

Appendix B: Socio-technical systems

B.1. Why is the socio-technical interface important?

The social-technical interface is important because there is a tendency to view social and technical issues as distinct, when in reality they are closely interconnected. Perhaps most common is so-called ‘technical determinism’, whereby the development and dissemination of technologies is seen as inevitable and unproblematic. The aim of a socio-technical approach is to think more holistically about social and technical issues, summarised as follows:

“The point is that whilst technology is a thoroughly social construction, society is a technological construction as well”
(Kirsch, 1995: 531).

In other words, politics, economics and culture are critical to the development (or not) of certain technologies, and likewise technologies help to shape culture and society (Bijker, 1995; Bijker and Law, 1992). An interdisciplinary approach is critical in order to counter the widespread assumption amongst academic and policy communities that once technologies are developed the only ‘barrier’ to overcome is then lack of societal uptake. In this way, society is represented simplistically as a collection of irrational individuals, and wider structural and cultural issues tend to be ignored. The literature similarly seeks to avoid misrepresentation of technologies as neutral actors, with no or little influence on their producers and users (Cowan, 1987; Street, 1992; Winner, 1977). A socio-technical approach draws attention to the broader context (social, political, economic, policy) in which new technologies emerge and diffuse.

The social-technical interface has been examined at various different scales: there is a lot of literature. There is specific material about socio-technical systems (see below), which is probably most relevant to the RCEP study. But there are also examples of the socio-technical interface being examined at a household/individual level (Jelsma and Rohracher, 2003; Ornetzeder, 2001; Rohracher, 2003; Shove, 2003) and a national level (Walker, 2000). In addition, there is a relatively small body of work applying these kind of socio-technical ideas to environmental issues in the housing sector (Bijker and Bijsterveld, 2000; Jelsma, 2003; Lovell, 2005a; Ornetzeder, 2001; Smith, 2004).

B.2. What are socio-technical systems?

Socio-technical systems are sectors or technical systems where the social and technical elements are strongly interconnected, such that it forms a coherent system. Examples are diverse and include utility systems (water, electricity, wastewater), transport systems, telecommunications and housing. The essential idea of the socio-technical systems literature is that technical systems are “both socially constructed and society shaping” (Hughes, 1987: 51), and hence technology and society need to be analysed in conjunction. Lots of science and technology studies authors have focused on single technologies, so the socio-technical system literature is important because it takes a broader sector-wide approach, which is especially relevant to housing. In more practical terms, the idea of socio-technical systems is one in which engineers and those from a technical background appear comfortable working with.¹ It provides a common language to consider the issue of socio-technical change in an interdisciplinary way, despite some deficiencies, discussed below.

¹ Evidence for this is anecdotal, based on discussions with the Environmental Policy Group at Wageningen University, the Netherlands, October 2005.

There is a confusing variety of terminology used to describe socio-technical systems, including socio-technical regimes (Kemp *et al.*, 1998; Nelson and Winter, 1982) and large technical systems (Coutard, 1999; Hughes, 1983). For simplicity, the term socio-technical system is used collectively here, defined broadly by Geels as:

“... a range of elements... linked together to achieve functionality, for example, technology, regulation, user practices and markets, cultural meaning, infrastructure, maintenance networks and production systems.”
(Geels, 2004: 1).

A key feature of socio-technical systems is that they are largely invisible, or rather, they are such an integral feature of modern life that their role can be overlooked (Graham and Marvin, 2001; Hinchliffe, 1996). In particular, socio-technical systems are judged to reach a stable point in their growth, termed ‘momentum’, whereby they:

“... gradually diffuse to become taken for granted and ‘normalised’ as essential, but largely invisible, supports of modern urban life.”
(Graham and Marvin, 2001: 180).

Thus socio-technical system relations become increasingly stable over time as they are embedded within social and technical infrastructures. In other words, habits, institutions and materials begin to dictate the pattern and speed of system change, as Berkhout summarises:

"The literature on change in technological regimes places emphasis on the persistence of change along well-defined pathways. Innovation and novelty are seen as being bounded by working assumptions, institutional networks and capital endowments inherent to a given regime."
(Berkhout, 2002: 3).

Rip and Kemp (1998) have taken the socio-technical system idea further by developing a three-tier model of socio-technical change, with *innovation niches* existing at the micro-level, a socio-technical *regime* or set of rules at the meso-level (a socio-technical system), and a macro-level socio-technical *landscape* of deeply embedded cultural and technological characteristics. Change takes place within and between all these levels, but micro-level change in innovation niches is most significant because it is where radical innovations occur. Other authors have explored in more detail the idea of innovation niches (Kemp, 1994; Kemp *et al.*, 1998; Schot *et al.*, 1994; Smith, 2004; Szejnwald Brown *et al.*, 2003; Unruh, 2002). Innovation niches are defined as learning spaces for new technologies, which comprise either a single experiment or project, or a cluster of several experiments (Weber, 2003). Thus:

"...a niche... protects [new technologies] against too harsh selection and provides space to grow."
(Schot *et al.*, 1994: 1061).

Hence the critical attribute of innovation niches is that they are protected from the momentum (inertia) of existing socio-technical systems. Niches are seen as the key mechanism for bringing about radical change in socio-technical systems. Radical change is viewed as most likely to be catalysed by a factor external to the socio-technical system, such as climate change in the case of housing. However, the precise mechanisms by which niches grow to become new socio-technical systems are not well theorised (Smith, 2002).

Criticisms of the idea of socio-technical systems include:

- Lack of focus on the householder/end user within socio-technical systems (see Cowan, 1987; Jelsma and Rohrer, 2003 for exceptions).
- The idea of coherent socio-technical systems is based on a model of public ownership. This is rather outdated now that in many countries the utilities have been privatised and liberalised;
- The socio-technical system literature oversimplifies the politics of technology change and the role of government actors. Those involved in policy making are not distinguished adequately, and policy recommendations are few.

B.3. Why are these ideas relevant for the UK housing sector?

Housing can be viewed as a type of socio-technical system. In thinking about change in the housing sector it is important to pay attention to social issues, as well as technical ones. The relationship between materials/technologies and society is judged to be particularly strong in sectors where the infrastructure is durable and capital and technology intensive: this applies to housing as well as other associated sectors like energy, water and transport. More interdisciplinary socio-technical concepts need to be developed to allow housing infrastructure to have some sort of agency in the policy process, thus expanding the ideas of housing policy theorists such as Malpass and Murie, who advise that:

"In considering the impact of policy it is an error to perceive policy and practice as acting on a *static object* and to conclude that if the effect of the policy is not as intended or expected the policy must be at fault"
(Malpass and Murie, 1999: 131, emphasis added).

In other words, a more active role for housing is suggested, whereby the material features of housing are recognised as influencing the process of change. In addition, in socio-technical systems with a durable material infrastructure contemporary policy making is heavily influenced by historical infrastructure decisions, as Shove suggests with reference to energy policy making:

"The grids of wires and pipes that permit energy flows... reveal patterns of past actions and priorities... These embodied practices and histories do not prohibit change, but they do make a difference to the scope, scale and form of contemporary decision making and to the character and location of energy policy making."
(Shove *et al.*, 1998: 226).

Further ideas about change in the housing sector raised by adopting a socio-technical approach include:

- Our housing material infrastructure is ubiquitous and plays a vital role in our everyday life: it is 'black-boxed'.² It helps explain why we rarely critically examine the ways in which it is provided, nor how we interact with it as householders;
- The role of the built environment in slowing, or in some cases speeding up, the pace of change. Existing (energy inefficient) housing comprises the majority of the housing stock in the UK, and presents a major difficulty for the Government in trying to reduce household energy consumption and carbon emissions. In other words, the housing infrastructure is slowing down the pace of policy

² 'Black boxing' is defined by Rip and Kemp as using (technical) artefacts "without an indication of their history and inner working" (1998: 329).

change. But there are other instances in which infrastructure offers significant opportunities to catalyse shifts in policy, for example lots of new housebuilding under the Sustainable Communities Plan.

- Recognition of the fact that most examples of environmental innovation in the housing sector have taken place within innovation niches (i.e. one-off housing developments or pockets of innovation), rather than through sector-wide shifts. This is a pattern of early system change predicted by socio-technical authors;
- Social networks and values have been important factors for those who have been successful in building/refurbishing environmental housing, thereby revealing how change is not just about technology – it is a socio-technical process.

B.3. Socio-technical systems and market transformation

Within the field of product policy, the main strategy employed to date has been a market transformation approach, which has been relatively successful in the domestic appliance market, particularly for refrigeration appliances (Schiellerup 2001). This approach works with the existing market using an interacting package of policies to help introduce a new (more efficient) technology and then shift the market to establish the technology so that it eventually ends up as the mainstream average. There are some parallels with the theories of socio-technical change as outlined in Section B.2. In terms of the three-tier model developed by Rip and Kemp (1998), the micro-level, or innovation niche, describes the position of the new technology when it enters the market. The meso-level identifies the set of rules which define the socio-technical system – part of this could be considered to be the rules or policies required (the ‘policy toolbox’) to help shift the market towards the new technology. And finally, the macro-level, which represents the deeply embedded socio-technical landscape, can be thought of as reflecting the overall distribution of technologies on the market. This landscape needs to be transformed so that the niche technology becomes part of the mainstream and is therefore embedded in the system. The pattern and speed of change will depend heavily on the nature of this macro-level, dictated by habits, institutions and materials (Lovell 2005a). For instance, the physical nature of housing – relatively durable and long-lasting – contributes to the stability of the socio-technical system (termed ‘momentum’), making it more difficult to bring about change. This is in comparison to the domestic appliance market, where less durable products with faster turnovers provide more opportunity for change, although the actors and institutions involved may prove resistant.

In terms of socio-technical change theory, market transformation is a planned approach to societal influence on technology, similar to strategic niche management (Schot et al. 1994) and technology forcing (Schot et al. 1994; Schot and Rip 1996). Strategic niche management describes the process by which the government or other actors set up relatively protected experiments with new technologies. Experimentation in niches allows any problems with the technologies to be sorted out and learning about social needs to take place. Technology forcing is similar, essentially brought about through government regulation and policies. By government setting stringent targets, it allows new technologies to flourish which would otherwise be unsupported and hold little chance against well-established technologies.

In order to link some of the more conceptual ideas from socio-technical system theory to the practical ideas and policy suggestions that make up a market transformation approach, a matrix was developed, representing a ‘middle ground’ between theory and policy research (Table 1). The text in italics within the table aims to briefly summarise the current picture at each scale in socio-technical terms, ie with

equal attention to the social changes that have and have not arisen, as well as to technical shifts.

It is apparent that positive environmental change has been most significant at a micro-level, with the current picture less positive at the meso and macro levels. The situation is thus broadly in line with theories of socio-technical system change, where radical change is predicted to emerge initially within small-scale niches, and then diffuse over time to the meso and macro levels. Nonetheless these small-scale niche innovations need support at a meso and ultimately macro-level if they are to be successful. Suggestions for future action at these levels are therefore aimed at providing that support. There are some limitations with the stark micro/meso/macro scale division of the matrix. Some examples of change cut across all levels, and for the micro level the most significant future action is really for the innovations to diffuse upwards to the meso level, rather than increasing the number of innovations at this scale.

The matrix illustrates the complexity of environmental change within the housing sector – the need for co-ordinated action by multiple actors across many (often competing) environmental concerns may explain why widespread change has not taken place in this sector and that any progress that has been made is slow. The transformation required here is of the whole regime, rather than a discrete technological change, and therefore involves a wider range of actors and institutions who must all recognise that the change is necessary, feasible and advantageous (Berkhout 2002). This complex mix of multiple actors and environmental issues also helps explain why the positive change that has taken place has tended to be at a micro-scale, typically with groups of actors or individuals with environmental values and a thus a strong commitment to environmental innovation. Co-ordination is easier at a local level, and learning about new technologies is facilitated by the close interaction between different actors.

Table 1 **Socio-technical change at different scales within the UK housing sector**

Scale of socio-technical change	Micro-level		Meso-level		Macro-level	
	<i>Small scale, local practices and technologies in innovation niches.</i>		<i>Formal and informal rules embedded in institutions and infrastructures</i>		<i>Deeply ingrained cultural and technological characteristics</i>	
	Current picture	Future action	Current picture	Future action	Current picture	Future aims
Housing industry (refurbishment)	<p><i>Some sustainable renovation at a local level, concentrated in social housing, and a few privately-owned homes. Overall a much greater level of innovation found in new build housing. Householders lack the confidence, expertise or (up front) capital to refurbish sustainably.</i></p> <p>Examples of positive change:</p> <ul style="list-style-type: none"> Westminster Council sustainable refurbishment projects (social housing); Nottingham EcoHouse (owner occupied). 	<p>The benefits of sustainable refurbishment need to be promoted to encourage more household-level action – not just environmental benefits but improved comfort too. e.g. via refurbishment show homes, providing more sustainability information in DIY stores and on TV programmes.</p>	<p><i>A large number of housebuilders/tradesmen working in the refurbishment sector, creating difficulties in providing information and training about sustainable technologies. Little incentive to gain new skills as the workload of most small builders is high.</i></p> <p>Examples of positive change:</p> <ul style="list-style-type: none"> Sustainable Homes Green Street website – information about sustainable refurbishment; Home Information Pack (2007) 	<p>Need to generate greater policy debate about sustainable refurbishment. Examples of possible policy initiatives include:</p> <ul style="list-style-type: none"> 'MOT' for homes – mandatory annual assessment of privately owned homes; buildings insurance linked to dwelling reaching a certain standard; Private sector follow up care/maintenance contracts with consumers. 	<p><i>Owner-occupation aim of majority of population. Renovation programmes/DIY part of culture – for aesthetic reasons, rather than environmental.</i></p> <p><i>Household size continues to fall and demand for homes remains high</i></p> <p>Examples of positive change:</p> <ul style="list-style-type: none"> Some change in living patterns prompted by disillusion with treadmill of work, consumption & travel and what this does to quality of life 	<p>Shift away from owner-occupation to more flexible housing arrangements – including provision for old age, maintenance agreements etc;</p> <p>DIY trend more focused on aesthetically-pleasing sustainable refurbishment.</p> <p>Training in skills needed for sustainable living, from infancy through to CPD</p> <p>Maximum visibility of energy use and on-site generation within the home</p>

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	Current picture	Future action	Current picture	Future action	Current picture	Future aims
Housing industry (new build)	<p><i>Pockets of environmental innovation, mainly in social and self-build sector, driven by entrepreneurial individuals. Strong social networks important. Closer producer-consumer relationship facilitates innovation.</i></p> <p>Examples of positive change:</p> <ul style="list-style-type: none"> Stringent environmental targets for private sector housebuilders building on publicly-owned land, e.g. Millennium Villages. 	<p>Encouragement of private sector innovation, e.g. through secondment of sustainable housing practitioners to large private sector housebuilders.</p>	<p><i>Reluctance to innovate amongst large private sector housebuilders. Housing industry profits based on land speculation rather than quality of the housing product. Compliance with regulations, not beyond; intense lobbying against regulatory changes.</i></p> <p>Examples of positive change:</p> <ul style="list-style-type: none"> EC Directive on the Energy Performance of Buildings (2006); EcoHomes; Sustainable Building Code (2006). 	<p>Expansion of initiatives such as Rethinking Construction, which rewards innovation through generating publicity for the company and gaining recognition amongst peers.</p> <p>Better integration of planning and building regulations.</p> <p>Increasing the stringency of EcoHomes and Sustainable Building Code; make mandatory.</p> <p>Encouraging consumer demand for higher quality environmentally sustainable homes, e.g. through labeling, environmental show homes.</p>	<p><i>Environmental issues recognised as increasingly important by consumers, but to date little action – other reasons for purchasing homes still take priority. Housebuilders concentrate on profits>innovation and are risk averse.</i></p> <p><i>Household size continues to fall and demand for homes remains high.</i></p> <p><i>Belief that can continue to build new homes with little or no environmental impact.</i></p> <p>Examples of positive change:</p> <ul style="list-style-type: none"> Same as 'refurbishment' above 	<p>Culture change in housing industry to embrace environmental and social innovation: affordable low-energy housing, tough restrictions on second homes, attractive housing with easy access to services and green space, especially for the elderly</p> <p>Consumer push for change: sustainable housing is demanded by consumers, becomes 'normal' as part of move towards sustainable ways of life.</p> <p>Training in skills needed for sustainable living, from infancy through to CPD.</p> <p>Maximum visibility of energy use & on-site generation within the home</p>

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	Current picture	Future action	Current picture	Future action	Current picture	Future aims
Appliances (water & energy)	<p><i>Low and zero carbon technologies are now much less 'socially-off', though many are expensive and so still have limited uptake via grants, and/or to rich households. Low energy and water appliances are mostly located in environmentally-committed households.</i></p> <p>Examples of positive change:</p> <ul style="list-style-type: none"> • Government grants available for low and zero carbon technologies, e.g. Clear Skies. 	<p>Action concentrated at the meso-level, on market transformation.</p> <p>Long-term evaluation research into the performance of, and integration between, different energy and water appliances in order to facilitate learning from existing innovations.</p>	<p><i>More attention to the efficiency of appliances, but at the same time growth in ownership of new appliances. The two trends are not currently seen as competing.</i></p> <p>Examples of positive change:</p> <ul style="list-style-type: none"> • Environmental labelling of appliances 	<p>Shift in policy focus to concentrate holistically on household appliance use.</p> <p>Encourage debate on level of ownership of appliances.</p>	<p><i>Eco-modernist outlook: can have economic growth and environmental protection, i.e. no incompatibility between level of appliance ownership and being 'green'.</i></p> <p>Examples of positive change:</p> <ul style="list-style-type: none"> • Possible shift in assessments of risk of climate change and willingness to act in small ways via appliance purchase 	<p>Shift to emphasis on uncluttered, slowed-down way of life as more enjoyable</p> <p>Much higher level of environmental awareness and action by industry and householders.</p> <p>Conversion of jobs in appliance manufacture from energy-guzzlers to LZC technologies - training and retooling</p> <p>Shift of emphasis from efficiency to demand reduction</p>

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	Current picture	Future action	Current picture	Future action	Current picture	Future aims
Waste	<p><i>Some pockets of innovation, but not widespread.</i></p> <p>Examples of positive change:</p> <ul style="list-style-type: none"> • Construction waste reduction targets for certain developments, e.g. Millennium Villages. 	<p>More examples of positive reuse & reclamation of building materials – saving waste and money.</p>	<p><i>Waste becoming more of a priority in government and industry, and incentives are changing to encourage less wasteful behaviour.</i></p> <p>Examples of positive change:</p> <ul style="list-style-type: none"> • Landfill tax; • Waste and Resources Action Programme (WRAP). 	<p>Mandatory reuse of materials where demolishing old homes.</p> <p>Integrated waste recycling bins mandatory in new build housing and kitchen refurbishments.</p>	<p><i>Waste reduction not a high priority.</i></p>	<p>Waste reduction becomes a normal part of construction practice and household management.</p>

B.4. Key actors

Type of actor	Role can play in producing positive change
Government	<p>Through providing overall regulatory framework and support to encourage innovation. By setting stringent targets Government can drive innovation – someone needs to take a lead and formulate a long-term strategy to reduce risks for others. Berkhout spells out why:</p> <p>"..the innovation and adoption of radical and risky new technological regimes is not possible without commitments....Unless governments and commercial organisations are prepared to make heavy commitment to new regimes, defection would be too easy and emergent technological regimes would be too fragile to develop." (Berkhout, 2002: 3).</p>
Housebuilders (new build)	<p>By experimenting more with sustainable housing housebuilders will help drive demand, in the same way that producers do in other industries, eg consumer electronics.</p> <p>Could use financial power to influence Government to change (or at least not lobby so hard against environmental legislation).</p> <p>If developed an ongoing relationship with consumers (ie not just a point of sale) might encourage better quality of production, and reduce the risks of experimenting with new building types and technology.</p>
Housebuilders (refurbishment)	<p>Through providing information to householders about sustainable technologies they could retrofit into their homes whilst undertaking building work and their benefits, eg reduced bills, improved comfort. Ensuring they keep up well informed about new sustainable construction products.</p>
Householders	<p>Through driving the market for new environmentally sustainable housing, and demanding better quality housing. If consumers were willing to pay a higher price for sustainable housing (and there is some evidence of this) then it would encourage housebuilders to take risks (financial and technical) in producing more of it. This would also encourage sustainable refurbishment, if sellers knew that buyers were looking for these kind of features in their home.</p> <p>Householders are of course critical in making environmental improvements to the existing housing stock, because the majority of UK housing is privately owned.</p> <p>Householders are also important sources of learning about new environmental technologies in the home. Their feedback from using new technologies could help drive change if they have found the technologies mean their home is more comfortable, cheaper to run, aesthetically more pleasing etc. Word-of-mouth communication through social networks is critical in producing change, particularly in the initial stages of system change.</p> <p>Some householders have built their own sustainable homes, or refurbished their existing homes sustainably, and this might well encourage others to take similar action.</p>
Planners	<p>The role of planners is often seen as negative in relation to sustainable housing, but there are some examples of where local planning authorities have brought about positive change, including:</p> <ul style="list-style-type: none"> • Merton Borough Council stipulates that in developments over

	<p>a certain size 10% of energy must be from renewable sources;</p> <ul style="list-style-type: none"> • Sutton Borough Council – created planning precedent in selling land to Bedzed team, who were not the highest bidder, because of their environmental objectives; • Newark and Sherwood Local Authority – Supplementary Planning Guidance on small-scale wind energy. <p>There are other examples of where local authorities have demanded higher environmental specs for new housing developments on land which they own (eg Leicester City Council, Ashton Green development).</p> <p>Planners have a good oversight of the housebuilding process and refurbishment work, and could act in more informal ways too to encourage change, eg through provision of advice in household visits.</p>
Mortgage lenders	<p>Mortgage lenders have a powerful influence on the housebuilding industry because of their financial clout. They could use their position to influence environmental action. They also have continued interaction with householders, and therefore are an important actor with regard to existing homes.</p> <p>Reduced mortgage rates could be offered to those living in sustainable homes (on the basis that running costs are lower).</p>
Building insurers	<p>Building insurers also have continued interaction with householders, and are therefore in a good position to effect change in the existing homes market. For example, insurance could be linked to the quality of the home, with lower insurance rates for sustainable homes.</p>
Surveyors	<p>With the introduction of the Home Information Pack and the EC Energy Performance of Buildings Directive, surveyors are set to play a more important role in terms of the energy consumption of homes. There is the potential for surveyors to play a role in educating householders (perhaps on a more informal basis) about a range of sustainable technologies, not just energy.</p>
Appliance manufacturers	<p>Continued investment in improving efficiency of appliances. Lobbying for continual improvement to energy and water efficiency labelling standards.</p> <p>Responsible attitude regarding household consumption of electrical appliances.</p>
Appliance retailers	<p>Ensuring retail staff are knowledgeable about the resource consumption of appliances.</p> <p>Encouraging housebuilders to install efficient appliances in new build housing.</p> <p>Responsible attitude regarding household consumption of electrical appliances.</p>

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