draws together issues that should be considered when thinking about or planning public engagement in energy research. These include:

a. the need to define engagement objectives (e.g., correcting misperceptions, changing attitudes to science or energy issues, viewing the public as resource of inspiration, oversight and legitimacy);
b. the need to define engagement forms (information provision, education, and consultation and deliberation) and the limits and challenges associated with each;
c. the need to define 'successful' engagement (e.g., makes a difference; is transparent; has integrity; is tailored to circumstances; involves the right number and right types of people; treats participants with respect; gives priority to participants' discussions; is reviewed and evaluated to improve practice; participants are kept informed); and
d. the need to learn from related engagement activity, such as public engagement with climate change.

8.2 Knowledge gaps and future directions

Here, we provide a summary of the amount of research we have found on range of supply- and demand- related energy topics covered in sections 4 to 6 (see Table 8.1). From Table 8.1, we can see there are clear areas where research on public attitudes and engagement has tended to focus, and other areas where there is far less literature. Note that this is a self-relative and also somewhat impressionistic assessment, nevertheless it highlights that topics such as large-scale wind, nuclear and energy efficiency have received most attention while energy systems and networks, energy research and certain technologies are relatively little researched.

Table 8.1 Amount of literature by topic

		High	Medium	Low
Supply	**Large-scale wind energy**		■	
	Biofuels			■
	Bioenergy		■	
	Tidal and wave energy			■
	Geothermal energy			■
	Large-scale hydroelectric power		■	
	Energy from waste			■
	Microgeneration			■
	Fossil fuels	■		
	Carbon capture and storage		■	
	Nuclear fission			■
	Nuclear fusion	■		
	Nuclear waste		■	
	Hydrogen and fuel cells		■	
	Electricity and gas networks			■
Demand	**Energy-efficient domestic appliances/equipment**	■		
	Energy-efficient homes		■	
	Energy-efficient transport	■		
	Energy consumption	■		
	Low-carbon/differential energy tariffs		■	
	Domestic energy conservation	■		
	Shopping, eating and waste behaviours		■	
	Travel behaviours	■		
	Energy conservation interventions/policies		■	
	Energy systems and scenarios			■
	Energy research			■

Furthermore, we list particular gaps in the literature that our analysis has exposed, and we consider to be important areas for future research to explore:

- Governance structures and issues relating to public engagement in energy policy and planning at local, regional, national and international levels.
- The conditionality, contingency and fluidity of energy perceptions and attitudes. In particular, development of attitudes before, during and after the construction of windfarms or implementation of transport policies
- Virtually all extant literature about public engagement with large-scale wind focuses on onshore wind energy. Given that offshore wind is likely to be a major growth sector over the next 25 years, and that offshore projects may be quite different to onshore in terms of public engagement and acceptance, for example due to the very different spatial implications of an offshore project, future studies of offshore are needed (and should not be seen as duplicating onshore wind studies).
- Public attitudes to nuclear fusion
- Unlocking and locking-in socially-embedded technology use and practice.
- Public attitudes to energy-efficient and/or low emission vehicles
- Public attitudes to low-carbon diets
- Public attitudes to and demand for air-conditioning
- Willingness to save energy associated with cooking behaviours
- Segmenting on particular energy-use attitudes/behaviours, e.g., cooking, heating (rather than environmental attitudes)

- Public responses to less well-known renewable energy technologies, e.g., biomass and geothermal
- Interdisciplinary work on energy consumption which integrates economic and social sciences
- Applying theoretical perspectives to both supply and demand side issues (e.g., place identity and domestic energy use) to integrate (cf. need for energy *systems* research)
- There is little information on how attitudes to new energy infrastructure evolve over time, from the development proposal through to living in proximity
- There is little literature on attitudes to gas pipelines; this may become more significant with use of CCS.
- Most of the UK research on attitudes to micro-generation has been commissioned by government agencies and is relatively limited in quantity
- There is hardly any work on UK attitudes to energy systems and scenarios, perhaps partly because of the multi-disciplinary challenges
- The value of conventional, consumer-oriented marketing has yet to be fully investigated for the purpose of encouraging domestic investment in microgen and energy efficiency measures
- Energy consumption should be examined at household (as well as individual) level, and include group dynamics and negotiation of energy decision-making and practices at the household level
- Early studies suggest that marine energy technologies may not be the 'Out of Sight Out of Mind' option that some may have thought. More research is needed as more devices are deployed and information on impacts moves more from theoretical models to monitoring results.
- As we have shown, much of the literature employs conventional survey methods. These have certain advantages (e.g., representativeness), but also many limitations (e.g., self-report bias; static and decontextualised perspective). Future social science energy research should focus on developing and adopting novel methods or combinations of methods to help overcome such limitations and shed light on aspects of public engagement which are often ignored (e.g., actual behaviour, framing).

8.3 Recommendations for Energy Programme

The following recommendations relate to both structure and content. We are well aware of the pressures and tensions between competing objectives in this context – and the difficulties in reconciling them. We categorise these into the two levels at which public engagement is likely to be used: (a) dissemination and education; and (b) strategic definition of research direction, governance, and structure. The former of these aligns principally with information/education forms of public engagement, and the later with consultation/deliberation forms, noted in section 7.2.2.

In developing these recommendations, we have focussed on where the RCUK Energy Programme is best placed to add value in respect of public engagement with low-carbon energy. While public engagement with low-carbon energy is pursued by many organisations (including, policy, industry and non-governmental groups) for a variety of reasons, research funders are uniquely placed to bring the public into decision-making about the *strategic direction* which energy *research* should take in order to meet societal needs and aspirations. At its broadest level this decision-making could include the relative importance of behavioural versus technological types of research to ensuring a low-carbon, secure energy

supply for the future. More specifically, it could include prioritising particular energy technologies and infrastructures to be the focus of research and development funding. At a more operational level, too, the Energy Programme is well-placed to *educate* the public about public funded technological and social innovations, and to *learn from* the public about how these innovations may (or may not) be taken up and used in diverse ways. With respect to the potential functions of public engagement – (a) to disseminate information and educate the public, and (b) to involve the public in strategic decision-making – we give the following recommendations on where the Energy Programme might focus its resources for public engagement.

We would stress that these two broad approaches to (and rationales for) public engagement are not mutually exclusive. Indeed, there will often need to be an educational component to interventions designed to include the public in decision-making, notably where technologies are new of little understood.

8.3.1 Dissemination and education

As discussed in chapters 3 and 7, there may be normative or pragmatic rationales for public communication of research. The normative argument speaks to the public's 'right' to learn about and shape public-funded research and innovation. From a pragmatic perspective, communicating research results may contribute to a more informed populace, potentially better able to make decisions about energy for their own benefit and that of society and the environment, and perhaps to a more inspired populace, who support energy research and scientific careers. However, we have argued that more information does not necessarily lead to behaviour change or to support for particular decisions or groups. On the other hand, *two-way information exchange,* whereby the public not only learns about energy research developments, but also provides answers about the social robustness of technologies and innovations, can provide significant benefits. This approach sees lay people as a 'reservoir' of knowledge, which may help shed light on whether and how technologies will be used; and the acceptability and efficacy of social (e.g., behaviour change) innovations. In addition, this approach allows the public to provide 'extended peer-review' of research findings and to open up and challenge expert understanding about certainty, risk and ethics. This may help expose 'blind spots', which those closely involved with scientific institutions become unable to see (e.g. through certain procedural rules, standardised objectives, research paradigms).

There are a number of areas where dissemination and education could be used to inform and learn from the public about energy issues. When prioritising areas for education-based public engagement the Programme should focus on areas where understanding is poor (i.e., either *public understanding* of the research or *researchers' understanding* of the social dimensions of their work) or where the Programme can add value. An example of this is in energy whole systems where the Programme has access to experts from a wide range of energy expertise (nuclear, energy demand reduction, CCS) and hence can play a role in bringing these people together to communicate a more complete picture of potential future energy provision. Educational approaches might also focus on particular areas identified in this review as where public understanding is low, such as the relative contribution of different energy-consuming activities to causing climate change (i.e., improving carbon and energy literacy) and certain novel or smaller-scale technologies (bioenergy, marine, geothermal, fusion, hydrogen and fuel cell, and CCS technologies). More broadly, public understanding is limited in respect of energy systems and low-carbon, sustainable energy scenarios. In addition, as we have outlined in section 8.2, there are also gaps in researchers' understanding about public responses to and engagement with energy, which the Programme may wish to prioritise.

For Energy Programme staff considering public engagement to *raise public awareness* about technological or social research outputs, it is also critical to consider (a) which groups within the public may benefit most from education (e.g., those most likely to be affected, those with particular interests), (b) how best to communicate with each group (using appropriate communication tools, media, messages, etc.), (c) to what end (e.g., to promote science or science careers, raise awareness about particular risks or innovations), (d) where researchers themselves may benefit from public engagement (e.g., in gaining feedback on results and debating their implications; to explore potential public reaction, uptake and/or use of novel technologies or social/behavioural innovations); and (e) how to evaluate the impacts of this communication. Further guidance is provided in sections 5.3.7 and 7.2.

8.3.2 Strategic decision-making

As discussed throughout this report, there is a key role for the public to play in strategic decision-making around energy research. There may be normative, instrumental, and/or substantive rationales for such 'upstream' involvement in the research and innovation process. In other words, public involvement in the strategic direction and conduct of energy research can help legitimise socially relevant and public-funded research; it may be used to increase acceptance from the public of potentially controversial areas of research; and – perhaps most importantly – it may improve the quality of decision-making by expanding the range of perspectives and types of knowledge involved. As mentioned above, the public may help elucidate social and ethical dimensions of energy research and innovation, and offer new and challenging perspectives on scientific assumptions and research objectives. Upstream engagement allows these social considerations and challenges to be considered and addressed early in the research process before attitudes become entrenched and potential controversy develops. Our recommendations at the level of strategic decision-making, then, include proposals for how research is funded and governed, as well as what research should be conducted.

For Energy Programme staff considering public engagement *for strategic decision-making* about energy research and development, it is critical to consider (a) which technological or social innovations are likely to most affect the public – either because a large number of people will be affected or particular risks are involved, (b) which innovations are likely to be particularly socially contentious – for financial, cultural, and/or moral reasons, and (c) which innovations are either upstream in the RD&D chain. Engagement should not be expected to resolve controversy, but it should at least increase mutual understanding among the concerned public and among energy experts. Given the above, it may be helpful to scope/screen RCUK energy technology research that meets the above criteria (i.e. early stage or contentious) and target this for engagement activity. This activity may be broadly conceived – including both educational and dialogue activity.[10]

No energy technologies or policies receive unequivocal public support or opposition. Public support is generally higher for renewable energy (especially solar) than for fossil fuels or nuclear energy; and for energy efficiency than for energy conservation. However, as we have shown, support or opposition is often contingent on the particulars of the proposed development, technology or policy, on concomitant proposed changes and measures, as well as how engagement has been conducted or attitudes measured. Our recommendations

[10] For a recent example of public-expert dialogue in the field of molecular biology, and associated issues, see e.g. http://www.nature.com/embor/journal/v10/n4/full/embor200943.html

for the strategic direction of RCUK-funded energy research must be understood with this in mind.

While these considerations may help in prioritising where to focus public engagement efforts at the strategic level, we would emphasise that, ideally, public engagement should be embedded in all levels of Energy Programme decision-making and that public perspectives should thus be represented within Programme governance. This might include representation on the Scientific Advisory Committee, for example, and/or a dedicated citizen's panel or advisory group; or ad hoc surveys or focus groups.

In addition, in respect of future funding, we suggest encouraging, where appropriate, the integration of social scientists active in the field of public perceptions of and engagement with energy (both psychologists and sociologists) within engineering research teams. This might be achieved via a supplementary fund focussing on engagement and dialogue, or via more cross-council integrated, coordinated calls which incorporate social science research (on behaviour, attitudes, practices, etc.) with natural science and engineering research. A separate fund might be established for education, which is a very different activity, and potentially taken as a top-slice across the RCUK energy budget. We suggest building societal awareness training into the doctoral training given to engineers. This would aim to explain that technological developments frequently have political consequences and that technical expertise is not value-free. Finally, suggest research is commissioned to address knowledge gaps about public attitudes and engagement (as detailed in section 8.2).

When thinking about strategic directions for RCUK public engagement in energy research, it is also necessary to think beyond the particular energy topics and policies that have been under-investigated in relation to public engagement and opinion (such as energy systems, scenarios, micro-generation, biofuels and others). The pattern of reviewed literature reflects additional dynamics that also require attention. Notably, the way in which a limited range of theory has been applied to particular topics and the way in which different theoretical perspectives are rarely brought together to shed light on the multiple dimensions of particular energy-related research problems. Such integration and multi-level work is rare, given the constraints posed by research programmes and hence proposal reviewers. It is via the design of these - funding calls and guidance to reviewers - that the most significant difference could be made to energy-related social science research in general and public engagement therein, in the broadest sense. It is arguably preferable to allow research teams to respond to calls flexibly with respect to specific technology focus, but to shape the mode of such responses such that proposals include an element of public engagement. While the Impact Plan component of proposals to Research Councils now requires some acknowledgement of this, it would seem doubtful that substantive public engagement in energy R&D will happen without stronger specification in calls. Rather than requiring this uniformly, which would have substantial cost implications, this would be better achieved through focussed calls. Finally, we would recommend attending to both social science theory and methods in public engagement research. Since there is now a substantial body of literature on public engagement with energy, more theory-driven projects are warranted to make significant advances to the field (and to cognate disciplines); and innovative methods or combinations of methods should be developed to help overcome limitations with, and to complement, some of the most commonly-used methods (e.g., surveys).

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