Coordinated Contractors and Contracting Knowledge: The Organizational Structure of Energy Efficiency Research and Development in the United States and the United Kingdom

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Comparison of the organization and management of government funded energy related research and development in the United States and the United Kingdom reveals a number of common features as well as some important differences. The U.K. pattern is one of centralized agenda-setting and competition in which rival research contractors bid for small, predetermined, ''bite-sized'' pieces of work. By contrast, the U.S. approach involves complex negotiations between federal energy and environmental policy agencies and semi-entrepreneurial national laboratories. How do these differing research environments influence the knowledge we have of energy efficiency: how do these organizational features affect the shaping of research agendas, the definition of research problems and the management and dissemination of resulting expertise? More specifically, what consequences do these arrangements have for the role of social science within this conventionally technical field? In exploring these questions, the paper examines the ways in which opportunities for interdisciplinarity are inadvertently structured by the mechanics of research management. While the U.S. and the U.K. differ in this respect, there are significant commonalities in terms of methodology and approach, and a shared reliance upon a dominant technological or techno-economic paradigm. This paper reflects upon the conditions under which such work is undertaken, and on the practical and theoretical consequences of alternative styles of research management.

INTRODUCTION

Since the 1970s, energy related research and development has revolved around basic problems of building physics. The thermal performance of materials, the efficiency of heating and cooling systems, the challenges of integrated energy efficient design, these have been the dominant concerns. While climatic, political and economic conditions vary widely between countries, the physics-based research agenda has remained relatively constant.

Subsequent questions about the uses and applications of research are typically framed in the familiar language of market economics. The expectation is that cost effective measures will be adopted by rational actors sensitive to the signals of costs, benefits and payback periods. For their part, engineers have accepted the notion that questions of cost should be central to hardware design and to the perception, selection and development of technological solutions.

To date, these key perspectives of physics, engineering and economics have dominated the energy research agenda. But it is increasingly clear that the resulting techno-economic paradigm is not enough. There is growing recognition of the fact that non-economic factors shape energy use patterns and condition the adoption of new technologies. The importance of social processes in technology shaping and diffusion is taken for granted by students of society-environment interactions, but sociologists are no longer alone in acknowledging that the successful introduction of energy related innovation depends upon the detailed configuration of sociotechnical systems (e.g., Union of Concerned Scientists 1993; National Academy of Sciences 1984, 1992; also see Stern 1993; Lutzenhiser 1994).

Despite demand for a ''paradigm shift,'' and for a broader, more sociological, analysis of energy efficiency, the precise role of the social sciences remains unclear. By one means or another energy researchers have come to constitute an international ''epistemic community'' (Haas 1990), sharing a remarkably uniform techno-economic perception of ''the problem.'' Social science sits uneasily alongside these established ways of thinking. Are sociologists and others to provide answers to questions defined and framed by engineers and economists, or is the challenge one of taking a more radical look at the basic tenets of established positions and perspectives? This is an important issue for the future direction of energy research is strongly influenced by its definition as a predominantly social or predominantly technological ''problem.''

Defining the Efficiency Problem

Over the last decade, interest in developing new technological fixes has waned in the face of increasing concern about the application of existing, tried, tested and proven energy

saving technologies. Accordingly, debate has edged away from the realm of physics, economics and technology toward the seemingly ''softer'' domains of market research and social science. Yet the way in which these ''new'' problems are understood reflects previous preoccupations—for instance with the model of the rational actor, and with related theories of market failure, market barriers and the like.

The contributions that the social sciences can make to energy analysis are many and diverse. They range from the sort of meta-analysis of policy and research that this paper represents, to micro-behavioral studies of social energy use in households. They include studies of lifestyles and consumption that go considerably beyond market segmentation to consider the roots of energy lifestyles in cultural practices, social stratification systems, settlement patterns, and organized market influences. And they involve examination and critique of the simplified models of society and sociotechnical systems used in energy policy debates, such as the notion that ''market barriers'' serve obstacles to realising ''technical potential''—conceptions that obscure the fact that the use of energy, while often ''inefficient'' by the standards of innovative possibility, is far from a disorganized affair. Social science analyses along these lines, while relatively few in number (the result of restricted research support), shed light upon household energy use behavior, the social patterning of consumption, lifestyles and conservation options, residential construction and materials innovation, the problems inherent in energy demand forecasting, and the possibilities of alternative building designs (see, e.g., Cramer et al. 1985; Dillman, Rosa & Dillman 1983; Diamond 1984; Guy & Shove 1994; Hackett & Schwartz 1980; Hackett & Lutzenhiser 1991; Kempton 1986, 1993; Kempton, Boster & Hartley 1995; Kempton & Layne 1994; Kempton & Lutzenhiser 1992; Kempton & Montgomery 1982; Ling and Wilhite 1990, 1992; Lutzenhiser 1992, 1993, 1994; Lutzenhiser & Hackett 1993; Shove 1992, 1995a, 1995b, 1995c; Wilhite 1996; Wilhite & Ling 1992; Wilhite & Wilk 1987; Wilk & Wilhite 1984; see Lutzenhiser 1993; National Academy of Sciences 1984 for detailed reviews of the energy social science literature). All contribute to a reconceptualization of the nature of energy use in sociotechnical systems and represent improvements upon the physics-engineering-economic paradigm that sees the mission of the social sciences as limited to investigation of ''individual preferences'' and ways to overcome ''irrational'' consumer resistance to ''best practice.''

Establishing Research and Development Agendas

But more than paradigms and theories are involved in the marginalization of the social sciences in energy analysis. Current perceptions of ''the energy problem,'' and of the role of social science, are also marked by the political economy of research funding: by the sorts of people involved in shaping research agendas, by the sorts of research contracts at stake, and by the terms in which research programs are defined and evaluated. And for all these reasons, our capacity to grapple with the complexity of energy efficiency as an interdisciplinary project is shaped and constrained by past and present approaches to research funding.

In this paper we explore the ways in which funding structures influence energy research agendas. More specifically, we consider the unintended consequences of present systems of research management in limiting effective interdisciplinary inquiry.

The idea that patterns of research funding have implications for the development of knowledge is hardly new (de Solla Price 1963; Mulkay 1979). Questions about the impact of science on society, the value of research funding, and the relationship between innovation and research investment, (Clark 1985) have also been of long standing interest in the world of science policy. By comparison, the detailed mechanics of research funding, and the relationship between research providers and research managers has received relatively little attention. The scale of funding has been an important issue, but not its form. Yet it is in this area that real issues arise regarding the day to day negotiation of research agendas and the role and potential contribution of different disciplines.

The idea that different methods of research funding have unintended consequences for interdisciplinarity and for the role of social science is of special significance for research in areas currently and traditionally dominated by technical concerns. Actual levels of funding for research and development are clearly significant, but so is the way in which that funding is managed and allocated. Taking the case of energy related research and development in the U.K. and the U.S., we review the implications of significantly different funding histories for the development of energy research agendas that acknowledge the social quality of technological change.

The next two sections outline key features of the energy research environment in these contrasting situations. In the U.S., government funded energy research is developed in conjunction with a network of national laboratories. Expertise is concentrated within these key institutions. In the U.K., the Building Research Establishment has a different role, acting on behalf of the Department of Environment and the Department of Trade and Industry in commissioning and managing research contracted out to a variety of private consultancies, universities, and research associations. As we shall see, both environments have distinctive implications for the role of social science within energy related research and development.

EFFICIENCY RESEARCH IN THE UNITED STATES

Government-funded energy efficiency research in the U.S. has been primarily the responsibility of the Department of Energy (DOE). Other federal agencies such as the Department of Housing and Urban Development (HUD) and the Environmental Protection Agency (EPA) also fund efficiency-related projects, but research is a minor aspect of their work. The National Science Foundation (NSF) has, on occasion, supported such research, as have various utility companies and trade associations. Shortly after DOE was established as the central coordinating agency for energy research and development (R&D), the nonprofit American Council for an Energy Efficient Economy (ACEEE) was founded—a significant promoter of efficiency research and its application. Though playing a key role in shaping research agendas, none of these groups routinely undertake research. As in the U.K., the bulk of this activity is contracted to university, corporate, and national laboratory researchers. But unlike the U.K., where state-sponsored research has generally been more receptive to the needs of policy, U.S. federal support for scientific research in the cold war period since has generally followed a ''hands off'' funding pattern (Bimber and Guston 1995; Smith 1990).

The energy crisis of 1974 closely coincided with the first major piece of social research on energy use—the Ford Foundation study, the American Energy Consumer (Newman and Day 1975). But the notion that the efficiency of societal energy use could be considerably improved was promoted most vigorously by physicists, one of the earliest occasions being a Princeton conference in 1976. By the late 1970s, a new DOE-supported Solar Energy Research Institute had been established, with a range of efficiency-related studies supported with DOE and other sponsorship. It was during this halcyon period that academic researchers pursued a variety of studies related to energy use and behavior (some of it funded by DOE), including the psychology of energy conservation, the social patterning of energy use and savings, and the ethnography of energy decision-making.

Unfortunately, what had begun as an expansive research and development agenda pursued on multiple fronts had, by the late 1980s, evolved into a DOE-centered effort conducted largely through the national laboratories. Despite shifts in emphasis and changes in funding patterns over the past fifteen years, relatively little social research has been undertaken within national laboratory environments.

Energy efficiency R&D was seen as a relatively unequivocal good by policy-makers in the late 1970s, although funding for this work has always been secondary to energy supply expansion. The executive branch has vacillated between hostility and indifference to efficiency programs, while congressmen and senators have alternately championed and attacked these efforts. DOE as the primary federal agency in the area has been under political assault since its inception. Along with its modestly funded energy efficiency and renewable energy mandates, the agency inherited responsibility for the nation's bomb production, a good deal of its high-level radioactive wastes, and large coal, oil and nuclear power programs. DOE also inherited a network of relationships with nine ''national laboratories,'' spread across the U.S., often in remote locations.

The Laboratory System

''The labs'' evolved out of World War II nuclear weapons R&D efforts, and their scientific roots were in physics, chemistry, and engineering. They have been funded for nearly fifty years by the federal government to pursue research in the national interest, originally on weapons-related topics, and later on a wide range of scientific problems. Some of the labs (e.g., Lawrence Berkeley) were originally created as academic centers for high energy physics research. Others (Los Alamos and Lawrence Livermore) were direct products of cold war weapons production efforts. In the 1970s, Lawrence Berkeley Laboratory organized an Energy and Environment Program, which has become a major center of DOE-funded efficiency research. Similar research programs were also established by the laboratories at Oak Ridge, Brookhaven, Pacific Northwest, and the National Renewable Energy Laboratory.

At first, the labs were one of several sources of research expertise for DOE. But during the 1980s, shrinking budgets led to a concentration of resources in the laboratory system. When DOE inherited an agency-wide relationship with the labs, the efficiency program managers found themselves with a ready-made cadre of highly trained and well-organized contractors. The labs had a long-standing symbiotic relationship with the federal government, largely being private appendages that government established to do work felt best kept out of bureaucratic hands. As a result, DOE inherited open-ended contracts with the labs; an efficient arrangement involving few transaction costs when compared to the effort involved in negotiating new relationships with outside bidders. Of course, DOE could remove support from the labs, but when making funding choices, the value to the government of an R&D infrastructure built up over nearly fifty years continues to represent a compelling reason to sustain the present system. DOE, as a result, finds itself with an R&D network that is interested in complex, time-consuming problems, and whose orientation to research design, influenced by years of defense R&D experience, has institutionalized an expectation of multi-year project support.

The consumers of research in this system are federal agencies, private businesses (e.g., materials and building systems manufacturers) and, indirectly, utility companies who find it in their interest to pursue energy efficiency in their territories. In the 1970s and 1980s, as a result of rising energy-productions costs and growing demand, many utilities found it in their interest (often after being urged by environmentalists, consumer advocates, and state regulators) to promote reductions in energy use in order to avoid building costly new power plants. They supported some efficiency R&D through their trade associations and, along with large industrial firms seeking to control their own energy costs, they became primary customers for federal R&D. The private sector invested in a few studies of energy and lifestyles, as well as a bit of market research aimed at identifying target firms and program problem areas. But, for the most part, these customers made few demands for social research from the federal DOE-lab system, nor did that system offer much on its own. Notable exceptions to these patterns were the studies of Schipper, et al. (1989) on lifestyles and energy use, a National Research Council assessment of social science knowledge regarding energy use (National Academy of Sciences 1984), and a variety of projects funded piece-meal to social scientists working in the laboratory system (although much of this research has contributed relatively little to the social science knowledge base). The more important point is that there has been no programmatic commitment to social research on energy use and efficiency—i.e., no effort to mount and support a program similar to other ongoing initiatives in the laboratory system that would bring the best/most appropriate social scientists (whether in the labs or universities) into a long-term program.

Some interdisciplinary university-based programs produced a small number of social scientists interested in energy efficiency in the early 1980s. Few of the students found positions in universities, although many joined research groups in and around the national labs, where their work involved policy analysis, surveys of firms, and evaluation studies of efficiency program impacts. They survived in these ''soft money'' environments by finding places in ongoing research programs—accommodating to technical research agendas by taking on small marginal problems, adopting techno-economic vocabularies, and, in many cases, internalizing the prevailing paradigm. As the pressure for efficiency programs to prove their cost-effectiveness grew in the 1980s, many found lucrative posts in private consultancies advising utilities and regulatory agencies. Meanwhile, most of the original academic programs disappeared.

Salvaging a Research Agenda

Early in the 1980s, it appeared that the entire energy efficiency R&D effort might vanish, having been virtually eliminated from the federal budget. It was saved, however, by a political coalition, primarily of energy efficiency and environmental groups, that used an ''alternative budget'' strategy to convince powerful congressional committees to restore funding. A focal actor in these efforts was the ACEEE, which was founded by a university-based group (mostly physicists) to offer alternatives to the Carter administration's synthetic fuels R&D plans. Through its ''summer studies'' and publishing activities, ACEEE provided science-based legitimacy for efficiency R&D outside of the narrow confines of government agencies and esoteric academic specialties (e.g., building science). The alternative budget coalition solicited research agenda items from the national labs, environmental groups, DOE, and various political constituencies, bundling them together in a more or less coherent package that Congress was able to support. The result has been a surprisingly detailed efficiency DOE R&D budget that provides some measure of protection for these efforts from administrative diversions. Some of these budget items are fairly detailed (e.g., ''$___x___ for motors research''), while others offer DOE some room to maneuver (''$___y___ for work on indoor health-related problems''). However, there has been little attention in these budgets, or within DOE, to the social aspects of energy use, whether these might have to do with behavioral use of machines, consumer assessments of efficient appliances, constraints upon efficiency innovation by manufacturers, or preferences of home buyers. The techno-economic perspective is deeply and exclusively embodied in budget details and agency practices, then, although the fault—to the extent that ''fault'' is involved at all here—cannot be laid exclusively at the doorstep of DOE and the efficiency advocacy groups.

The social sciences should shoulder a large share of the blame (more about that later). But within the efficiency R&D scene, the problem is rather evenly spread, being reproduced by a long-standing system of relations between the labs and DOE. As the early arguments by physicists for more efficient energy use became a part of environmental, economic development, and consumer protection discourses, a call for expertise went out. It was answered by university physical science departments and the national laboratories, where available models and methods were deployed in a rather hurried effort to expand efficiency R&D. The social sciences were marginal in these settings, and years would pass before the failure of some efficiency innovations would be noted.

Even so, societal energy use had declined by the late 1980s, and there was an endless supply of ''technical'' solutions to pursue whenever a blind alley was encountered. In the national laboratory setting, physicists and chemists could focus on the production of technical knowledge with little concern about problems of diffusion, uptake, suitability, or hardware performance. When these ''consumer,'' ''user,'' or ''industry'' issues do come up—and they do in some laboratory settings—the techno-economic framing of the

agenda effectively guarantees their exclusion from research plans.

Back at DOE, research planning flows from the program managers along established program areas and budget lines, with de facto preference for ongoing research. A rationalized system is used to compare potential agenda items (on the basis of cost, past investment, nearness to completion, contributions to knowledge, etc.), and program managers often solicit suggestions from the labs for new research initiatives. But scarce resources mean long-standing research programs almost always take priority. In a system of well-knit dependency relations, shrinking budgets offer a compelling justification for remaining firmly within the governing paradigm, and for avoiding risky excursions into the uncertain territory of the social sciences. When times are hard, ''marketing'' issues seem to be of considerably less importance than the ''scientific'' problems at hand.

To a significant degree, the laboratories set the agenda. Certainly DOE and its program managers have the ultimate responsibility for funding decisions, a fact that they make certain the labs don't forget. But the agency is also responsible for getting R&D done competently and expeditiously. And it is responsible for the survival of the lab network, considered by many to be a national treasure. Program managers are civil servants who would not necessarily be expected to have extensive technical training, although they often have considerable experience in their program areas. But they are dealing with investigators at the labs who have the kind of professional expertise that can come only from having done cutting-edge work in a specialty area for a number of years—literally defining, in many cases,global knowledge development. This sort of distributed expertise seems to work reasonably well in an often conflictual political environment. And the scrutiny that the labs receive from DOE, efficiency and environmental advocates, peer review processes, and the sometimes Byzantine laboratory bureaucracies, seems likely to assure a high-quality product. It is, however, a ''technical'' product, generally devoid of any sense of producer, consumer, or technology user—and it is hard to see how it could be otherwise. In the face of decreasing budgets the efficiency research system closes ranks around the techno-economic paradigm encoded in its budgets, headquarters structure, and research group organization.

Possibilities and Prospects

Looking forward, we can imagine both positive and negative scenarios in regard to research agendas. An anti-environmental Congress seems likely to strip more resources from the system. Interest in the potential of energy efficiency to increase economic productivity and fatten profits has offered a potent argument for federally-sponsored R&D in the past. But a growing faith in markets, and demands for ''smaller government,'' can easily swamp that boat. In any event, the logic of the debate doesn't seem likely to provide support for new R&D initiatives that would broaden exploration of consumer pull or producer push in energy and technology markets. These are matters that are seen, in the present political climate, as best left to producers and consumers.

Other developments are more promising. The movement toward energy system deregulation has caused utilities to withdraw funding from collaborative R&D projects (presumably, in order to avoid the kinds of interactions with potential competitors that might result in the leakage of strategic information). But as competitive encounters take place and the players settle into their respective niches (albeit, to emerge on occasion for jousts), questions of ''customer satisfaction'' are of immediate relevance for utilities striving to keep competitors at bay. Openings for social science are also likely to appear as a rising tide of anxiety about global environmental change, the poor performance of the U.S. and other signatories in meeting their agreements under the Climate Change Convention, and an invigorated environmental justice movement raise new concerns about energy use and efficiency. This may simply reward DOE and the labs. But to the extent that such problems are seen to be rooted in sociotechnical processes, it may also encourage more expansive thinking about energy efficiency R&D. There are already promising signs in NSF's Human Dimensions of Global Change research program, and in the central place accorded the social sciences in the proposed reorganization of federally-sponsored environmental research under a National Institute for the Environment.

To summarize, U.S. energy research has reflected the combined interests of the national labs and DOE. Reducing budgets have led to a re-grouping around the core scientific concerns of natural scientists within the labs. While this system fosters quality research, there is as yet little reference to the consumers or users of knowledge. Moves in that direction have been prompted under the new banner of environmental, rather than energy related concern. Lacking an established base within the national laboratories, the future of energy-related social science appears to depend upon the development of a more varied research economy.

EFFICIENCY RESEARCH IN THE UNITED KINGDOM

Government funding for energy research now takes so many forms that it is difficult to track down the sums of money involved or to come to definitive conclusions about the formation of any one research agenda. Research councils such as the Engineering and Physical Sciences Research Council and to a lesser extent the Economic and Social

Research Council have a part to play. Two major Department of Environment supported programs, ENREI (Energy Related Environmental Issues) and the ''Best Practice program,'' are managed by groups specializing in technology and in its application at the Building Research Establishment (BRE). These, together with passive solar research, funded by the Department of Trade and Industry and managed by the Energy Technology Support Unit (ETSU), and a further program of investigation to support energy-related aspects of the building regulations (again based at the BRE) represent the main blocks of U.K. research activity.

This spreading of research management is a relatively new development. So too is the current approach to research funding. Leaving the research councils aside, it is instructive to review the management history of energy related research since the early 1970s.

In the post-war years, the Building Research Station at Watford (now the Building Research Establishment) was the focal point for construction research, most of which was undertaken by directly employed researchers of various disciplines. In the words of its historian, Frederick Lea, ''The building research station was one of the earliest examples of a multi disciplinary organization depending on the working together of staffs trained in many different branches of the arts and sciences'' (Lea 1971). The first major programs of energy related research reflect this enthusiasm for problem oriented scientific inquiry and for team work. Yet they were also marked by developments in science policy as represented in the Rothschild report of 1971. Rothschild introduced the notion that ''R and D with a practical application as its objective, must be done on a customer-contractor basis.''

Privatizing the System

This separation of the role of customer and provider led to the dismantling of the earlier, rather cosy culture of in-house research, and to the creation of a new breed of project officers. Research such as ETSU's passive solar program, was therefore managed by people whose task was not to actually do research but to bring together teams of experts to work together on the project in hand.

During the 1970s and early 1980s, contracts were large enough to keep researchers going for years at a time. Established ''suppliers,'' mostly but not exclusively drawn from the university sector, were able to exploit this ''gravy train'' of research funding and retain groups of increasingly experienced researchers. Given the continuing emphasis on problem solving there was a good chance that project team members would be drawn from different disciplines as well as from different organizations. Within this broadly collaborative environment, researchers jointly re-defined technical research priorities as the work progressed. Not only that, they were in a position to develop parallel analyses of the social acceptability of proposed technological solutions. In this context, recognition of consumer interests, and of the practicalities of building design and building use could and did lead to a re-orientation of technical inquiry. Though clearly in the role of contractors, relevant researchers retained control of key methodological decisions. In theory at least, this permitted the development of coherent and complementary lines of social inquiry. Resulting studies included analyses of the preferences and priorities of potential house buyers, investigations of the real as opposed to the theoretical economics of house building, and reviews of different organizational contexts of design decision-making.

In the event, the climate of research management changed before the full force of these insights were felt. Through the late 1980s, pressure for greater accountability led to the ''sharpening'' of management procedures. Projects were divided into smaller and smaller portions, thereby increasing competition between contractors. This focus on value for money and competitive tendering has had far reaching, sometimes unintended, consequences for customers and providers and for the form and scale of of interdisciplinary research.

Driven by the need to ensure value for money and to keep research to cost and on time, technically trained project officers set out increasingly detailed invitations to tender. As a result it is now they, rather than the researchers, who determine questions of methodology and who prescribe the timing of project milestones and the content of project deliverables. Equally, it is they who have to piece together fragments of ''findings'' to form the total mosaic of a hopefully coherent research program. Engulfed by a rising tide of administration it is increasingly difficult to build on what went before, or to be flexible in exploiting and developing emerging lines of inquiry.

Paradoxically, growing recognition of the significance of technology transfer and the application of existing knowledge coincides with the development of a system of project management that effectively restricts the role of social science. Given their typically technical backgrounds, and given the constraints under which they work, it is not surprising to find project officers employing a singularly limited understanding of what the social sciences have to offer. Funding patterns underline the conceptual separation of social and technical inquiry providing the social sciences with a clear but limited role in promotion and marketing and leaving technical expertise to follow its own course. In this environment there is no room to influence the shaping of technical research or to develop interdisciplinary analyses of sociotechnical change. Instead, social scientists are employed to understand and sweep away ''non-technical barriers'' that

appear to impede progress toward a technologically determined future.

Competitive tendering for ''bite sized'' contracts has also changed the world of the research provider. No longer able to sustain groups of experienced researchers, universities have either set up their own consultancy groups or left the field to organizations able to cope with sudden fluctuations in flow of work. In this short-term world neither researcher nor project officer have an effective institutional memory and there is a real sense in which the current system of contract research leads to a contraction rather than an expansion of energy-related expertise (Gibbons 1994).

This is the context in which the 1993 white paper on science and technology, ''Realising our Potential'' (HMSO 1993) is having effect. Still endorsing the Rothschild principle of distinguishing between the functions of customer and provider, the 1993 white paper underlines the role of research in promoting U.K. ''competitiveness and wealth creation'' and in enhancing ''the quality of life.'' The effect has been to promote a steady and in some cases radical reviewing of ''industry'' relevance, of the utility of research and of the needs and interests of potential research users. In the energy sector, the languages of wealth creation and quality of life introduce a new set of distinctions. Proposals and projects are explicitly oriented toward one or another of these goals: regulations related research falling into one camp, and research that promises to generate immediate commercial benefits for energy consumers falling into the other.

Less direct effects are just as important. The technical priorities of project officers drawn from the ''old establishment'' of building science are being challenged by a new gathering, perhaps even a ''new establishment,'' of industry steering groups. BRE itself is to be privatized and though the implications are as yet unclear, the building science based culture of research management is likely to change. Meanwhile, relatively new research groupings are taking shape. Trade associations, often linked to universities (which are themselves under pressure to forge new relationships with industry) are establishing research capacities of their own.

Also influenced by the 1993 white paper, research councils are demanding that project applicants demonstrate the ''user relevance'' of their work. From this perspective,users can be drawn from government as well as from industry, non governmental organizations, and even the wider public. One of the more surprising consequences of these reorientations, and especially of the reference to research users and to industry, is the growing demand for social rather than technical inquiry. Guided by similar concerns, the Department of the Environment is seeking collaboration with the Economic and Social Research Council in developing research on energy efficiency and environmental management in order enhance understanding of the ''social dimensions.'' In these and other ways, emphasis on the utility of research has generated a new range of questions regarding the process of technology transfer, the relevance of technical research, and the social contexts and circumstances in which energy expertise is developed and applied.

Possibilities and Prospects

As with the U.S. we can identify two possible scenarios. The first negative possibility is that further privatization of project management will reinforce trends already underway leading to ever closer contract control and a narrowing of the energy research agenda for administrative and managerial, if not intellectual, reasons. In this case we might expect the grip of the techno-economic paradigm to tighten even further. This would be bad news for researchers dealing in what seems to be uncertain knowledge about complex and often unpredictable processes.

Such a development would also influence perceptions of relevant and important areas of inquiry and would in turn restrict the government's capacity to act as an ''intelligent customer'' or research user. The risk here is that the research councils' emphasis on producing work relevant to ''users,'' including policy users, would merely underline these tendencies. If government users believe that the utility of social science lies in overcoming non-technical barriers, or in understanding and identifying ''levers of change,'' and if research councils defer to these views, the result will be a progressive narrowing of the role and potential contribution of the social sciences.

A more positive scenario is one in which reference to ''users'' brings with it a requirement to re-engage with questions about the social as well as technical or economic viability of energy saving technologies. This might involve a whole hearted revival of long buried agendas relating to patterns and practices of energy use. Analysis of the conditions and circumstances of sociotechnical change would then become central, not marginal issues, with far reaching implications for the future of energy related research and development. Debate about the relevance of technical research many not inspire a significantly different research agenda but it does create a space in which to consider the variability of social contexts in which energy choices are made. In addition, it makes it increasingly difficult to hang on to entrenched, if tacit, belief in the intrinsic merits of technical research. In these respects, that simple question: ''Who are the users of this research?'' threatens to undermine established positions and priorities and promises to introduce real uncertainty into the present regime of contract research management.

To summarize, non-governmental pressure groups and utilities have little part to play in the relatively uncontentious relatively invisible definition of technical research priorities. The separation of customer/provider relationships sets the scene in which hired researchers respond to the demands of technically trained project officers. In this context, the administrative requirements of competitive contract research limit the potential for interdisciplinary inquiry.

CONCLUSIONS

In the two cases we have examined, current developments in research funding and research management limit the potential for significant paradigm shifts in energy research. Though the techno-economic model is increasingly called into question, present systems of research management make it difficult to develop alternative analyses.

In the U.S., as in the U.K., we see a pattern in which the research agendas of the late 1970s were both more accommodating and more flexible than those of the late 1980s and early 1990s. For different reasons these two research environments currently disadvantage forms of inquiry that are, or that appear to be, dealing in the seemingly uncertain territory of the social sciences. In the U.S. shrinking budgets have led to a re-grouping around traditional fields of natural scientific inquiry. In the U.K., growing concern about value for money and efficient research management, favours the tight scripting of well defined programs of technical investigation or of supporting market research.

In other respects the two systems have evolved in opposing directions. Starting with a more varied research economy, the U.S. now concentrates research resources in a handful of national laboratories. By comparison, the U.K. system, that initially depended on the in-house expertise of staff at the Building Research Establishment, now involves competitive tendering amongst an increasingly scattered assortment of private sector consultancies and university research departments. The changing balance of power between natural scientists and civil servants illustrates similarly opposing tendencies. The fragmenting effects of contract research management appear to have weakened the influence of the natural scientific research community in the U.K. Though energy research resources are increasingly limited in the U.S., their concentration within the national laboratories has, by contrast, reinforced the influence of those key players.

In thinking about these alternative scenarios and in reviewing the history of energy-related research funding, we have sought to examine influence of alternative forms of research funding on the shaping of research agendas and the role of technical, economic and social analysis in the area of energy related research and development.

Neither the U.K. nor the U.S. systems really foster the sort of interdisciplinary interaction that seems to be required. Yet both these systems are experiencing new and unfamiliar pressures. In the U.K. current preoccupation with the ''users'' of research is, perhaps inadvertently, raising the profile of the social sciences. In this environment,the scattering of research funding, and the process of contracting knowledge offers a form of flexibility denied to researchers working within the more contained, more cohesive research programs of the U.S. national laboratories.

In the U.S., as in the U.K., the focus of energy research is shifting in response to wider environmental concern. Together, these factors generate a new sense of urgency about energy and environmental policy, and growing unease about the efficacy of familiar forms of policy analysis and technical inquiry. The range of legitimate research questions is expanding fast. Of course, there is no guarantee that social scientists will respond to emerging opportunities for interdisciplinary research in the area of energy efficiency. The roles on offer may still not be especially attractive to researchers schooled in mainstream social science disciplines and there are still real tensions regarding the definition of relevant inquiry and the relationship between social and technical/economic knowledge.

In conclusion, current systems of research management appear to be at odds with current research questions. Social science may well be in demand but it is genuinely difficult to know how to handle, let alone promote, this form of inquiry within current frameworks of research management. In both the U.S. and in the U.K., social science may be commissioned and undertaken as an adjunct to conventional forms of techno-economic analysis—and movement toward energy system deregulation and competition may provide additional incentives to seek a better understanding of what consumers value, need and desire, for firms in pursuit of loyal customers.

But disciplinary perspectives, buried deep within the infrastructures of research funding, conspire against any more substantial re-orientation of the energy research paradigm. Accepting this argument, we need to think again not only about the vested interests that sustain present forms of research management, but also about the shape and form of alternative research regimes that would positively maximize opportunities for effective interdisciplinary inquiry.

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