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The Politics of Innovation for Environmental Sustainability: Celebrating the Contribution of Stewart Russell (1955–2011)

This is the second part of the special issue of *Science & Technology Studies* on the *politics of innovation for environmental sustainability,* initiated by a colloquium held at Edinburgh University to recognise Dr Stewart Russell's contribution to Science, Technology and Innovation Studies (STIS). The papers in the first part of the special issue, *Science & Technology Studies 27(3),* revolved around issues which preoccupied Russell for much of his academic life: the rescaling and decentralising of energy systems, and the role within this of district heating and combined heat and power. The papers explicated Russell's core intellectual project and considered how this had contributed to contemporary theoretical debates in STIS. As part of his theoretical contribution Weber (2014) fleshed out Russell's specific multi-level approach with its particular interest in political and institutional contestation.

The four articles that make-up this second special issue cover a wider range of sustainable technologies, innovations and transitions across energy, transport and buildings. They share Russell's concern to develop detailed but incisive understandings of the dynamics, barriers and resistances to sustainable innovation, using STS-based and wider sociological analytical resources (Williams et al., 2014). The papers focus on a range of sociotechnical innovations with environmental benefits as they attempt a transition from an 'alternative' to more 'established' or, to use the language of the Multi-Level Perspective (MLP) from 'niche' status to 'regime'. In doing so, they pay attention to both absent voices as well as those present; to those technologies which fail to become established as well as those which succeed; to the relative resources available to different actors; and to the ways in which the social and environmental characteristics of sustainable innovations may be transformed (and in some respects lost) in the course of their development.

Collectively, the papers thus provide an opportunity to explore Stewart Russell's contribution in relation to a wider range of developments in the field of STIS. After briefly introducing each of the papers below, we then draw together their shared concerns under three themes: the barriers and resistances to sustainable innovation; the transformation of green innovations in the course of their diffusion; and lessons for researching and intervening in the politics of innovation for environmental sustainability.

In the first paper, Knut Sørensen seeks to develop an understanding of the long-term challenges of achieving the systemic changes in technologies and practices needed for environmental sustainability. He does this by a retrospective examination of

how some cleaner and greener technologies moved from being part of the 'alternative technology' movement of the 1960s and 1970s to part of the present-day mainstream. Sørensen considers the fortunes of three alternative technologies – wind turbines, electric vehicles and ecological architecture – in terms of their development in response to more recent concerns, such as climate change. Sørensen uses the concept of 'sociotechnical mainstreaming' – the transformation of radical niche technologies by dominant interests and institutions – to explore the differing patterns of change. His comparative analysis highlights four different technological and institutional forms of mainstreaming: pragmatic, expansive, dominant design and conceptual.

The second paper, by Graham Spinardi and Rebecca Slayton, also offers a multi-case historical analysis of the fortunes of 'green' innovations. However, while Sørensen considers cross-sectoral patterns, the empirical terrain here is narrower, focused on a single sector. Spinardi and Slayton present three case studies of innovation in aviation (engine designs, advanced materials and wing design) to develop an STS-based account of the resistance to radical sustainable innovation seen in risk-averse sociotechnical systems. In doing so, they also critique the Multi-Level Perspective and suggest ways in which it may need to be extended. They argue, as did Russell, that in 'opening the black box' of innovation the MLP should give greater attention to technological specificities. In the aerospace sector, for example, technologically-specific risks and a conservative regulatory system (with a complex suite of tests and standards built around established proven technologies) present significant barriers to certain kinds of radical (greener) innovation.

The third paper by Kean Birch and Kirby Calvert, critically considers the prospective role of biofuels in the US transition to a low carbon economy. Drawing particularly on Timothy Mitchell's diagnosis of 'carbon democracy' (the deep-rooted dependencies of Western political economy on fossil fuels) Birch and Calvert attend to a wider range of sites, actors and timescales than is commonly the case in studies of innovation. In doing so, they call into question any portrayal of bioenergy as a 'drop-in' fuel – a socio-technical solution to climate change requiring only limited disruption to broader energy systems. The barriers and resistances to prospective sustainable innovations, they argue, are rooted in the deep entanglement of our political, institutional and economic, as well as technological systems in the current carbon economy. Moving away from fossil fuels will require not just technological change, but also new political machinery, new forms of economic knowledge and accounting practices. This echoes arguments in papers from the first part of this special edition by Hawkey (2014) and Webb (2014) who highlight how governance and market structures, respectively, may need to be reformed for more decentralised energy innovations. This raises still unresolved issues about how readily such institutional barriers may be overcome (a point we return to below).

Whilst the first three papers span relatively large scale and long term sociotechnical processes, the final paper, by Christian Clausen and Wendy Gunn, is concerned with micro-level structure and agency, and the more immediate temporalities of design practice. Prompted by some longstanding concerns among STS scholars on the absence of user perspectives about the design process, and the gap between technical solutions and user practices, Clausen and Gunn focus on the use of ethnographic-based interventions

to create 'temporary spaces' for more meaningful participatory innovation. Drawing on their own efforts to promote awareness of sustainable innovation in the building sector, they explore the scope to reconfigure the metaphorical and literal spaces in which innovation players – developers and users – may interact.

The Barriers and Resistances to Sustainable Innovation

As was evident from Russell's work on combined heat and power, and from the articles in the first part of this special issue, superior environmental performance is no guarantee of the adoption of a technology, even where there appears to be a strong sustainability imperative. Studies of such 'failures' are still far less common than analyses of successful adoptions, but they can provide important insights into the politics of sustainable innovation.

Spinardi & Slayton's analysis of the lack of adoption of a number of environmental innovations within the same sector is interesting in this context. Given the strength of concern over climate change, one might have expected the aviation industry to be vigorously pursuing innovations which promote better environmental outcomes. However, factors such as the close alignment of players within the industry and the strongly risk-averse context and associated regulatory controls are shown to favour incremental developments over radical innovations. The analysis of the different cases is used to unpick further the dimensions of the widely adopted concept of 'radical innovation' – for example in terms of the engineering knowledge involved, or the issues it poses for particular technology adopters or users.

Birch & Calvert's analysis provides a different perspective on the barriers to environmental innovation created by powerful institutions, actors and embedded infrastructures – what Gregory Unruh referred to as 'carbon lock-in' (Unruh, 2000). Focusing on the energy sector, they critique the advocacy of a particular 'version' of bioenergy: 'drop-in' biofuels. Though this is seen as attractive by some because it promises a non-disruptive transition, the authors argue that this fails to recognise wide and complex socio-technical associations, particularly in relation to land use and transportation. While Spinardi & Slayton offer a call for a detailed elaboration of specific forms of sociotechnical lock-in, Birch and Calvert criticise the narrowness of much techno-economic energy analyses which engage only with immediate barriers to change, and call for attention to more pervasive but perhaps more decisive forms of socio-cultural-technology lock-ins. These 'hidden' resistances to sustainable innovation are found *within* and *across* the systems often analysed in sustainable innovation studies research.

What Can Be Lost When Sustainable Innovations Are Taken Up?

In the 1970s proposals for environmentally beneficial 'green' innovations were often also seen to have other desirable social characteristics, – such as promoting craft skills and local production. Alternative technologies were thus conceived as a challenge to the dominant industrial regime, which, with its emphasis on specialisation, centralisation and economic imperatives, was seen as having caused and therefore unable to resolve contemporary social and environmental problems. The papers included here present a more complex picture.

Sørensen's paper poses a general question about what may be lost as an initially politically-radical innovation, geared towards widely distributed local

capacities, becomes taken up in a more conventional mainstream industrial and commercial framework. Sørensen finds that those projects which continued to emphasise critical outsider perspectives seem to have been less 'successful', in terms of being taken up on a large-scale basis (or merely surviving). However, in more 'successful' projects, the radical social goals seem to have been abandoned in the process of institutionalisation and wide diffusion, and a relatively narrow pursuit of climate change mitigation rather than more radical socio-economic sustainability agendas.

Birch & Calvert also critically engage with the suggestion that, in order to be successful, sustainable technologies should be made acceptable to the mainstream. Promoting 'drop-in' solutions to environmental problems, they argue, not only favours existing institutional actors in terms of preserving current structures, it also constrains the resources available to different actors to engage in decentralised political action. They contrast this to a scenario with more decentralised energy provision based on biofuels. Rather more explicitly than Sørensen, Birch & Calvert argue that 'genuine' sustainability (social, economic and environmental) requires a broader and more radical approach to innovation. A possible counter argument here is that efforts to realise broad disruptive sustainable transitions may increase uncertainties and resistances to climate change mitigation. Winskel and Radcliffe (2014) have argued, similarly, that the increasing urgency of climate change mitigation in UK energy policy had led to a focus on continuity-based change.

At a different scale and locus of analysis, Clausen & Gunn also show that pursuing apparently environmentally superior technologies without regard to their social context – and in particular to those who will be using the technologies – is likely to compromise their environmental credentials. They explore the ways in which the engineering and marketing expertise that drive product development can lead to technologies which are ill-suited to the way people wish to control their indoor climate. The implication here is that users will either fail to adopt or appropriately use such environmentally benign technologies. As with Russell's (2005) work on representations of use on 'intelligent' polymers as well as Birch & Calvert and Sørensen in this volume, the lesson here is that the contexts and processes for the uptake and use of technologies can undermine the envisaged sustainability transition. Assessing the sustainability benefits of new technology requires critical social analysis regarding its likely appropriation patterns, contexts and practices, and calls for continued interventions in the course of their typically extended development periods.

Researching and Intervening in the Politics of Innovation for Environmental Sustainability

These concerns raise questions about the advantages and disadvantages of particular strategies for achieving socio-technical change. For some of the authors their research has led to a critical engagement with the highly influential Multi-Level Perspective that has, under the term Transition Management (TM) (Rotmans et al., 2001; Geels, 2002; Geels & Schot, 2007), achieved wide currency in discussions of promoting an environmentally sustainable society. The appeal of the MLP schema, with its readily intelligible templates that tacitly convey a sense that sustainability transitions could be anticipated and managed, contrasts with the empirical complexity of actual development pathways revealed by historical and sociological studies – as many

MLP-based case studies have themselves illustrated (Winskel & Radcliffe, 2014).

Rather than the MLP's typologies of change, Sørensen argues that the concept of *mainstreaming* captures the complexity of interactions and resistances – for example, in how 'alternative' ideas are transformed and incorporated within dominant institutional frames. Stewart Russell, though broadly supportive of the MLP-TM project (Russell et al., 2012) which he saw as exemplifying his call for analysis which attended to the interaction between local developments and 'layers of context' (Russell & Williams, 2002: 59), also called for attention to be paid to the intricacy of these interactions – which could reveal particular impediments as well as opportunities for policy and intervention. The maintenance of theoretical commitment in the face of complex and perhaps ambiguous empirical evidence was a recurring theme in Russell's work.

From the outset STS articulated a critique of the factors shaping traditional technology design, accompanied by a vision that design and development processes could be redirected to achieve alternative (e.g. human-centred or greener) technologies (Russell & Williams, 2002; Stewart & Williams, 2005). However, in the early stages of STS there was very little practical experience of intervention to change design practice and outcomes. Some decades later, greater experience of attempts to intervene in and redirect technology innovation have highlighted the difficulties in achieving this, given the complexity of interactions involved. Clausen and Gunn's work exemplifies the sustained efforts of STS scholars to engage with technological practitioners – efforts which yield very different understandings of the character of innovation processes, how they are shaped, and the scope to intervene therein.

The papers presented here all illuminate the complexity and situatedness of 'transitions' in practice, both in relation to the adoption of effective environmentally sustainable technologies, and, in cases where adoption does occur, in links with other social values.

As well as emphasising the value of research studies of 'failed' or 'incomplete' transitions, these papers also raise questions about the strategies which could be pursued by those concerned with achieving more sustainable, and equitable futures – be that through high-level policy interventions or at the level of design and development.

One reading of Sørensen's cases might suggest that those wanting to see environmentally sustainable products break out of their 'alternative' or 'niche' status will need to accept that their diffusion will require them to be reshaped by institutions in ways that may lead to a loss of wider social characteristics. However, the variety of ways in which such 'mainstreaming' is shown to have occurred by Sørensen perhaps opens up alternatives paths, which retain such characteristics. In a related way, Birch & Calvert's paper underlines the importance of paying attention to the wider 'political materialities' of energy if we are concerned about social outcomes and the ability of diverse – and currently largely absent – actors to have a stake in policy debates.

Together, the papers represent lines of conceptual development and empirical enquiry which resonate strongly with Stewart Russell's own concerns: the need to analyse sociotechnical change and sustainable innovation in specific institutional and practice contexts; to empirically study contestation over sociotechnical outcomes under the influence of individual and collective actors; and to hold structure and agency (and theory and empirics) in tension rather than

favouring one over the other to understand the dynamics of innovation.

We close this review by highlighting a broader feature of Stewart Russell's intellectual project – his concern to promote the health and vibrancy of our still emerging field of STIS. In its early stages its striking intellectual dynamism was characterised by proliferation of empirical studies and conceptual schema – benefitting enormously from pathbreaking inputs by some outstanding individual scholars.

However, developing a field of enquiry is not just an individual task but is a community achievement. It involves different kinds of intellectual work. As well as empirical and conceptual extension, there is also an important, but often unheralded, job of work in integrating and systematising our understanding. Concern that this vital task had not been adequately pursued by the STIS community prompted Stewart Russell to develop a Glossary of "some key social shaping concepts" (Russell & Williams, 2002: 108). Here, he proposed a principled approach to such a project: rather than impose one particular analytical tradition and ignore other schools, Russell argued for the need to attend to and engage seriously with other intellectual traditions within and outwith STIS.

Focusing upon "Confluences and tensions" Russell and Williams (2002: 97) argued for a conception of STIS as a broad church, valuing diversity and debate as a source of creative tension. The papers in this special edition can, we hope, be seen to contribute to this project in two ways. First, they point to the productive interleaving over time of contributions amongst a diverse intellectual community around a broadly shared programme of enquiry. Second, the papers testify to the value of contributions that, while empirically engaged, are able to stand back from particular empirical studies and reflect upon the longer-term evolution of sociotechnical domains, and the changing ways in which we have sought to understand and to shape them.

We hope, through this special edition, to have enabled a more effective understanding of the distinctive analytical contributions of a valued colleague to important ongoing theoretical and policy debates within our field.

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