Gaps, Barriers and Conceptual Chasms: Theories of Technology Transfer and Energy in Buildings

Elizabeth Shove, University of Sunderland

1. SYNOPSIS

This paper takes a critical look at theories of technical change embedded in current programmes of energy related research, development and dissemination.

2. ABSTRACT

Analyses of the potential for energy conservation typically begin with estimates of technical opportunity. The first step is to assess energy savings which might be achieved by the adoption of economically worthwhile measures and technologies. Framed in these terms, the task is one of technology transfer: of closing the gap between current practice and recognised technical potential. The trouble is that the practical application of energy efficient technologies seems to be impeded by what are routinely referred to as "non technical barriers". The conventional view is thus one in which social obstacles inhibit the realisation of proven technical potential.

This familiar logic depends upon a strong conceptual distinction between the social, on the one hand, and the technical, on the other. But does it make sense to talk of technical potential in the abstract? If we question the notion of pure technical potential, we must also reconsider theories of technology transfer. Do people really have technologies "transferred" upon them? Questions about the nature of technical change in turn lead us to review the conceptual status of the gaps and barriers which dominate discussion of energy efficiency.

Drawing upon ideas from the sociology of science and technology and on recent research funded by Britain's Economic and Social Research Council, this paper unpacks conventional beliefs about the diffusion of energy efficient technologies and develops an alternative model which acknowledges the social structuring of technical innovation.

3. INTRODUCTION

Levels of interest have ebbed and flowed over time but since the oil crisis of the early 1970s, western governments have invested substantial sums of money in energy-related building research. The rationale for such investment has shifted in the intervening years with concerns about environmental protection and global climate change first adding to, and then supplanting, earlier anxieties about energy security and finite fossil fuel resources. Whatever the underlying motive and whatever the sums involved, the value of technical research remains more or less unquestioned. Having defined the challenge of energy conservation in technical terms, correspondingly technical solutions are sought. But that is not the end of the story. Research and development is intended to generate new knowledge, so exactly what new knowledge is required to promote the cause of energy efficiency? What expertise is presumed missing and, if that missing knowledge can be generated, how is it to be translated into energy saving action? In practical terms, how have governments decided what research to support, and how is that knowledge expected to relate to building practice?

This paper is based on recent research funded by Britain's Economic and Social Research Council as part of its Global Environmental Change Programme. The element of the study discussed here involved in-depth interviews with a total of sixty researchers, research managers and project officers in the UK, Ireland, France, Italy, Sweden, Finland and the USA. These interviews generated a wealth of material on the formation of technical agendas and on the visions and models of technical change currently underpinning research and development programmes in each of the seven countries.

As might be expected, detailed procedures for formulating and managing research agendas varied significantly, some being tightly prescribed by government project officers, others emerging in negotiation with academic institutions, still others reflecting a much wider network of commercial and governmental interests (Shove, 1994). But looking back at the interview data and at the technical literature collected during the course of the research the most striking feature is that countries with very diverse building stocks, climates and cultures shared such extraordinarily similar views of the nature of building research and its role in the promotion of energy efficiency.

This paper begins by reviewing key components of these shared theories of energy related building research. The second section unpacks some of the assumptions and conceptual distinctions upon which the conventional view depends. Building on this analysis the final section outlines an alternative approach which takes due account of the inextricably social character of technical change.

4. THE CONVENTIONAL PACKAGE

As presented in this deliberately simplified account, respondents subscribed to a limited range of inter-related, taken-for-granted, beliefs. The first concerns the nature of technical potential. The second relates to gaps and barriers believed to inhibit the realisation of that technical potential while the third concerns the process of technology transfer. Locked together, these three elements provided an underlying rationale for energy related research and development in ES all the countries included in the study.

4.1 Technical Potential

The notion of technical potential is an essential ingredient in policy debate at a number of different levels. Estimates of unfulfilled potential typically inspire further technical research. The fact that there are some eight million homes in Britain with uninsulated cavity walls is, for instance, itself used as a powerful argument for more technical investigation. Second, and more familiarly, choices about whether or not to fund basic or applied research projects frequently depend upon assessments of replication potential. By implication, measures which work well in one case, as in a demonstration project, are expected to work as well in other technically similar situations. Judgements about funding then hinge on scale of potential application. In an ideal world, projects would be ranked in terms of pure technical potential before being evaluated with reference to other temporally and culturally specific factors such as cost and economic value. Used in this way, the concept of technical potential acts as a filter in the selection and rejection of competing research proposals.

The idea has other equally significant uses for it also underpins discussion about the setting and realisation of energy and environmental targets. Whether on a national or international scale, such debates routinely begin with the same question: "Do we have the technical potential to reduce CO2 emissions by x% by the year z?". If the answer is "no", further technical research is required. If "yes", achievable targets can be set. Used in this way, the concept of technical potential constitutes the cornerstone of energy related policy and the driving force of energy related research.

Not all energy related research and development is expected to extend the margins of technical potentiality. Indeed it is increasingly clear that the "problem" of energy efficiency is as much to do with the "inadequate diffusion of apparently cost-effective energy-conserving technologies" (Jaffe and Stavins 1993, p2) as with the limits of current technical capacity (Schipper and Meyers 1993, Gordon and Bigg 1994).

4.2 Gaps

Equipped with a clear model of technical potential (or of cost-effective technical potential), that is of what could be achieved by the effective application of all known (cost-effective) energy saving technologies, and provided with a clear understanding of present practice, it is, in theory at least, relatively easy to measure the gap between the two (Hirst and Brown, 1990). Arguments about the scale and nature of this gap are typically framed in terms of market failure (Stansted, Koomey and Levine 1993). If energy saving measures are indeed cost effective, and if individuals act in an appropriately rational fashion, the gap should not exist. But because there is a gap, something must be wrong. Diagnoses vary but the first conclusion is usually that decision-makers do not have enough of the right kind of information to make the right kind of rational economic choices. Accordingly, the way to overcome market failure is to provide information, education and advice.

4.3 Non-technical barriers

This is not usually enough for the market-mending effects of these initiatives are frequently undermined by what are referred to as "barriers" or "non technical obstacles". Referring to an evaluation of the EU's Energy Demonstration

Programme, Caprioglio suggests that "there is ..a growing appreciation that market penetration of well established or successfully demonstrated technologies is often impeded by barriers which are not technical nor economic in nature" (Caprioglio 1988). These include such complicating features as the landlord-tenant relationship (in which those who might invest in energy saving technologies don't directly benefit from lower fuel bills) or the nature of the professional fee structure (if professional fees represent a percentage of the cost of heating and ventilating systems, engineers have no incentive to design systems with less energy intensive equipment), and so on. The array of potential obstacles is impressive, as demonstrated by those who have sought to itemise barriers to energy efficient technology transfer (Evans 1991) or to draw distinctions between "structural and behavioural barriers" (Hirst 1992). Repeated calls for "additional research to understand barriers, to assess their importance, sector by sector and to examine the effectiveness of policy options that might overcome them" (Hirst and Brown 1990, p278; Bondi 1988) reinforce the belief, first, that such barriers are real and, second, that governments have a legitimate part to play in supporting efforts to correct these and other market imperfections.

4.4 Technology Transfer

As represented so far, the conventional view depends upon a concept of relatively pure technical potential, the realisation of which is impeded by lack of information or by some other non technical barrier. In diagrammatic form, energy saving technologies fight their way across the page from left to right: research leading to development, demonstration and dissemination and on through successive hurdles of information blockages and non-technical barriers before being taken up and incorporated into normal practice.

Research   Development   Demonstration   Dissemination   Building Practice

Conventional understandings of the process of technology transfer depend upon this unambiguously linear model of innovation, also embodying two equally important beliefs about the nature of individual action and the relative insignificance of social context.

In describing the process of technical change and the development of energy saving technologies, respondents frequently referred to the classic model of technical diffusion outlined by E. M. Rogers (Rogers 1962). In this account, technical change depends upon the actions and decisions of a population of individuals each of with a personal propensity for risk taking. New ideas are tried out by a limited number of experimentally inclined "early adopters". More cautious members of society follow in increasing numbers, with "laggards" bringing up the rear at the top of the S curve. The diffusion of discrete energy saving gadgets can be charted in these terms and retrospective analyses have been undertaken of the spread of solar water heating systems (Warkov and Meyer 1982). It is rather more difficult to trace the development of architectural practice in these terms but the belief that architects copy ideas adopted by the "stars" of their profession is well entrenched (den Ouden 1990, Kealey 1989). Accordingly, deliberate efforts have been made to persuade recognised heroes to adopt and promote energy efficient technologies in the hope that this will inspire others to follow suit (for example, DGXII's "Solar House" competition). Adopting a similar logic, promotional initiatives (such as the UK Energy Efficiency Office's "Corporate Commitment" programme) have sought to convert market leading companies to the cause of energy efficiency.

In all cases, innovation is thought to depend upon individual belief and action. In this essentially psychological analysis, attention focuses upon "key decision-makers" and upon people conceptually stripped of all social context. The presumed irrelevance of cultural and organisational environment parallels the presumed transferability of proven technological solutions. Simulations, trials, case studies and demonstrations are expected to generate broadly transferable scientific conclusions, applicable in any number of different settings (Macey and Brown 1990). International conferences and seminars (including this one) allow technical researchers to present results and compare notes, thereby sustaining the notion that science-based understandings of building technology transcend localised forms of practical knowledge and experience. The presumed transferability of technical knowledge, together with an implicitly linear, and ultimately psychological understanding of technical change represents the third critical ingredient in the conventional paradigm (Shove 1993).

4.5 Attractions of the conventional package

Analysis of the sixty interviews suggests that each element of this pervasive bundle - faith in the transferability of technical knowledge, acceptance of an individualistic theory of technical change, reliance upon the sequential logic of research and development, commitment to a vision of uncomplicated technical potential inhibited by non technical gaps and barriers - feeds into the next, creating a web of taken-for-granted belief strong enough to encapsulate technical researchers and their project officers and elastic enough to span countries and continents.

It is useful to reflect on the attractions of these extraordinarily influential beliefs before going on to review their limitations. Four features are, I think, especially important.

First, key elements of the package have a long and familiar history within science policy. The notion that governments should support basic research, like the idea that basic research leads to development and application, embodies a deeply entrenched "top down" view of the development of knowledge. As discussed in the next section such a view takes no account of the ways in which building practice grows and emerges through first hand experience, nor can it readily acknowledge localised interpretations of technical risk and reliability (Shove 1991). Despite these and other limitations, the conventional sequential model is enormously useful in that it provides ready-made justification for government funding and simple guidance for the development and implementation of sensible responsive strategies. Translated in policy terms, government funding is required and justified in areas in which there is some identifiable market failure or in which the market would be unlikely to take the necessary risks.

A second powerful advantage is that conventional definitions of the problem point to a way ahead which fits comfortably within the parameters of government action. Individualistic theories of technical change and market economics support a range of politically uncontentious responses: successive waves of energy-saving information are consequently targeted at "people" defined and treated as socially anonymous free agents. Cast in terms of the prevailing techno-ideology, such programmes can be pursued without reference to wider political issues surrounding the shifting contexts of energy-related decision-making.

Thirdly, and more theoretically, the conventional package of belief explains success and failure in the development and application of energy saving technologies without questioning the implicitly inevitable trajectory of technological progress. Successes, that is the speedy application of proven technology, are typically explained in terms of the individual enthusiasm of key decision-makers. Analyses of failure, that is the slow or perhaps very slow "uptake" of proven technology, mirror equally individualistic notions of apathy, ignorance, traditionalism and lack of political will. In this account, social-psychological or loosely political factors may accelerate or delay the application of proven cost effective measures but whatever their effect they do not themselves shape the process of technological innovation. As Bijker wryly observes, "Technology is like a train running on a track that is fixed though not known in detail; one cannot hope to change the train's direction, only to check its speed and improve the safety of the crossings" (Bijker 1995, p253).

Finally, conceptual separation between the realm of the technical and the realm of the social places technical researchers in an especially privileged position: it is they who define the technical fixes upon which energy efficiency depends. Sociologists, economists and market analysts are then charged with the secondary tasks of removing blockages and easing channels of communication so as to allow proven technologies to flow unhindered into everyday practice. These "non technical" jobs are generally defined and specified by project officers equipped with a background in engineering and an understanding of social science mediated by popular images of market research and by psychological theories of "what make people tick". This hierarchical relationship is of practical significance for challenges to (and defences of) the conventional techno-ideology threaten (or sustain) the livelihoods of researchers dependent upon present definitions and associated divisions of labour.

For all its neatness, coherence, and familiarity and for all the vested interests at stake, I want to argue that the standard model is deeply flawed. Let us now consider some of its limitations.

5. UNWRAPPING THE CONVENTIONAL PACKAGE

In simplified form, the conventional view holds that energy-related decisions are made by socially anonymous individuals, that knowledge comes from research, that technical change is a one-way process of technology transfer, and that social obstacles or non technical barriers impede technological progress.

What is missing is an appreciation of the social context of energy saving action and of the socially situated character of technical knowledge. As we shall see, reinstatement of these missing elements has knock-on consequences for the rest of the model, so much so that the whole tidy edifice begins to crumble.

5.1 Contexts of action

Two simple examples serve to illustrate the significance of social context for energy saving action. Imagine a designer keen on energy conservation and equipped with up-to-date knowledge about energy saving methods and measures. Let us say that this person works in the public sector, designing housing schemes within a local authority. The designer's capacity to put his or her energy saving knowledge into practice depends, in significant part, upon the organisation's internal accounting practices, on the current priorities of local and national government, and upon the division of labour between relevant building and housing professionals. If this designer leaves the local authority and gets a new job in the private sector the translation of knowledge into practice will be governed by quite different considerations. In this context, the designer's energy related choices will reflect the need to produce marketable properties at a profit, rather than the need to conform to standard cost guidelines or to produce houses which tenants can afford to heat. Thus the same person with the same psychological propensity for risk taking, and confronting the same decisions (in this case, decisions about housing design), will arrive at different solutions depending upon the organisational environment in which he or she happens to operate. Part of the ESRC funded project "Putting Science into Practice: Saving Energy in Buildings" involved detailed analysis of the practical implications of these and other contexts of action (Guy and Shove 1993; Guy 1994).

But it is not just that the contexts of action, and thus the outcome of energy-related decisions, vary from one working environment to another. They also vary over time. As a result, energy-related choices which make sense - that is to say which make sense given a specific configuration of social, economic and organisational circumstances - this year may not make sense in the same terms a year or so later. The changing energy standards of both speculative commercial property developers and owner-occupiers exemplifies this process. In times of boom, and particularly when commercial properties are viewed primarily in terms of their investment value, developers tend to increase specifications. Under these conditions, and in the UK market, "headquarters" standards, including energy intensive technologies and full air conditioning spread to become the norm (Guy and Shove 1993). In times of recession, users have rather greater influence. As Simon Guy explains, in this context, issues of facilities management, maintenance and running costs come to the fore with immediate consequences for energy-related design (Guy 1994). Different countries have their own histories of property development, each associated with a different network of players and interests and each following its own temporal pattern. While technologies of energy efficiency might be "transferable" in the rather abstract sense that similar measures could function effectively in different countries there is a real sense in which unique socio-commerical histories preclude any simple transfer of technology.

As suggested here, options are identified and energy-related choices made within varied and dynamic worlds. Building designers consequently select, adopt, and adapt only those elements of technical knowledge which apply or which fit given the fine grained social, organisational, and economic circumstances of the moment. More than that, experience of working within one or another context is itself cumulative. Technical knowledge grows from the ground up, as well as from the top down. Described in these terms people simply do not have contextually disembodied technologies transferred upon them. Instead they acquire and develop knowledges which mesh with or which emerge from local, culturally and temporally specific working environments. When viewed as active and creative social agents, rather than as the passive recipients of science-based research findings, and when treated as social, rather than psychological, beings, we begin to see decision-makers and energy-related decision-making in a rather different light. This has important consequences for the conceptualisation and understanding of technical change.

5.2 Contexts of technical change

Recent studies in the sociology of science and technology (Callon 1991, Callon, Laredo and Rabeharisoa 1992, Bijker 1995) allow us to take discussion of the socially situated character of technical change a stage further. Let us begin by borrowing the idea of the sociotechnical regime (Rip 1993) and let us assume that technologies, including technologies of energy conservation, imply a certain set of social relations. As we have already seen, what qualifies as a reliable, cost effective, worthwhile energy saving measure in one socio-cultural domain might count for nothing in another. Moreover, we know that the commercial and cultural contexts of building practice vary widely, that they change over time and that this has important implications for the development and use of energy saving technologies. Present practice consequently represents a certain alignment of technical, organisational, social and societal aspects and the introduction of new technologies takes place against the backdrop of this inter-connecting whole, that is against the backdrop of existing sociotechnical regimes. Re-alignment or modification of any one of these dimensions has consequences elsewhere in the sociotechnical system: technological change implies social change and vice versa.

In addition, existing sociotechnical regimes set the scene for future development, favouring and constraining alternative courses of action. If we accept these arguments it is extremely difficult to sustain belief in the "natural" diffusion of technology or in sequential theories of technology transfer. Looking back, it may be possible to discern "S" shaped curves of the classic variety but such retrospective analysis does not in itself explain the process of sociotechnical change. If ideas and measures appear to spread then it is because of some uniformity in the contexts in which they are adopted, not because of the psychological characteristics of key decision-makers and not because of some essential quality embedded in the technology itself. In defining a range of elastically bounded sociotechnical environments and in arguing that there are many contextually specific worlds in which new and not so new technological strategies "make sense" at different moments in time, we begin to describe a bumpy, uneven, terrain in which ideas are selectively incorporated, adapted and abandoned.

This certainly does not correspond to the neatly ordered model of technological progression implied in the conventional, linearly sequential theory of technical change. There is more to come for if we are to take full account of the diverse contexts of action, and of the variety of sociotechnical landscapes, we must also recognise the multiple contexts in which experience develops and localised technological knowledges are formed. This raises further questions about the transferability of disembodied building technology and indeed about the meaning of pure technical potential.

5.3 Conceptual chasms

At this point the gap between the conventional view (which depends upon a strong distinction between the social and the technical) and an alternative sociotechnical analysis (which presumes that the two are indistinguishable) widens into a chasm.

On one side of the divide, proponents of the conventional view talk of technical potential, believing that energy related choices are made by free, more and less knowledgeable individuals whose rational economic actions may be clouded by a variety of "non technical", social or psychological barriers. Lined up along the other bank, we have an analysis which denies the possibility of pure technical potential (Bijker and Law, 1992) and the existence of social barriers and which instead suggests that technical change is an unremittingly social, and thus contextual, localised and temporally specific, process.

This alternative, sociotechnical, account hangs together as tightly as the conventional view against which it is pitched. If the notion of pure technical potential makes no sense, neither does the idea that there are barriers and obstructions limiting realisation of that potential. But if there are no barriers and obstructions to overcome is there then any useful role for social science?

As currently organised, energy-related research labour is divided into two camps: there are those who develop technical knowledge, and those who try to get it applied. Such a division mirrors the conventional view for the ready-made "sociological" roles of barrier analyst and/or marketing expert presume a strong distinction between the social and the technical (Guy and Shove 1993; Robinson, 1991). If we reject this two part analysis new roles emerge. So what are these alternatives? What are the practical implications of a sociotechnical theory of energy efficiency: what sorts of jobs does it create, what does it imply for the division and management of research activity, and how might it change the terms of debate and analysis and the orientation of government policy? The next section of the paper examines some of the options.

6. RE-FRAMING THE DEBATE

If we jettison the conventional distinction between the social and the technical we must also abandon many of the terms routinely employed in energy analysis. Talk of "technical potential", of "non technical barriers" and even of "technology transfer" brings with it a baggage of increasingly suspect ideas. The suggestion that this terminology be ditched involves much more than a change of semantic clothing. It is not simply a question of substituting "contexts of action" for "non technical barriers", or of swapping "technology transfer" for "sociotechnical change". Rather, such a switch requires a complete overhauling of the basic elements of the conventional view, starting with the notion of technical potential.

6.1 Abandoning technical potential

Assessments of the potential for reducing environmental damage routinely rest on analyses of "purely" technical capacity. Such assessments are generally optimistic, confirming the view that any number of environmental targets could be achieved once intervening social barriers have been overcome. In this fairy tale world, abstract models of absolute technological potential dominate.

But technical potential which cannot be realised for a range of perfectly explicable sociotechnical reasons is not really technical potential, or at least it is not technical potential which is of any relevance in the race to reduce CO2 emissions. To complicate matters, and to finally confound the possibility of abstract assessment of technical potential, the chances of realisation or, to put it more accurately, the chances of incorporation and adoption, are themselves dynamic: what qualifies a socially viable technology one day may not count a such the next. Although technological assessments do not, and cannot, tell us anything about the dynamic and contextually specific practicalities of actual energy saving action, the idea of technical potential continues to have a significant political function, witness the efforts of the IPCC and continuing government support for national and international modelling exercises. Going full circle, such assessments have an active part to play in the formation of government policy and the shaping of research agendas.

Driven by the demands of already agreed targets founded upon assessments of technological potential, government research and development programmes seek to steer the social world towards a technologically determined vision of the future, that is towards a future in which proven technological potential is realised. But if the idea of pure technical potential is to be abandoned, must researchers and policy makers relinquish all sense of the future? Surely not, for one of the problems of the conventional approach is that insufficient thought is given to the shape of the future. What is missing is any analysis of what the rest of the energy efficient utopia might look like: what new techno-economic networks do technological visions presume and what forms of social re-alignment are required along the way? There is real work to be done in articulating the features and characteristics of social worlds presupposed by, and implicitly buried within, proposed energy-saving scenarios (Rip 1994).

Taking a different tack, an alternative or additional strategy would start by defining and perhaps modelling portions of the sociotechnical world in all their complexity. Working from this base forward, it might be possible to identify socially as well as technically viable opportunities for energy conservation. Before considering these options in more detail, let us re-consider the language of gaps and barriers.

6.2 Overcoming obstacles and leaping barriers

As already explained, the terminology of social barriers presumes pure, asocial, technological potential on the one hand, and a confounding set of social obstacles on the other. If we see technical change as an irredeemably social process the language of barriers is as instantly irrelevant as the notion of technical potential. Having jumped across the conceptual chasm, the landscape changes dramatically: once obstructive barriers collapse to reveal a perfectly ordinary scene of sociotechnical regimes, some favouring the adoption of specific energy saving methods and measures, others not. This is not a fatalistic conclusion for in attending to the detailed contexts of decision making it should be possible to identify conjunctions of interest arising and receding but each time opening up new combinations of plausible and socially viable opportunities for energy efficiency. Equipped with a careful, localised understanding of contemporary patterns of interest and opportunity, sociotechnical analysts would be able to specify ways of advancing the cause of energy efficiency given current social, organisational and economic circumstances (Morrill 1994, Lutzenhiser 1994), and identify opportunities for fostering the development of new techno-economic networks (Callon, Laredo and Rabeharisoa 1992).

6.3 Forsaking technology transfer

The terminology of technology transfer again draws upon a linear model of technological diffusion. As conventionally understood, knowledge flows out from the world of building research and into the world of building practice with programmes of technology transfer hastening the "uptake" of proven research results. But what if knowledge does not translate into action in this way (see the discussion of contexts of action above) and what if actors creatively and selectively scavenge for ideas that promise to improve their lot - whatever that lot might be (Bruno 1991). More worryingly still, what if the conventions of evidence in one domain (for example, in the realm of building science) do not qualify as such in the varied worlds of building practice? These and other difficulties are transformed by the simple expedient of scrapping the one-way language of technology transfer. Having taken that step it is possible to define and address a much broader agenda, engaging with the whole process of sociotechnical change and with the living breathing networks of existing knowledge and practice in all their complexity. Such a move has other advantages for it highlights questions about the transferability of energy related building technologies, questions which the terminology of technology transfer paradoxically obscures.

6.4 New languages, new agendas and new jobs

In conclusion, it seems that we require a new language and with it a new agenda for energy-related policy and for energy related research. Although the case for a sociotechnical approach is compelling enough, and although such an approach generates practical programmes of action and enquiry it lacks some of the immediate attractions of the conventional view. Most importantly, it is difficult to discern a ready justification for the direction and extent of government involvement. Justifications framed in terms of basic research and development, technology transfer and market failure carry much less weight when technical change is viewed as an inextricably social process. That is not to suggest that it is impossible to define and legitimise government programmes designed to support the emergence, constitution and maintenance of techno-economic networks only that different languages are required (Callon, Laredo, and Rabeharisoa 1992, p216). A second snag is that sociotechnical approaches promise to generate specific proposals of necessarily limited contextual and temporal relevance. The method and the way of thinking might be applicable in any number of different contexts but there will be no broadly generalisable conclusions of the sort which policy makers tend to favour. Finally, the new language and the new agenda implies a new division of labour. The current hierarchical arrangement is one in which government research agendas are defined in technical terms, with social researchers following behind. Some new arrangement will be required if there is to be any chance of responding to the interdisciplinary challenges of articulating scenarios buried within technical predictions; of mapping sociotechnical opportunities for energy conservation; of developing and managing efforts to re-align actors and formulate new techno-economic networks and of re-evaluating of the transferability of building expertise.

At the very least, this implies a significant re-ordering of disciplinary interests within the research world. The difficulty is that the conventional view has generated a range of equally conventional jobs and a self-sustaining division of research labour. Although it is important not to underestimate the deep rooted qualities of this mutually reinforcing arrangement, research environments do vary. Systems of research management foster and reflect particular forms of interaction between government, industry and academia and between social and technical researchers and some are more conducive to inter-disciplinary interaction than others. The ESRC funded study suggests that systems which which involve extensive interaction with industry or which depend upon negotiation between a range of academic departments and institutions are typically more flexible than those dominated by relatively powerful government project officers. The close communities of small countries such as Finland, Sweden and Ireland and the practices of networking expertise and co-financing which characterise the French research environment were, for instance, both more accommodating than the patterns of co-ordinated consultancy, typical of Italy and the USA, or of contracting knowledge as practiced in Britain (Shove 1994). Although these working arrangements do not necessarily engender different ways of thinking, it is clear that the chances of developing alternative more socially sensitive analyses of energy saving technologies are themselves socially structured.

7. ACKNOWLEDGEMENTS

This paper is based upon research funded by Britain's Economic and Social Research Council, as part of its Global Environmental Change Programme: Project reference no L320 253 021

8. REFERENCES

Bijker, W., and Law, J., (Eds) 1992, Shaping Technology/Building Society: Studies in sociotechnical change, The MIT Press, Cambridge, Massachusetts

Bijker, W., "Sociohistorical Technology Studies", 1995 in Jasanoff, S. et. al (Eds), Handbook of Science and Technology Studies, Sage Publications, California, USA

Bondi, H., (Chairman), 1988, Evaluation of the Research and Development Programme in the Field of Non-Nuclear Energy, 1985-1988, Commission of the European Communities, Volume 1, Research Evaluation Report No24, EUR 11834 EN/1

Bruno, S., et al. 1991, Modes of Usage and Diffusion of New Technologies and New Knowledge: A Synthesis Report, Forecasting and Assessment in Science and Technology, FOP 227, Commission of the European Communities

Callon, M., Laredo, P., and Rabeharisoa, V., 1992, "The management and evaluation of technological programs and the dynamics of techno-economic networks: the case of AFME, Research Policy, 21, 1992, pp215-236

Callon, M., 1991, "Techno-economic networks and irreversibility" in Law, J., (Ed), A Sociology of monsters: Essays on power, technology and domination, Sociological Review Monograph, Routledge and Kegan Paul, London

Caprioglio, P, 1988, Evaluation of the Energy Demonstration Programme, Energy Efficiency and Renewable Energy Projects, CEC, Directorate General for Energy

den Ouden, C., (Ed) Proceedings of a Workshop on Design Support to Architects, Edinburgh, Scotland, UK, 19 - 20 June 1990, Commission of the European Communities

Evans, R., 1991, "Barriers to Energy Efficiency" A report for the Energy Efficiency Office, London

Gordon, J. and Bigg, T., 1994, 2020 Vision: Britain, Germany and a New Environmental Agenda, Goethe Institut, London, p18

Guy, S., 1994, "Developing Alternatives: Energy, Offices and the Environment", paper presented at "The Cutting Edge", Conference of the Society of Property Researchers, City University, 3rd September

Guy, S. and Shove, E., 1993, "Leaping the Barriers", paper presented to the British Sociological Association Risk and Environment Study Group, York, December 1993

Hirst, E. and Brown, M., 1990, "Closing the efficiency gap: barriers to the efficient use of energy", in Resources, Conservation and Recycling, 3, 1990, pp267-281, Elsevier Science Publishers

Hirst, E., 1992, "Making Energy Efficiency Happen", in Kuliasha, M., Zucker, A., and Ballew, K., (Eds), Technologies for a Greenhouse Constrained Society, Michigan, Lewis Publishers

Jaffe, A., and Stavins, N., 1993, "The Energy Paradox and the Diffusion of Conservation Technology"

Kealey, L., 1989, "Ideology and Information in Low Energy Design", in Steemers, T and Palz, W, (Eds) Second European Conference on Architecture: Science and Technology at the Service of Architecture, Proceedings of an International Conference, Paris, December 1989, Commission of the European Communities, Kluwer Academic Press

Lutzenhiser, L., 1994, "Why Isn't the Housing Stock More Efficient?: Organizational Networks and Technology Transfer", Proceedings, American Council for An Energy Efficient Economy, 1994 Summer Study

Macey, S. and Brown, M., 1990, "Demonstrations as a Policy Instrument with Energy Technology Examples", Knowledge, Creation, Diffusion, Utilization, Vol 11, No 3, March 1990, pp219-236, Sage Publications

Morrill, J., 1994, "When the Straight Line is Not the Fastest Route: Counterintuitive Approaches to Improving Energy Efficiency in Building", Proceedings, American Council for An Energy Efficient Economy, 1994 Summer Study

Rip, A., 1993, "Introduction of New Technology: Recent insights from sociology and economy of technology", University of Twente, The Netherlands

Rip, A., 1994, "Alternatives to the Modernist Stance: or the relation between ST studies and the "real" world of science, technology and management" University of Twente, The Netherlands

Robinson, J., 1991, "The Proof of the Pudding: Making Energy Efficiency Work", Energy Policy, September 1991, pp631-645

Rogers, E M, 1962, Diffusion of Innovation, New York, Free Press

Schipper, L., and Meyers, S., 1993, "Using scenarios to explore future energy demand in industrialized countries", Energy Policy, March 1993, pp264-275

Shove, E., 1991, "Professional Environments of Energy Conservation", paper presented to workshop at the Building Research Establishment, September 1991

Shove, E., 1993, "Technical Possibilities and Building Practices: The Realities of Passive Solar Design", in Foster, N and Scheer, H, (Eds), Solar Energy in Architecture and Urban Planning, H Stephens

Shove, E., 1994, "Energy Efficiency in the Making: Cultural Contexts of Building Research", Global Forum Academic Conference, July 1994, Manchester

Stansted, A H., Koomey, J G., and Levine, M D., 1993, "On the Economic Analysis of Problems in Energy Efficiency: Market Barriers, Market Failures, and Policy Implications", Energy and Environment Division, Lawrence Berkeley Laboratory

Warkov, S. and Meyer, J., 1982, Solar Diffusion and Public Incentives, Lexington MA, DC Heath