THE SOCIAL SHAPING OF TECHNOLOGY:

LESSONS FOR ECO-INNOVATORS

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ABSTRACT

The following discussion paper provides an overview of ways that insights from the interdisciplinary field of STS (Science and Technology Studies or Science Technology and Society) might assist eco-innovators in the IT sector. Drawing very broadly from the social shaping of technology literatures we have identified 4 interlocking themes we believe that eco-innovators should keep in mind to help promote their success: (i) The importance of building sustainable networks of people, things and knowledge; (ii) The significant role that is played by developing new forms of knowledge and expertise facilitated by 'knowledge brokers or 'knowledge - entrepreneurs'; (iii) The important roles that can be played by users in re-shaping technology in practical settings; (iv)The importance of conceptually situating plans for optimisation and the ongoing evaluation of their effectiveness within particular technological paradigms or trajectories.

INTRODUCTION

A range of innovative technologies and applications offer exciting opportunities to address environmental issues. This is particularly relevant to computers and Information Technology (IT) more generally where new computational techniques and approaches to supporting business decision making have the potential to not only redress the carbon cost of that particular industry, but offer carbon savings to the broader community. In the following discussion paper we provide an overview of ways that insights from the interdisciplinary field of STS (Science and Technology Studies or Science Technology and Society) might assist eco-innovators in the IT sector. We identify four interlocking themes emerging from STS scholarship, drawing in particular on studies that have examined the links between technological change, IT and environmental issues. These are discussed and interpreted in the light of the theme of the paper.

THE SOCIAL SHAPING OF TECHNOLOGY

We begin by recognising the importance of the so-called 'Social Shaping of Technology' (Williams & Edge, 1996; Bijker et al. 1994; Mackenzie & Wajcman, 1985). In simple terms *most* STS studies adopt the position that to understand the relationship between social and technical change we need to recognise 'the social shaping of technology' We should however note that there are some STS approaches which offer variations to a social shaping position, such as 'actor network theory' (see Callon 1994, Law 1994). The 'social shaping of technology' offers an opposing theoretical position to so-called 'technological determinism'. Technological determinism is generally recognised by its emphasis on technology as the primary causal factor in explaining socio-technical change although there are obviously a wide variety of approaches that drift into possessing technological determinist tendencies (see the discussion in Smith 1996). There is a tendency in such frameworks to attempt to identify how the introduction of a key technical artefact, or artefacts as a by-product of its, their, physical attributes automatically influence particular social outcomes and lead to various 'knock on' effects. These type of explanations regularly overlook the possibility for similar artefacts to be put to different uses, have different effects in different social contexts, and if they are involved in influencing patterns of social change, that they do so, in concert with other technologies, and economic and social factors. Proponents of the social shaping of technology *do* acknowledge the important role technologies play in influencing social change but consider contingencies, unexpected outcomes, interpretive flexibility in design and adoption of technology and the ever present hypothetical possibility of technological alternatives (Bijker & Pinch, 1994).

The most common practical manifestation of technological determinism in approaches to solving environmental problems is the tendency for the promotion of 'technical fixes' ahead of re-shaping social practices (e.g. carbon sequestration as opposed to using less coal) and viewing policy development in strictly instrumental terms (e.g. providing limited space for feedback, in policy formation for 'learning by doing' and iteration over time (Sorenson, 2002). For promoters of programmes for technological innovation, the social shaping of technology offers a reminder that coming up with plausible IT technical solutions for managing carbon emissions that satisfy narrow technical criteria alone are unlikely to guarantee success, and that even the notion of successful technological innovation requires ongoing reflection.

Drawing very broadly from the social shaping of technology literatures (Williams & Edge, 1996; Mackenzie & Wajcman, 1985; Bijker et al. 1994) we have identified 4 interlocking themes we believe that eco-innovators should keep in mind to help promote their success:

1. The importance of building sustainable networks of people, things and knowledge.
2. The significant role that is played by developing new forms of knowledge and expertise facilitated by 'knowledge brokers or 'knowledge -entrepreneurs'.
3. The important roles that can be played by users in re-shaping technology in practical settings.
4. The importance of conceptually situating plans for optimisation and the ongoing evaluation of their effectiveness within particular technological paradigms or trajectories.

This list is obviously not exhaustive nor should it be treated as a simple formula, some of our suggestions will also overlap with insights offered by others in neighbouring areas of scholarship interested in innovation: such as 'organisational theory, 'economics of innovation' and 'decision system analysis. We propose that the predominant historical/socio/cultural focus of STS scholarship will stimulate constructive dialogue with such approaches by offering a subtly different vantage point from which to view similar issues.

BUILDING SUSTAINABLE NETWORKS OF PEOPLE THINGS AND KNOWLEDGE

Historical studies of large-scale technological change, of a similar and greater breadth to that aspired to by current eco-innovators, have noted that successful adoption of change has also involved systemic changes in the patterns of social and economic organization surrounding the new technology in question. This theme can be illustrated by examples drawn from studies of the development of automobiles, electricity generation systems and the telephone (Hughes, 1994). Given that this journal has a readership that is more likely to be interested in IT we will mainly provide a brief historical sketch of the development of the telephone.

The dominant form of a telephone system which first emerged in the United States, and then diffused to most developed countries, was broadly recognizable and largely stable in its basic features from the early to middle part of the 20th century up to at least up the last 20-30 years. It relied not only on basic technological hardware such as telephones, wiring, switching and telephone exchanges, but also the development of new forms of knowledge, institutions geared to promoting such knowledge, the promotion and consolidation of particular patterns of use and economic and legal models for 'controlling' users, and service providers. Some of these elements emerged early in the development of the system whilst others appeared as the system itself grew (Flichy, 1992; Winstone, 1998; Mercer, 2006). A number of different types of telephone systems could have developed from the basic technology that allowed 'voice to voice' communication. In the early years of the telephone system numerous possibilities were either canvassed or appeared for brief periods. For example multiple private telephone lines owned and serviced by multiple private companies, patterns of use being dominated by business communication, as had been the case with the telegraph system, and as a system of public broadcasting (Aaronson, 1997).

Instead, the first US telephone system consolidated over time into a particular form of protected private monopoly structured by government input into the regulation of prices and services, shaped by various 'universal service' provisions that were geared to the spread of telephone services to as many users as possible. These users paid a mixture of licence fees and call charges, and in response to various regulatory pressures, there was considerable re-investment of profits into ongoing innovations such as long distance telephony and improved switching technologies. Whilst it is open to conjecture whether better systems may have been possible and there have always been critics of the tendency for telecommunications to be controlled by private or public monopolies. The system that did develop and persisted for considerable time was robust not only because it fulfilled a socio/technical function i.e.: improved communication, but because of the way all these social and technical components were linked together and provided positive feedback to each other. For example, attempts to break up the early Bell monopoly encouraged a quick burst of technological activity but ended up leading to the reconsolidation of Bell into a more regulated or monopolistic form when competition lead to problems of technological incompatibility between local and long distance telephone systems and difficulties in satisfying the emerging politically desirable aims of universal service (Mercer 2006, 57-71).

A number of lessons can be drawn for IT eco-innovators from the brief historical example above. Developers of eco-innovations will need to be sensitive to the fact that aside from deriving improvements to programmes and hardware that effort will need to be placed into developing economic models compatible with their technological aims. For example, just as there were numerous possible models originally available, and are still available for telephone use, e.g: payment of license fees, the effective control of pricing of calls to allow for reinvestment in infrastructure etc. there may different forms of economic incentives and disincentives that encourage computer based carbon solutions. Incentives to introduce eco-innovative solutions will also be likely to be enhanced by a mixture of government support and the emergence of 'political ideals' (such as universal service), based on an awareness of the importance of innovative technological-procedural solutions to environmental problems. Such ideals could also have an 'aspirational' element facilitating thinking outside of short term market or regulatory solutions, buffering planned innovations against being prematurely dismissed if their immediate efficacy is not apparent and also providing a yardstick for measuring success that are not bound by previous forms of thinking (Sorensen 2002). A further possible lesson from thinking of the network aspects of emerging technological systems is the value for the creation of structures for ongoing technological improvements that can be closely linked to contexts of use so as to facilitate ongoing feedback and future technological development (Hoddeson 1981).

NEW FORMS OF KNOWLEDGE AND EXPERTISE

Persisting with the example of the classic telephone system we can next consider the significant role played by a small a number of key players who became conscious of the need to help facilitate the links between the various technical, social, political and economic dimensions of the emerging telephone system. The most significant was Theodore N. Vail who served 2 terms as general manager and president of Bell between 1878-1887 and 1907-1919 (Mercer 2006, 62). During Vail's second term he extended a systems approach to promoting technological innovation. To keep up with competitors he instructed the Bell system to buy up rival patents and also encouraged them to develop new ideas within their own institutional structures. Vail encouraged innovation that was "adaptive" allowing the Bell system to be efficiently standardized and responsive to markets, but also "formative" anticipating and promoting future developments such as solving the problems of long-distance telephony. Vail described the network and his strategies as, "an ever living organism" [whose development involved] "unceasing effort, continually improving and up building ...never standing still ... the plant and methods of each company must be coordinated with those of all of the other companies, because each is but a part of the unified structure ..." (quoted in Galambos 1992, 4). Vail's understanding of the role of innovation for the Bell system also encouraged the business structure from which the Bell Laboratories emerged. They would become one of the most important sites for scientific and technical innovation of the twentieth century (Hoddeson 1981, 530).

Figures such as Edison in his role in developing electricity systems and Ford in the case of automobiles bear similarities to Vail in that their efforts can be described as heterogenous engineering, engineering both social and technical components in a system by using a mixture of knowledge of the technical the social, and also, in a sense a third form of knowledge, knowledge geared towards the needs of the 'emerging' system (Hughes 1994, Law 1994).

Historical examples of the important role of system builders in implementing successful innovation have also been reinforced in more recent studies such as the PESTO project (PESTO 2000) funded by the EU, which focused on the socio-cultural dimensions of technological innovation and sustainable development. A key aspect of this study was the identification of the important role played by different kinds of 'knowledge brokers':

> In much the same way that policy entrepreneurs were crucial in establishing meaningful interactions between public and the policy makers, the coherence and effectiveness of networks was strongly dependent on mediators, or brokers, who serve both as information conduits as well as promoters and network builders (quoted in Jamison 2002, 30).

The PESTO report (2000) identified 4 main styles of brokers:

(1) Network Builders: One type who establish links between individuals and research groups in a top down fashion (more often than not from transnational organizations or corporations) and another type operating at a more horizontal level engaging in "mediation and creating new arenas of interaction" linking people together from "different social domains or constituencies.

(2) Translators or interpreters: "Who serve to transfer a certain language or conceptual framework that has been developed in one sphere of knowledge production into another, thereby making a concept or a method or policy approach fit into a particular context or situation" (quoted in Jamison 2002, 31). An example of translation is the techniques of environmental accounting moving out from their economic origins to become parts of the discourse of academia bureaucrats and public, and the opposite movement of concepts such as 'life cycle analysis' and 'ecological footprints, making the transition from academic and public discourse into the domains of business and government .

(3) Business leadership: this primarily involves the creation and recruitment of new managers for environmental management units located within businesses. These managers growing out of a business environment have advantages of local knowledge that may be required to institute change.

(4) Knowledge Entrepreneurs: These brokers take risks, mobilise resources and create organisational innovations and can be found across business, government and universities (Jamison, 2002,31).

The PESTO study noted that the success of these forms of knowledge brokerage in developing new systems was strongly influenced by a variety of cultural/ contextual factors. The most successful networks were the ones that effectively combined resources from business, university and non-governmental organizations which linked public and private initiatives, where there was substantive political interest and willingness of political and public figures to serve as policy entrepreneurs taking risks and open new communication channels, where resistance to new initiatives by traditional academic disciplines, business firms and industry was poorly mobilised and where green initiatives were not compartmentalised(Jamison 2002, 37).

Coupling the observation from our historical examples with the PESTO report a number of useful recommendations could be made for eco-innovators. Such eco-innovative groups (for example the Carbon-Centric Computing Initiative at the University of Wollongong (Ghose, et.al., 2009) often being initially university based, have strong resources to encourage the development of knowledge translators drawing upon their interdisciplinary and pedagogical base. These initiatives could be pursued by engaging in curriculum development to help generate in the longer-term new forms of expertise, and facilitate the development of new arenas for interaction for different types of relevant expertise. Out of these efforts it would be hoped that that locating and translating key concepts that might help encourage the successful adoption of new optimisation technologies and better IT carbon management would occur.

Finally, following from the example of Vail, facilitating the growth of flexible but strong institutional structures geared to the perpetuation and implementation of eco-innovative agendas is important. Overall, eco-innovators should place energy into becoming involved in curriculum development, knowledge translation, creating arenas for the exchange of ideas and for the gradual building of their institutions. These efforts would all assist in creating an environment where eco-innovative groups could evolve and most importantly help create an environment where they're not merely compartmentalised as an isolated green initiative.

THE IMPORTANT ROLES PLAYED BY USERS IN RE-SHAPING TECHNOLOGY

The role of users in reshaping technologies is an important area of interest in STS following the processes of innovation from designers and inventors to the point of use, sometimes described as the 'consumption junction' (Schwartz–Cowan, 1994) provides insights into the way users may, resist, reshape technological systems, provide explanations for why some systems fail, similar systems have different implications for different users, and help account for unexpected consequences of technological innovation.

> By detailing the network of social relations in which a consumer is embedded, this form of analysis reminds us that different social groups, acting in what they perceive to be their own best interests, can, because they are embedded in a complex network, produce effects that may be quite different, perhaps even diametrically opposed, to what they intended. (Schwartz Cowan, 1994, 279)

Numerous examples can be found in the history of technology that reinforce the importance of this theme (Oudeshorn & Pinch, 2003). In keeping with discussion thus far examples will be taken yet again from the history of the telephone.

In the early era of the development of the telephone system there were significant contradictions in the attitude of telephone companies and designers about what the most significant social function of the telephone should be. Many telephone company managers, partly as a hang-over of telephone systems developing out of the electrical telegraph, held the view, well into the 1930's, that the primary function of the telephone was as a tool for business communication and household management. Early promotional campaigns and telephone trade magazines emphasized the variety of practical functional services that the telephone could offer such as weather reports, sports results, fire fighter alerts, and baby lullabies. Accordingly advertising starting around 1910 was directed toward businessmen and emphasized the role of the telephone in saving time, planning, impressing customers, being modern, and keeping in touch with work while on vacation (Fischer 1988, 40). Telephone managers began to be troubled by women and rural users who didn't behave the way they were meant to and were using telephones extensively for "day-to-day" conversation and sociability and attempting to overcoming social and geographical isolation (Mercer, 2006, 68-69; Martin, 1991, 318–320).

In 1909, a local Seattle telephone manager, after listening to a sample of calls from the exchange determined that 30 percent of calls were "purely idle gossip", 20 percent orders to stores and business, 20 percent from subscriber homes to their own businesses, and 15 percent social invitations. The manager believed that these types of ratios were representative of other cities and exchanges. The high percentage of gossip calls was defined as an "unnecessary use" and something that needed to be eradicated by education programs (Mercer 2006, 69; Fischer 1988, 48). Users nevertheless kept on using telephones for sociability and the industry began to realise that, rather than resist it, enhancing sociability was something that could be lucrative and should actually be marketed. In a trade manual in 1923 the South-Western Bell Company announced that it was selling something: "...more vital than distance, speed and accuracy ... [T]he telephone ... almost brings [people] face to face. It is the next best thing to personal contact. So the fundamental purpose of the current advertising is to sell the subscribers their voices their true worth—to help them realize that "Your voice is You." ...to make subscribers think of the telephone whenever they think of distant friends or relatives. ..." (quoted in Fischer 1988, 41; Mercer 80-81).

A more recent parallel case of the consumers reshaping technological systems can be found in the development of SMS or Text Messaging. Whilst the idea of SMS was discussed in the mid-1980's by GSM planners it was originally envisaged as little more than a useful way of alerting telephone users of incoming messages something a little similar to existing paging systems the industry and engineers didn't anticipate that it would become such a huge activity (Trosby,2004, 193; Mercer,124-125).

Whilst these examples are drawn from technological systems involving consumer technologies, so feedback from users is more direct, various lessons may still be drawn for promoters of eco-innovation. Some basic lessons involve the recognition that successful innovation is a process that unfolds over time where there is a need for designers to be sensitive to the feedback that might be offered by users and where designers need to provide spaces in their plans to allow for the possibility of users interpreting the possibilities of a technology in different ways to those which were anticipated. An area of direct relevance to eco-innovative groups where these factors are at play, is in plans to encourage things like greater use of computers to facilitate working from home rather than the workplace and encourage things like teleconferencing. Designing technologies to facilitate these changing patterns of communication is clearly important regarding developing user friendly interfaces, etc. But there are also important sociological and psychological factors that effect the adoption of such technologies. For example, the possibilities of telecommuting have been around for considerable time (Toffler 1981). The first generation of experiments with telecommuting suggested a raft of unanticipated psychological problems for home workers and a desire in many cases for users (workers) to favour mixed patterns of work performed in the workplace and home rather than working from home alone (Forrester, 1991; Flew 2002).

SITUATING PLANS FOR OPTIMIZATION WITHIN PARTICULAR TECHNOLOGICAL PARADIGMS OR TRAJECTORIES

A final observation that can be derived from acknowledging the importance of socio-technical systems is that existing and mature technological systems can develop - to use the term coined by the eminent historian of technology Thomas Hughes - 'technological inertia'(Hughes 1994, Sorenson 2002; Kemp 2002). A little like Thomas Kuhn's notion of scientific paradigms, within a well established technological system there are tendencies for efforts to be directed at technologically and socially solving problems within a system through adopting familiar approaches that limit impact on the equilibrium of the system. For example, problems with the cost or availability of fossil fuels for automobiles can be addressed by attempting to make petrol driven cars more efficient. Optimising car designs, and efficiency of engines, quality of roads, traffic management, and driving skills, may all offer incremental improvement to carbon use, within an automobile orientated socio-technical framework or paradigm. Energy and effort being directed at these types of improvements may nevertheless be irrelevant to, or given that there are not unlimited financial and intellectual resources in society at any one time, being promoted at the expense of alternative socio-technical systems being developed (Sorenson 2002; Kemp 2002). For example, optimising the elements of the socio-technical systems of automobiles, or coal fired power generation, may prove to be at the expense of developing better public transport systems relying on quite different socio-technical frameworks with their own quite different potentials for optimisation.

Eco-innovative groups will need to be able to reflect not only on how the effectiveness of IT inspired optimisation may operate on one socio-technical paradigm or framework but also how this framework or paradigm sits with others that may offer alternative optimisation challenges. They may also need to consider whether there may be contexts where using IT to facilitate optimisation in one socio-technical framework or paradigm, such as improved use of coal for energy production, may indirectly be limiting the future development of what might be ultimately more carbon friendly alternatives.

CONCLUSION

Considering the four interlocking themes sketched above we contend that understanding successful innovation involves thinking in terms of fluid boundaries between the technical and the social, identifying that users can play an important role in innovation and that successful innovation involves the generation of new forms of knowledge, not just of a technical nature but in forms that can translate technical understandings into social and economic domains. Underlying these themes we also made the broader observation that technological change needs to be thought of in terms of systems and processes and that eco-innovators need to think of promoting their solutions and applications as emerging systems not just as individual technological innovations. We concluded by drawing attention to the need for eco-innovators to be aware that possible contributions of such initiatives to any one socio-technical system may not always represent the best outcome in terms of carbon management if such a system is in possible competition with others with more minimal carbon footprints. In all, whilst our sketch has been rather introductory, we hope that the basic four themes we have identified may stimulate further discussion and provide a helpful starting point for a refinement of eco-innovators' stated aims and their further development.

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