

Innovation, sustainability and democracy: an analysis of grassroots contributions

Article (Published Version)

Smith, Adrian and Stirling, Andrew (2017) Innovation, sustainability and democracy: an analysis of grassroots contributions. *Journal of Self-Governance and Management Economics*, 6 (1). pp. 64-97. ISSN 2329-4175

This version is available from Sussex Research Online: <http://sro.sussex.ac.uk/id/eprint/15968/>

This document is made available in accordance with publisher policies and may differ from the published version or from the version of record. If you wish to cite this item you are advised to consult the publisher's version. Please see the URL above for details on accessing the published version.

Copyright and reuse:

Sussex Research Online is a digital repository of the research output of the University.

Copyright and all moral rights to the version of the paper presented here belong to the individual author(s) and/or other copyright owners. To the extent reasonable and practicable, the material made available in SRO has been checked for eligibility before being made available.

Copies of full text items generally can be reproduced, displayed or performed and given to third parties in any format or medium for personal research or study, educational, or not-for-profit purposes without prior permission or charge, provided that the authors, title and full bibliographic details are credited, a hyperlink and/or URL is given for the original metadata page and the content is not changed in any way.

INNOVATION, SUSTAINABILITY AND DEMOCRACY: AN ANALYSIS OF GRASSROOTS CONTRIBUTIONS

ADRIAN SMITH

a.g.smith@sussex.ac.uk
Science Policy Research Unit,
University of Sussex

ANDREW STIRLING

a.c.stirling@sussex.ac.uk
Science Policy Research Unit,
University of Sussex

ABSTRACT. In this paper we introduce an area of activity that has flourished for decades in all corners of the globe, namely grassroots innovation for sustainable development. We also argue why innovation in general is a matter for democracy. Combining these two points, we explore how grassroots innovation can contribute to what we call innovation democracy, and help guide innovation so that it supports rather than hinders social justice and environmental resilience. Drawing upon qualitative case studies from empirical domains including energy, food, and manufacture, we suggest it does so in four related ways: 1. Processes of grassroots innovation can help in their own right to cultivate the more democratic practice of innovation more generally. 2. Grassroots innovations that result from these processes can support citizens and activities in ways that can contribute to practice of democracy. 3. Grassroots innovations can create particular empowering sociotechnical configurations that might otherwise be suppressed by interests around more mainstream innovation systems. 4. Grassroots innovations can help nurture general levels of social diversity that are important for the health of democracy in its widest political senses. The paper finishes with a few suggestions for how societies committed to innovation democracy can better support and benefit from grassroots activity, by working at changes in culture, infrastructure, training, investment, and openness.

JEL codes: O31; O32; Q55

Keywords: grassroots innovation; sustainable development; democracy; society

How to cite: Smith, Adrian, and Andrew Stirling (2018). "Innovation, Sustainability and Democracy: An Analysis of Grassroots Contributions," *Journal of Self-Governance and Management Economics* 6(1): 64–97.

Received 6 February 2017 • Received in revised form 27 June 2017

Accepted 27 June 2017 • Available online 20 July 2017

1. Introduction

“The fundamental problem of democracy today is quite simply the survival of agency in this increasingly technocratic universe.”
(Feenberg, 1999: 101)

“Policies for science and technology must always be a mixture of realism and idealism.”
(Freeman, 1991)

In this paper¹ we analyze how grassroots innovations for sustainability can contribute to a largely ignored aspect of innovation in society: namely the scant provision of democratic ways of addressing the politics inherent in innovation (Sclove, 1995). Innovation is the capacity of people successfully to exploit a new idea or method and realize some material and social effect (Freeman, 1991). In these terms, then, innovation can involve the development of novel technologies, processes, organization, and services. It can present incremental, radical or transformational changes to wider social life. Innovation is undertaken through networks of people working on things in diverse organizations for varied purposes. Innovation for sustainability directs this creative activity towards novel practices that transform markets, public services, communities, and societies more generally into more socially just and environmentally resilient forms (Smith et al., 2010; Leach et al., 2012; Geels et al., 2008). An expanding coalition of leaders in state, business and civil society organizations invoke innovation as a means to rise to the twin challenges of inclusive economic development and environmental sustainability (Scoones et al., 2015).

Less explicitly recognized, however, is that some forms of innovation are also culpable in many of these same societal challenges: contributing to environmental degradation, disrupting of livelihoods, exacerbating of inequalities, and heightening war and oppression (Chapman, 2007). For all these reasons, innovation processes need to be “opened up” to greater public scrutiny, wider participation, and a more responsible ethics such that the particular directions that innovation takes in any given area become more socially accountable (Stirling, 2008). As such, public discussion and action, including policy, has to make more explicit that innovation is inherently political. Too often, the very real politics of innovation is masked by technocratic and exclusive approaches imposing narrow criteria of efficiency, profit and convenience. The dominant image (and practice) of innovation continues to focus upon rent-seeking, technology-based firms working with research institutes and investors, aided by a policy environment that facilitates systemic interaction between these institutions in the pursuit of economic growth (OECD, 2010;

Martin, n.d.). Overlooked are the ways these arrangements privilege certain values, interests and positions towards innovation in society, and carry with them a less democratic politics than might be merited by the stakes at hand.

We argue innovation is an intensively political activity (Smith et al., 2005). The innovations developed amongst people working in firms, research institutes, state agencies, and investment funds shape our lives in profound and pervasive ways: as much, if not more, than the laws of the land (Feenberg, 1999). Indeed, innovations can surpass and trouble legal frameworks and social institutions and force adaptations. Citizens are rarely consulted directly within the institutions responsible for innovation, and almost never are citizens in the driving seat (Ely et al., 2010). We might exert marginal influence as consumers at a late stage in the innovation process, when products are marketed to us. Or we might be consulted over regulatory reforms once the innovation is out (of control) in the world. But rarely are citizens central to prior deliberations, decisions and developments (Stirling, 2008; Chilvers & Kearnes, 2016).

Innovation therefore needs to become more democratic. But how? In this paper we suggest a lot can be learnt from grassroots innovation activity. We explain and define grassroots innovation and innovation democracy later. Grassroots innovation can be introduced here as novel solutions for sustainable developments generated by people active in grassroots settings. Innovation democracy implies the capacity of people to challenge the direction of innovations, and for even the least formally powerful communities to have a say. Notice also that we tend to use (sustainable) developments in the plural in order to signal the multidimensional, plural and contested characteristics of purposeful social changes.

Our aim is to explore how grassroots innovation activity can contribute to what is (unusually for such a source) called in a recent annual report of the UK Government Chief Scientist: “innovation democracy” (Stirling, 2014a). The present paper draws upon research we have done in grassroots innovation over the last decade (Smith et al., 2016; Seyfang & Smith, 2007; Smith, 2004). Examples from the UK provide illustrative cases in boxes within the main text; although our analysis is based on a series of qualitative case studies over the last 15 years in UK, South America and India, and which cover the domains of energy, food, housing, manufacturing, and local development (Smith et al., 2017; Smith et al., 2015; Smith, 2016).

2. Grassroots Innovation

Wind energy, community supported agriculture, social technologies, car clubs, free software, open hardware, repair cafés, participatory design, agro-ecology, eco-housing, recycling, shared machine shops, rainwater harvesting, comple-

mentary currencies, credit unions, socially useful production, seed swapping, community energy cooperatives, garden sharing, community forestry, green spaces, and many, many other ideas and practices for sustainable development began in innovative grassroots activity.

Grassroots innovation is a diverse set of activities in which networks of neighbors, community groups, and activists work with people to generate bottom-up solutions for sustainable developments; novel solutions that respond to the local situation and the interests and values of the communities involved; and where those communities have control over the process and outcomes (Gupta et al., 2003; Seyfang & Smith, 2007).

Unencumbered by policy silos, commercial logics, disciplinary boundaries, and other institutional pressures, grassroots groups are free to innovate how they see fit.

Throughout the history of modern environmentalism and development there has always existed an undercurrent of grassroots activism, working directly on sustainable local solutions (Ely et al., 2013). This has played out equally in the global north and south; in urban or rural settings; and across all sorts of sectors, including food, energy, housing, manufacturing, leisure, health, communications, education, and so on (Hess, 2007; Thackara, 2015; Schumacher, 1973; Gupta et al., 2003). In a few cases, what began as grassroots activity has evolved into substantial commercial activity in green industrial sectors, such as wind energy and car clubs (Truffer, 2003; Jorgensen & Karnoe, 1995). Often the mainstreaming of grassroots innovation involves input from – and hybridization with – more conventional research, development and investment in institutions for science, technology and marketing (Fressoli et al., 2014).

Sometimes grassroots innovation is an entirely indigenous endeavor, with people creating their own technologies, methods and organizations in order to realize a community need or aspiration. The Honey Bee Network in India, for example, has documented thousands of ingenious developments in villages across the country (<http://www.sristi.org/hbnew/>). Honey Bee has worked for decades to build up a system of support and diffusion that connects these grassroots innovators to formal research, development and marketing organizations in order that local ingenuity can be turned into marketable products (Gupta, 2016; Kumar & Bhaduri, 2014).

In other instances, grassroots initiatives appropriate technologies or models from elsewhere and adapt them to their own needs in unusual ways. Hackerspaces and makerspaces, for example, are popping up in many towns and cities globally – helping to make available to local communities versatile, small-scale industrial prototyping technologies, such as laser cutters, micro-electronic controllers, design software, and 3D printing, but also traditional hand tools too, including lathes, drills and sewing machines (Kohtala, 2016;

Smith, 2017). Inspired by ideas from free software, open design and peer production, these community-based workshops enable neighbors to cultivate the skills of using these tools and appreciate the new working practices of peer production, and apply these tools and practices to their own projects (Hielscher & Smith, 2014). Many hackerspaces and makerspaces are networked with one another, and form part of a global phenomenon that shares designs, instructions and code over social media platforms. In this way collaborative projects can be pursued and replicated internationally.

In grassroots innovation, skills are developed through the practicalities of creating an initiative, as well as the innovation presenting new capabilities for communities to develop (Sen, 1999; Bell, 1979). Take a community micro-hydro project, for example, where a group wishes to convert the run of a river into clean electricity for the local community (and thereby opening up new possibilities for that community). The community group will have to constitute itself and attract members. They will have to learn about the technology options, and begin the demanding task of raising funds and securing permission to develop a suitable section of their local river. Throughout, they will need to reinforce commitment, maintain solidarity, and have the emotional stamina to keep going. This requires a continuous articulation of the plurality of reasons motivating different members, to support the project and its aims (Seyfang et al., 2013); but also the negotiation of sometimes painful compromises.

Without learning to talk planning language, convincing local planning officials to take seriously a group of “amateurs” can be tricky. Access and influence might be eased with an influential political figure intermediating for the micro-hydro group (with issues of class and elitism sometimes bubbling under the surface). When difficulties arise in national policy – such as the absence of any meaningful framework of support or commitment to community energy (Box 4) – then groups need to mobilize and lobby alongside other community energy groups in order to get the policy frameworks they need (Smith et al., 2015).

Obviously, the community energy group will also be operating in a local (and national) context whose circumstances and politics they must come to terms with. Challenging features of social life become apparent in very practical form: such as how rules of access to electricity markets are designed to favor large-scale suppliers (for instance, in the UK). Quite fundamental issues of power come to the fore, such as ownership of land and resources (when siting the micro-hydro plant), control of capital investment (when trying to get a loan), cultures of expertise (being taken seriously), and local and national political patronage. These are all issues material to the working (or not) of the technology – and factors influencing the realization of a working micro-hydro electricity project.

In trying to do something differently – in innovative and unusual ways – the exclusions (and hence politics) of incumbent technology systems become very apparent (Light, 2014). In making their projects happen despite challenges such as these, grassroots innovators not only create a working artefact or organization, but they also develop critical knowledge about the injustices imposed by incumbent technology systems (Miranda et al., 2011; Smith et al., 2015).

Individual citizens can only rarely cultivate all these capabilities. So, there is a division of labor in grassroots innovation. People bring different forms of expertise and experience into the collective endeavor (Middlemiss & Parrish, 2010). It can be technical knowledge built up through one's job or professional training, such as accounting and doing the books for the initiative, or some engineering knowledge. Or it can be the vital, expert knowledge of the social dynamics in the neighborhood, and using ones standing or contacts to bring people on board and earn legitimacy. And, of course, there are the negotiating skills and political acumen to deal with all the regulatory authorities and investors involved.

Grassroots innovation initiatives, networks and movements are not the only spaces where citizen capacity-building happens. But the centrality of material activity in grassroots innovation, and by implication awareness of (and motivation due to) the exclusions and problems of incumbent technology systems means prior capabilities are strengthened and attuned to the politics of innovation.

Frequently, grassroots activity (and its consequences) plays out way below the radar of formal institutions – especially those institutions committed to the promotion of innovation. But from time to time elites do take an interest in grassroots activity and seek to support or promote it through policy and strategic programs. Examples include interest in Appropriate Technology in the 1970s and 1980s, Local Agenda 21 in the 1990s, and Inclusive Innovation and Social Innovation more recently (OECD, 2015; World Bank, 2012). Often, however, this official interest goes little further than programs to package, scale-up and roll-out ingenious initiatives arising from grassroots activity. They present little more than an attempt to insert grassroots ideas and devices into existing systems and institutions for innovation: for example, turning initiatives into social enterprises or marketable artefacts. There is rarely any attempt to try to understand the broader origins, implications and possibilities of grassroots involvement in new, more democratic forms of innovation. Yet this is the most powerful and important feature of grassroots innovation: an insistent opening up of innovation agendas, institutions and practices.

3. Technology, Sociotechnical Developments and Democracy

The philosopher of technology Andrew Feenberg writes that, “[t]echnology is power in many societies, a greater power in many domains than the political system itself” (Feenberg, 1999: 131). The design, development and control of technologies can be key in determining patterns of urban growth; or the kinds of energy systems powering societies; or the production and consumption of food; or forms and scales of manufacturing, and the kinds of labor available; the way we inhabit households; how we move about; and so on and so forth, with implications for how and where many of us work, live, shop and play. The move from steam-powered belts to electrically-powered motors in manufacturing, for example, enabled a re-organization of production and how we work with machines. The computerization of data-processing, machine-tools, offices, city planning (smart cities), communication, and other areas of life has radically altered the way these activities sit in our lives too. Consider the technologies you use in the course of your day, and the kinds of meaningful and routine activity they enable, and you will see the point we are making; and then imagine the forms of life those same technologies foreclose and even jeopardize – such as through contamination, congestion, surveillance, and the disciplining pace of your routines at work, if you are fortunate enough to have a job.

The pattern of these developments begs questions concerning their consequences for peoples’ lives and the kinds of society embodied in our technologies. If, as Andrew Feenberg claims, the development of technologies constitutes societies in ways akin to legislation in the political system, then who writes the rules? We have to take care here to avoid slipping into technological determinism. The idea that technologies determine our lives in manifold ways is a powerful one (Winner, 1977): especially when technologies fail and reveal our dependency upon them; or simultaneously harm us socially whilst benefitting us individually. Technological determinism becomes apparent in the mundane devices and infrastructures for our lives when their generative design decisions and social choices have faded into the past. But it remains misleading to say these are *technological* determinations (Winner, 1992). What appear to be exclusively technological considerations turn out to be the result of all sorts of social and cultural factors, both in the design of the technology and in its subsequent daily use (Bijker, 1995). Technological determinations are as much socially constructed as they are materially experienced.

Critical technology scholars are concerned about the kinds of societal vision and user expectations that become material to the development of a technology: how expected roles are inscribed into the physical development of technology, and which social considerations are marginalized or neglected

in development decisions. For example, certain ways of using the technologies by given groups and for particular purposes are assumed by those involved in their development, such as engineers, designers and entrepreneurs, and feature in the way they are marketed (Akrich, 1992).

Even apparently mundane incremental innovations have politics. Disability rights groups had to campaign vigorously for years in order for pavements to be re-designed incrementally, so that junctions always have lowered sections, and feature tactile paving, so that their use could include wheelchair users and the visually impaired. Traffic engineers had hitherto neglected this social group in their assumptions and designs for pavements and roads. It seems like a technical matter, to lower some sections of pavement. But behind it lie ethical considerations over which social groups come to be represented in our material world (Feenberg, 1999: 141). Multiple interdependent social choices put technological materials to work; by researchers, designers, investors, safety regulators, engineers, marketers, and a host of other people, including early users of the technology, who may have adapted its use into new forms, and which subsequently feed back into the technology development.

The term *sociotechnical* has been introduced by researchers in an attempt to overcome artificial divisions between what is technologically determining our world and what is socially determining it (Teixeira, n.d.). In this way, the initial focus for an innovation need not be a technology, but could involve a novel process, service, or organizational change. The motives might be economic, social or some combination. Whatever the starting point, such focal activity soon becomes linked to complex networks of other social, cultural and technical factors (de Laet & Mol, 2000; Latour, 2005). Innovation involves a sociotechnical reconfiguring, and the search for new arrangements that perform better according to some agreed criteria. We began with technological innovation in this section (cf. social innovation) merely in order to emphasize just how social even hardware can be.

Institutions such as capital markets, professions, public research and so forth can exercise quite powerful selection pressures over the directions taken by innovations, and they can reinforce the rise and stability of particular sociotechnical configurations in societies, such that these configurations dominate over other possible configurations (Smith et al., 2005). A socio-technical configuration can appear as an obdurate technological regime, such as fossil-fuelled electricity, or personalized automobility, precisely because it works within an institutionalized arrangement so dominant as to be taken for granted (Hommels, 2005). Such regimes actually sustain particular interests, worldviews, and everyday relations, many of which have built up with the technology (Geels, 2014). We illustrate this in Box 1 below.

Box 1 Sociotechnical developments in wind energy

A physical feature in the design of wind turbines means the wind energy available for conversion to electricity increases with the square of the blade length (and thus roughly the height of the turbine). It is a physical relation that powerfully influences the size of wind turbines and where to site them: introducing bigger turbines onto windier sites results in a non-linear increase in electricity generated. Whilst a design trend for larger turbines makes sense in terms of delivering large quantities of electricity per turbine, such concentration is not necessarily or entirely socially desirable (Byrne et al., 2009; Abramsky, 2010). It creates an innovation dynamic that requires large-scale operators, with access to significant capital and engineering expertise, at high-wind sites, and connected to infrastructures capable of moving large flows of electricity. It disadvantages communities with little access to capital and overlooks more holistic solutions based on different sociotechnical configurations.

The backyard engineers and local cooperatives that pioneered wind energy were committed to a more decentralized and democratically owned vision for energy in society. Yes, they were seeking wind-powered electricity, but they were doing so within a broader framework for a low energy demand society – one that did not need giant turbines, and that saw efficiency and sufficiency in a different way (Abramsky, 2010; Jorgensen & Karnoe, 1995; Byrne et al., 2009). Only later did their activities win recognition and support from the state and business. Interests from the last two took advantage of the ability to increase swept areas (physically and metaphorically), and utterly transformed the innovations the activists were pursuing. The alternative technologists were seeking decentralized energy for an ecological society; business built a global green tech industry.

Getting the balance right between large-scale wind energy exploitation and smaller-scale arrangements involves all sorts of responsibility and commitment to different winners and losers, present and future, human and non-human. Running through an ostensibly physical equation is a host of social choices with political implications. We have contrasted a sociotechnical configuration for wind energy based around massive turbines in the hands of capital, with a sociotechnical configuration involving smaller turbines under community ownership. One could also imagine massive turbines under some form of socialized ownership, as innovations in the co-operative ownership of windfarms have gone some way towards; and we also see entrepreneurs marketing small turbines for private investment. At stake are different ideas for how wind energy should be used, and who has dominant and who exploited positions in relation to wind. These social relations are enacted differently in any given sociotechnical configuration. The differences are a matter of ethos as much as engineering; indeed, the two become inextricable (de Laet & Mol, 2000). But which of these configurations becomes more dominant depends upon institutional and cultural reinforcement.

An artefact, such as a wind turbine, comes about and works as much through social relations – that cultivate engineering knowledge, mobilize investment, imbue wind power meaning in modern societies, negotiate the siting of turbines, and so forth – as it works through the velocity of the wind, the angle of the blades, their swept area, the strength of the materials in the tower and foundations, electrical flows in the dynamo and their controlled distribution to grids and so on. It is possible to develop wind energy to sociotechnical configurations that reflect utility visions and/or community-oriented visions. Much depends upon which assumptions and visions become inscribed into the sociotechnical configuring process, and how roles are delegated to technologies and groups that put the overall sociotechnical configuration to work (Latour, 2005). There is always scope for contesting this configuring through an argument for other visions, groups, elements – that is to say scripts – to be included (Akrich, 1992). This is the basis for democratizing innovation. Innovation – sociotechnical configuring – is a political program.

The material features in technologies act in relation with a host of social and cultural factors. If we think of technological risk issues like pollution, then the distribution of these risks will also be influenced by choices in the design and development of the technology. Consider the agendas and investments for a “green tech” revolution (Scoones et al., 2015). There are questions about the social distribution of those revolutionary benefits (and risks), and who is able to invest (and seek returns) from, say, energy transformations. When hitherto neglected resources like daylight and wind attract strong economic value in green economies, then is it fair that those able to exploit this new-found resource are the owners of historically accumulated capital who have the means to invest in wind turbines (earned through practices environmentally destructive in the past)? Or is it fair that wealthier home-owners can benefit from solar installation grants, where tenants cannot? Should societies develop sociotechnical arrangements under the control of all those neighbors over whom the same sun shines and wind blows (see Box 1)? These are critically important questions for the social justice dimensions of sustainable developments (Abramsky, 2010; Newell & Mulvaney, 2012).

The global consultation process of the World Commission on Environment and Development in the mid-1980s brought together some of these social and political – as well as technological – issues at stake in sustainable developments (World Commission on Environment and Development, 1987). Reporting in 1987, it was this process that came up with the widely cited definition of Sustainable Development that forms the basis for the Sustainable Development Goals of today: “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts: The concept of ‘needs,’ in particularly the essential needs of the world’s poor, to which overriding priority should be given; the idea of limitations imposed by the state of technology and social organization on the environment’s ability to meet present and future needs” (World Commission on Environment and Development (WCED), 1987: 43).

There is much to debate in this definition. What are essential needs? What is meant by environmental limitations? What is a state of technology and social organization? What kinds of developments, and for whom, and why? Who gets to decide these things? Here, an additional crucial feature of the WCED formula comes to the fore, concerning not just the *outcomes* of sustainable developments, but the *processes* by which they are realized.

Sadly neglected in subsequent policy debate (but still just about present in the Sustainable Development Goals), the WCED consistently emphasized the importance of “effective citizen participation” and “greater democracy.” This highlights that the political and technological changes envisaged in this

approach as necessary to achieve greater sustainability chime closely with what is described in this paper as innovation democracy (Wakeford, 2004).

Either way, innovation is central to the kinds of transformation in technology and social organization required for sustainable development. In this, any application of principles of sustainability in innovation has to grapple with questions of the driving purposes and the particular ways in which values of human wellbeing, social justice and environmental integrity are conceived and addressed (Agyeman, 2013; Jacobs, 1999). In short, the issues are not so much about the overall pace of innovation as with the details of its direction.

Looked at in this way (as dynamic and socially constructed), calls for sustainable development are as much about raising critical questions as about insisting on supposedly definitive answers. In other words, it is one of the most valuable features of sustainable development, that it is intrinsically normative and inherently contestable in nature (Jacobs, 1999). It is a matter for principled deliberation and democratic action to figure out how to construct development pathways that best express the driving imperatives of sustainability.

The key issue here, from a democratic point of view, then, is to interrogate the conditions that “create a separation of technology and sociality that makes us feel determined by a technology as if it were an ‘outside’ factor” (Jordan, 2015: 46). Democracy is crucial in this, because it brings the social back into technology (Sclove, 1995). A concern for democracy helps subject the social choices involved in technical developments to more effective public deliberation.

The trouble is that democracy is a slippery term. It can mean many contradictory things and is often used quite lazily or cynically. Yet the associated ideas (and practices) themselves are too important to be abandoned – no less for technology than in other areas of social life. In order to have practical progressive meaning, democracy must also be viewed as a process rather than any endpoint. Involving all the many weird and wonderful ways in which power works in society, democratic struggle is about kinds of social relations more than categories of outcome.

So, putting our emphasis as a matter of principle on the interests of the most marginalized groups, we would define democracy in a broad sense – as “access by the least powerful to the capacities for challenging power” (Andy Stirling, 2014b). To put this more specifically in terms of innovation politics, this means: access by the least powerful people and communities to the capacities for challenging the directions of the innovations that affect them.

In these terms, democracy includes but goes well beyond formal notions of representative democracy – or even any single model of direct democracy (Shapiro & Hacker-Cordon, 1999). Being organized or convened in many

different cross-cutting ways, this notion of democracy is starkly at odds with the ideas based on special events (like elections) (Arblaster, 2002; Bohmann & Rehg, 1997). It is likewise challenging to ideas that innovation is just about end products (better technology) rather than including the quality of the processes involved and their consequences (Veak, 2006; Marres, 2005).

Two quite distinct meeting points thereby open up between democracy and innovation (including grassroots innovation). The first concerns how innovations might contribute towards enhancing processes of democracy in the above senses. The second concerns the nature and degrees of democracy that are actually realized within the processes of innovation. Rather than being a static endpoint, our analysis points instead to the compelling need for democratic innovation to be seen as an ongoing process – about innovation of all ongoing kinds that serve to improve in any way, access by the least powerful people, to the capacities for challenging power. In the next section we seek evidence for the ways and degrees in which these qualities might be met by grassroots innovation. In short: how is grassroots innovation helping to improve democratic capabilities in society, and especially in how it generates and engages with innovation democracy?

4. Grassroots Contributions to Innovation Democracy

So far, we have introduced grassroots innovation and painted a picture of innovation not just as a technical matter, but as deeply value-laden; and not just about technology, but sociotechnical configurations (that include many social dimensions). In this view, it is possible to identify four related ways in which grassroots innovation can contribute to innovation democracy:

1. Processes of grassroots innovation can help in their own right to cultivate the more democratic practice of innovation more generally.
2. Grassroots innovations that result from these processes can support citizens and activities in ways that can contribute to practice of democracy.
3. Grassroots innovations can create particular empowering sociotechnical configurations that might otherwise be suppressed by interests around more mainstream innovation systems.
4. Grassroots innovations can help nurture general levels of social diversity, that are important for the health of democracy in its widest political senses.

These contributions are interlinked. None are guaranteed. Realizing their potential depends upon the social conditions in which grassroots innovation arises. We will now discuss each of these issues in turn.

4.1 Cultivating democratic innovation practices

On the face of it, there need be nothing inherently democratic about the internal workings of grassroots innovations. Usually grassroots initiatives involve a voluntary group of people creating solutions to local development issues as they see them, and with little thought for seeking permission or consent from society more widely. Nevertheless, in seeking to get their project off the drawing board, grassroots initiatives need to cultivate support and legitimacy locally; and if they wish to endure and be influential, then the grassroots initiative will need to draw into their negotiations wider interests and commitments (Smith et al., 2013; Hess, 2007).

Precisely because grassroots innovators hold an explicitly value-based, voluntary, and socially-oriented approach to their collective problems, so grassroots innovators have to be even more adept at negotiating than do conventional innovators. Grassroots innovators must go well beyond the authority of appeals to market-share and investor profits that tend to dominate in the institutionalized routines of mainstream innovation processes, to also articulate a wider variety of knowledges, forms of authority, and other social and material resources. Even where grassroots innovations involve clear financial and economic motivations, as with community energy projects like the micro-hydro example above, the groups involved are nonetheless trying to realize this in a way that does not contradict other values, such as for environmental integrity or social inclusion (Seyfang et al., 2014).

So, whilst grassroots initiatives might be just as susceptible to social, economic and cultural constraints as the wider societies in which they operate, it is often precisely these constraining social structures that grassroots actions aim to counter with their innovative efforts. They tend to aim to bring otherwise-marginalized issues and groups into innovation processes. They tend to work on a different – much broader – set of inclusions (e.g. issues, groups, values, visions, criteria) than is the case in conventional innovation management practice.

However, countering structural power is not easy (Smith et al., 2016; Stirling, 2014). Inclusive agency has to be worked at (Smith & Light, 2016; Johnson & Hall, 2014). To the extent that grassroots innovation processes attempt this, then they offer up a rich variety of practices and methods relevant for making innovation more democratic (Jamison, 2003). Conversely, to the extent that any grassroots innovation only struggles – or ultimately fails – to be democratic in the senses we use here, then it may also provide valuable lessons and useful food for thought in onward efforts. Box 2 provides an example of some democratic practices that were cultivated when workers tried to shape more actively the introduction of computer-controlled technology into their workplaces in the 1970s.

Box 2: The movement for socially useful production

Manufacturing workers in the UK in the 1970s, as elsewhere, were facing a bleak future. A combination of international competition, new technologies, and the movement of capital into services were threatening jobs and communities. A remarkable grassroots response from workers began at Lucas Aerospace in 1976, rapidly moved to other companies, and developed into a movement for socially useful production (Smith, 2013). Workers developed alternative industrial strategies for their companies, and proposed that rather than redundancy, the owners and government commit to socially useful production. Workers presented analyses and prototypes for socially useful products based on their skills, experience, and technologies available (Wainwright & Elliott, 1982). Their suggestions included hybrid electric engines for cars, devices for the disabled, heat pumps, wind turbines, and many other products that businesses are trying to develop forty years later.

There are many aspects to this history, but interesting here is worker commitment to democratizing the introduction of new technologies (Cooley, 1987). These skilled operators were very aware of developments in computer-aided design and computer-numerically-controlled machine tools. In the hands of capital these technologies threatened to displace worker skills through automation. However, rather than resisting computer technology, workers at Lucas wanted a say in how it should be developed and introduced. They sought human-centered production technologies in which computing power enhanced work rather than displaced it. They set about researching and designing computer-assisted tools that served to heighten operator skill and made workers more valuable to the company rather than redundant. At heart, these workers wanted to democratize the design, development and use of industrial technology. In so doing, they provided a practical counter to vision compared to the automated, workerless factory purveyed by management consultancies at the time.

The Lucas workers' aspiration was shared internationally, and particularly inspired the most advanced work in this area amongst researchers and workers in Scandinavia (Kraft & Bansler, 1994; Ehn, 1988; Rasmussen, 2007). There, a Collective Resource Approach to computer technologies pioneered practices in participatory design. Study groups were created. Action-research in the workplace was undertaken. Activities for appraising and articulating different values were established. Mock-ups of new technological arrangements were built. Design specifications and prototypes were developed collectively and iteratively modified through consultation cycles.

The industrial democracy sought by workers ultimately proved elusive. Nevertheless, the case for skilled operator input and overrides in computer-numerically-controlled machinery was made, and the role for user-centered design and development was persuasive. The techniques and practices for participatory design, intended as democratizing activity, have been selectively co-opted and adapted for the purposes of user-centered product designs (Asaro, 2014). Nevertheless, in seeking to democratize developments in manufacturing technologies, these workers cultivated techniques whose use under appropriate conditions has continuing relevance for innovation democracy today (Smith, 2014).

Grassroots initiatives are informed as much by ideas in community development, collective action, participatory design, action research, direct democracy, and voluntary organization as by the “good practices” of innovation management in the conventional sense. In striving to work to different agendas, with different groups, and with different practices, grassroots innovation movements offer up a variety of practices that can be informative and potentially helpful to innovation democracy more generally (Smith et al., 2016).

4.2 Supporting wider activities in innovation citizenship

Innovation citizenship refers to a situation in which people have the right to be involved in deliberations over the directions of innovation, and they have the opportunities and capacities to inform the issues at stake. Grassroots innovations provide instances and materials that can be drawn upon by others interested in deliberative democracy for innovation (Wakeford, 2001). Material deliberations move interaction beyond the spoken word and persuasive arguments, and permit people to experience the affective possibilities of situated objects and activity (Davies et al., 2012; Marres, n.d.). Such practical encounters can open up participation to people who may be less articulate in discursive terms, or less attracted by talk and debate, but who nevertheless have vital contributions to make (Ratto & Boler, 2014; Cooley, 1987). Crucially then, grassroots innovations provide concrete things around which to enliven such material deliberations over claims, aspirations and expressions of the values and visions at stake.

Neighbors can, for example, visit the community allotment, and see, feel and try their hand at participation in a local produce initiative. Or they might visit the hackerspace in their town on one of their open days, and similarly experience in a very engaged and practical way some of the possibilities of inclusive design and decentralized manufacturing. Presence at (and participation in) material activity can also facilitate different kinds of talk and expression towards the underlying values and visions (Marres, n.d.). People disinclined to (or perhaps less adept at) debating verbally can find different embodied forms for skillful expression. Such material encounters thus enhance the quality of engagement in the politics of innovation.

None of this necessarily means citizens actually need to become committed members of a grassroots initiative (or start their own), in order to experience these benefits to some extent. Of course, some citizens may do so – and become self- or local-providers. But even the mere existence of opportunities for less intensive engagements with this kind of material deliberation can open up crucial forms of access to new kinds of capacity (in the sense referred to in our definition of democracy).

For instance, simply being in contact with a space of material deliberation in the form of a local food initiative or makerspace can help build greater familiarity and knowledge of the deeper and more abstract concepts and possibilities for local food sovereignty or decentralized peer-to-peer manufacturing. People can touch, see, hear and try out these concepts in embodied – more accessible – form. So, grassroots innovation provides a forum for deliberating over ideas and forming views about them (Smith, 2014). In addition to expressing positions and possibilities differently, these material deliberations can also engage people who might not be so included in invitations to more purely discursive events (see Box 3).

Box 3: Seedy Sunday

Seed swapping has always existed; practiced globally, and often informally. Growers, perhaps whose farms, allotments, land, or gardens neighbor one another, or who know one another, share seeds saved from their crops. Seed swapping is part of the conviviality and culture of food. However, such activity becomes cast with political significance in light of developments and debate in industrial food systems. A few firms dominate seed markets; and their commercial decisions shape seed availability and diversity. Genetically modified seed, with its logic of intellectual property and design for pesticide and herbicide tolerance, has exacerbated concerns about ownership, control and the loss of diversity in food systems. Reforms proposed recently by the European Commission to tighten seed regulation would have outlawed seed swapping. Popular events that promote seed swapping and attract people into this everyday activity become a form of resistance. Indeed, seed swaps across Europe became one source of pressure organized successfully against European regulatory proposals.

Seedy Sunday in Brighton was one of those events that helped mobilize local citizens to join the international campaign to protect the right to swap. Yet Seedy Sunday is not a political campaigning organization, nor were the regulations the motive or intent for the initiative. Rather, on the first Sunday of every February in Brighton, volunteers host one of the largest and longest running seed swapping events in the UK. The first event was held in 2002, and inspired by a similar event in Vancouver. As one of the founders, Andrea Goring, wrote for the program in Brighton, “The [Canadian] event was about promoting and protecting biodiversity and one of the amazing things was the social diversity, as people of different ages and class excitedly discussed what they had found or had to swap. As a result that year we only needed to buy two packets of seed for an abundant allotment full of diverse and delicious crops. In fact the day was so inspiring we decided to import the idea to England” (Seedy Sunday 2003 leaflet). The motivations for Seedy Sunday, then as now, were multiple: Promoting biodiversity by increasing it in the garden and on into the local food chain; Saving heritage crops from extinction; Connecting with local community food projects and allotments; Increasing local food security by involving more people in growing their own food; Take control of food production from the hands of the few in agribusiness and into the hands of the many.

This founding ethos, blending community, biodiversity, education, support, fun and activism has remained in Seedy Sunday as it has grown and developed. Everyone at Seedy Sunday is welcome to bring saved seeds to swap. There are workshops for people to learn how to save and store seeds from trickier plants too. Always there is lots of interest in local varieties and seeds with stories. Each Seedy Sunday event includes a program of speakers discussing topics consistent with the aims of the event. And there are stalls for organizations working on food, growing and environment issues to present their work and meet attendees.

As such, Seedy Sunday events attempt to welcome people into the wider issues through seed swapping. The events cater not just to the experienced gardener, but to the novice also. Attendance at Seedy Sunday has grown from around 300–400 at the first event, to over 2,500 now. BBC Radio 4’s Gardeners’ Question Time has broadcast from there to over a million listeners. Other events have spread independently around the UK, with some groups coming to Brighton to learn from them how to do it.

Social media helps spread the idea and lift swapping to a new plane. People can post information and films about their seed stories, map the details of their cultivation, and at the same time facilitate swaps at a larger-scale, and validate or rate the swappers. Even the open practices of peer-to-peer production that pioneered free and open software are penetrating the world of seeds, with digital platforms helping innovations in open source seeds. Social media combines with physical gatherings to great effect; connecting hand-by-hand local tacit knowledge with a scale of activity that questions industrial trends towards concentration, enclosure and exclusion. The significance of initiatives like Seedy Sunday for innovation democracy should not be underestimated. Whilst many volunteers may balk at the idea of overturning industrial food systems, they are part of a sustainable food movement that opens up such systems to scrutiny.

Of course, citizens may also leave an encounter with grassroots innovation, in a state of some bemusement by what “idealists” are getting up to – pursuing their utopian dreams. But they will nonetheless perhaps leave with some of their taken-for-granted assumptions unsettled (Ratto & Boler, 2014). And citizens may also leave with a sense that the forms of economic and social development that these grassroots innovators are struggling to express does have greater legitimacy or potential than they might have thought before, and reflect a little more on some of the hitherto unquestioned assumptions and values that are so strongly embodied in more dominant sociotechnical configurations.

It is in these kinds of ways that grassroots innovation can contribute very concretely to the democratization of innovation – by creating sociotechnical configurations that permit the exploration and experience of democratic social values and visions, and in so doing opening spaces for deliberation (Chilvers & Kearnes, 2016). And it is these ways that the open and “uninvited” nature of grassroots innovation (where people simply engage directly of their own will), contrasts quite significantly (and is complementary) with more formally structured “invited” forms of discursive public engagement in science and technology (see below) (Wynne, 2007).

Grassroots innovations are neither formally constituted by innovation institutions nor are they linked into decision-making processes of conventional innovation policy. Yet they provide important sources of difference and contrast. They stimulate new forms of experience and discussion of innovation issues. They help cultivate an innovation citizenship with the skills, knowledge, organization and tools for debate and action on public matters of innovation in society.

4.3 Creating sociotechnical configurations that would not otherwise exist

In building alternative sociotechnical configurations, grassroots innovators are often bringing different values, visions and priorities into the process. In many respects grassroots innovators are unencumbered by the demands of investors, policy silos, institutional logics or disciplinary boundaries that pervade conventional innovation settings. The grassroots is at greater liberty to explore different values and visions. These can be neglected or marginalized concerns, (such as seeking more creative or meaningful work), or environmentally sustainable practices (like organic food production), or more localized production and consumption (like a makerspace) – each also involving distinct forms of wider solidarity with distant providers and communities. It is these values and visions that can motivate an innovative initiative.

We can think of examples like car clubs, small-scale renewable energy technologies, agro-ecology, green housing practices, open source software, fair trade and so on – all of which emerged from grassroots settings and

communities of users whose priorities, values and vision were different to mainstream industries and innovators. In this sense, grassroots innovation creates socio-technical configurations that would otherwise have been suppressed by existing patterns and concentrations of power (Smith, 2007).

Of course, entrepreneurs and firms have been adept in some cases at tapping into – or even partly appropriating – this grassroots ingenuity while contributing their own innovative energies in order to steer variants of the new configurations in more commercial directions. Indeed, bringing grassroots innovations into new markets is an important mechanism in the scaling-up of their influence and accessibility to wider populations – as can be seen, for example, with renewable energy and organic food. However, as grassroots innovations are adapted for market-based diffusion, they are often reconfigured such that some of the originating values or visions get lost in the process (Smith, 2007).

For example, the organic frozen ready-meals sold in major supermarkets hold out a very different prospect for “organic food” compared to the fresh, whole-food, locally produced vision of organic pioneers. The industry sees organic food as a value proposition free from synthetic inputs; the latter sees the organic movement as cultivating a different kind of food system (Smith, 2006). There is a perpetual need to keep pushing for sociotechnical configurations that go deeper and further in their expression of sustainable development principles. This may come from the grassroots, or its energies may also come from elsewhere. Most likely is a constant process of hybridization and contradiction – of a kind that (at its best) can also help energize the innovation process.

Box 4 illustrates this in the case of community energy. Over recent years, activities of community groups have introduced important new sociotechnical configurations into the energy system, and as such, opened up debate and widened possibilities for the kinds of low carbon, sustainable energy systems available to us for further development.

Box 4: Community energy

Community energy has grown rapidly in the UK for more than a decade now. However, it was not until January 2014 that central government launched a Strategy for Community Energy. This is remarkable recognition in a policy sector still accustomed to highly-centralized, large-scale, and supply-push operations. For years prior to the Strategy, community energy arose despite (rather than because of) public policy (Smith et al., 2015).

Community energy involves a variety of sustainable energy practices, singularly or in combination. In the UK, these include relatively small-scale renewable energy projects – such as neighborhood solar energy; projects dedicated to retrofitting energy efficiency measures – such as solid wall insulation in homes in a neighborhood; activities aimed at supporting sustainable behavior changes whether through publicity, support groups, or other means; and initiatives for the collective purchasing of sustainable energy. Organizationally, the groups driving this activity take a variety of forms, including formally constituted co-operatives, social enterprises, volunteer organizations, as well as informal associations of neighbors or interest groups.

Sociotechnically speaking, community energy activities introduce considerable diversity into the energy system. Such diversity arises in terms of new arrangements for supply, demand-management, and awareness and behavior change. Important practical knowledge is being produced about such activities. Knowledge is also being produced about how these novel energy initiatives perform differently to a variety of criteria. These criteria can include economic performance and carbon emissions reduction, but also insights into social performance and community benefits. Conferences, events, newsletters, and online forums share experiences and help. Such knowledge has also been turned into handbooks, guidance, and toolkits for taking groups through the process of creating an initiative. Mentoring programs have been established. Web-based knowledge repositories pull together case studies and online tools like carbon footprint calculators. Other sites contain news bulletins, survey results on the development of the sector, and step-by-step toolkits that outline in detail particular project-related activities.

All this provides a platform for mobilizing evidence and argument for community energy (Hargreaves et al., 2013). Recognition in DECC's Strategy was eventually won this way. Yet it is precisely at this moment that the diversity and sharper edges in community energy need reinforcing (Smith et al., 2015). The Strategy presents community energy as something with potential for State energy policy goals, rather than as having value in and of itself; something needing to scale-up and become bigger, implying less interest in smaller initiatives; and something that must exercise market power, because policy remains committed to a market-based understanding of energy in society. Not everyone sees community energy in those terms. As a report from The Corner House, a research group committed to environment and social justice, argued: "They [local communities] are far from indifferent to technical issues – for example, how to learn about, develop, experiment with, install and pay for wind technology – but tend to understand the development of technology as entwined from the outset with issues of local democracy, local concerns, exploitation, and, often, local resistance to the energy projects that the state consistently seeks to justify on economic grounds" (The Corner House, 2013: 25).

Community energy projects can beg challenging questions about changing energy systems. Community energy experiences generate diverse insights and questions relevant to innovation democracy in energy, including what is meant by "community" and questions of inclusion and exclusion in groups (Simcock, 2016; Johnson & Hall, 2014); the social justice of utilities enclosing local renewable resource commons (Murphy & Smith, 2013); the technical narrowness of funding criteria and performance indicators (cf. any cultural significance in community energy); or debate about the political economies responsible for energy-intensive infrastructures (Abramsky, 2010). As policy and industrial support for community energy develops along a trajectory that follows a more professionalized, micro-utility, and energy service forms – including through partnerships, hybrid models, and attempts to scale – it becomes important not to lose sight of what community energy does differently (Smith et al., 2015).

A corollary of introducing new sociotechnical configurations is the increase in diversity this presents. Such diversity is the lifeblood for innovation democracy.

4.4 Increasing sociotechnical diversity

Important as grassroots innovations are, we would like to stress how important it is not to focus too narrowly and exclusively on the material objects and visible social organizations produced by grassroots innovation. What is at least as important – and often overlooked – are processes and practices involved in grassroots innovation and their fertile potential to constantly generate a greater social as well as material diversity. Table 1 provides an attempt to summarize this variety.

Table 1 Grassroots contributions to sociotechnical diversity

Grassroots contribution	Description	Examples
Knowledge	A variety of relevant contextual and technological knowledge is created through grassroots innovation activity	Knowledge about community aspirations and social needs Know-how in providing solutions to problems Critical knowledge about socio-economic limitations on grassroots activity
Artefacts	The development of novel objects and services	Solar heaters, water collectors, non-toxic leather tanning, water-cooled refrigerator, open-source book scanner
Methodologies	Procedures for involving people in knowledge production, design, and developments	Participatory design, agroecological techniques, open and collaborative prototyping, grassroots entrepreneurship, scouting, prizes
Infrastructures	Facilities for people to access tools and enter into development spaces	Workshops, training centres, databases of open designs, shared tools, skill-swapping events, mentoring facilities, web platforms
Actors and alliances	New identities and social relations formed through grassroots innovation activity	Grassroots innovator, innovation scout, citizen scientist, empowered community, solidarity through prototyping, mutual awareness
Concepts and ideas	New ways of thinking and approaching innovation activities and their purposes	Appropriate and social technologies, commons-based peer-production, grassroots ingenuity, empowerment, transformation, democratizing innovation, socially useful production, design for care and repair
Skills	The development of different types of organizational, material and social capabilities	Technical and innovation capabilities (e.g. learning to build a cistern, or to teach others to build); capabilities to lobby for institutional change or to claim spaces

Source: Smith et al. (2016)

When organizations that are more deeply embedded in mainstream institutional structures try to engage with the diversity created by grassroots innovation, they can understandably often tend to hang on to the assumptions, agendas and routines with which they are pervaded (Fressoli et al., 2014). Innovation agencies, research centers, public policy programs, entrepreneurs and investors usually see grassroots innovation as producing objects in need of further professional development. The emphasis is placed on scaling up promising artefacts or service models and rolling them out widely. What gets overlooked is the diversity of other things and relations that are being produced and reproduced in grassroots innovation.

A true innovation democracy would recognize, embrace and debate all the products of grassroots innovation summarized in Table 1. The cultivation of knowledge, skills, capabilities, working practices and community development is simultaneously a requirement for grassroots innovation and a measure of successful outcomes. Finance, materials, tools, prototyping facilities, even markets, are an important part of the story, but so too are participants' imaginations, values, skills and social relations, which animate these materials and motivate other people to join in and put their ingenuity into grassroots innovation for sustainable development. Even where the focal technologies do not work out, more often than not the efforts nevertheless cultivate capabilities and lessons that have a more enduring democratic value.

5. Recommendations for Working with Grassroots Innovation and Practicing Innovation Democracy

It would be odd for a pair of academics to pretend to have a comprehensive menu for realizing the rich possibilities noted above. Better places to start would be to involve grassroots innovators in the discussions, and seek their views on how they could be helped to better contribute to innovation democracy in all its varied forms. Such conversations would also require innovation elites to reflect on the excluding effects of much current mainstream activity, and consider how their organizations and institutions could be opened up. Nevertheless, as observers and analysts of grassroots innovation internationally – and people who have worked in institutions for research and knowledge production over many years – we can at least offer a few suggestions. We suggest five main priorities for action:

1. Culture
2. Infrastructure
3. Training
4. Investment
5. Openness.

We elaborate each briefly below. We were originally thinking of making suggestions for specific types of organization or groups of people, such as policy-makers, business-people, scientists, engineers and activists committed to innovation democracy. But it proved difficult to think about specific measures for each without them rapidly requiring complementary actions from other groups. Which is to say, innovation democracy is not so much about specific interventions by individual social actors, but more fundamentally about changing the relationships that all these groups have with one another. So, our suggestions cover different areas where these kinds of new relationships can be worked through.

5.1 Culture

In our view, arguably the most important thing to recognize is the role of culture in innovation. This may seem an odd thing to highlight in a section making recommendations about action. After all, how can “culture” be deliberately acted upon let alone steered? But it is exactly these undirected qualities in culture that make grassroots activities so important. In the end, the long-run directions taken by innovation are too large a scale phenomenon to be directed by any narrow individual intentions. To whatever end, the steering of innovation is an inherently emergent process – about the collective “culturing” of futures (Stirling, 2014). It is exactly this feature that makes innovation so important in what social movements do – and grassroots collective action so important to innovation.

The key questions for innovation democracy, then, are about the particular kinds of cultures that are most influential in shaping and guiding innovation. So, arguably the most important qualities to cultivate in mainstream innovation processes are abilities to listen very carefully and engage with grassroots activity in a reflexive, self-aware way. By this we mean first trying to understand grassroots innovation initiatives on their own terms, and the different motivations and values amongst the groups of people involved. What are their aspirations or needs, and why are they addressing them in the ways that they do? That is, a question of recognition (Fraser & Honneth, 2003).

Reflexivity also means being aware of one’s own position towards these initiatives and reflecting upon that carefully. What are the assumptions and agendas that you are bringing with your attention to grassroots innovation? Are there any preconceptions that need to be checked? This is as much about a culture of respect, care, sensitivity and transparency in articulating one’s own position as it is about specific practices (Stirling, 2016). It needs to run through the way we are trained, employed and cultured as engineers, researchers, policy-makers, investors, campaigners and so forth.

None of this is to say that agreement and consensus will be reached – or should even be a major aim – nor that grassroots innovations are always right.

That would be odd for the kind of agonistic, pluralistic and political understanding of innovation democracy that we set out in this working paper. Rather, we are emphasizing how the full range of contributions that grassroots innovation can make to innovation democracy, as set out above, will not be achieved unless and until those possibilities are recognized by all groups involved.

Recall that our particular understanding of innovation democracy turns on access by the least powerful to the capacities for challenging the directions of innovation. Those capacities are distributed across the abilities of grassroots innovators themselves, and the extent to which they can be further empowered, and the ability of innovation institutions or groups dominant in innovation processes to open up to greater and more equal grassroots involvement. That is to say, people interested in grassroots innovation democracy need to think how they can either encourage and support more grassroots innovation, or open up institutions to greater grassroots involvement, or both.

5.2 Infrastructure

The facilities for doing grassroots innovation and the sites for institutions to engage with grassroots innovation need to be expanded. Workshops, land, classrooms, laboratories, streets, offices, meeting rooms, tools, and so forth need to be made increasingly available to grassroots groups. So too does the means for communicating, visiting, documenting, sharing, and exchanging activities and experiences. Much greater and more systematic thought and work on the public infrastructure for grassroots innovation needs to be undertaken. There are some interesting initiatives already underway (e.g. Medialab-Prado) – whose challenges as well as achievements provide valuable knowledge and experience.

For example, city authorities in Barcelona and São Paulo are investing in the creation of public “fablabs” and activities where citizens can become involved in digital design and fabrication (Smith, 2015). There are also examples of training institutions making their facilities, including advanced machine tools, available to grassroots groups outside formal training hours (e.g. RDM Makerspace in Rotterdam). This has had to involve a lot of negotiation and reassurance with lab technicians and safety officers – but arrangements have been reached. This is a very practical example of a more general point, which is for people working in innovation-related facilities to make them much more porous and open to community use and grassroots involvement (Smith, 2014).

Soft infrastructure is also required. This involves expertise in community development, and experience in engaging with people in the design, provision and use of grassroots innovation infrastructure (Smith & Light, 2016). Opening up community workshops can be very demanding – in terms of providing

the facilities and making them genuinely accessible. But this is nevertheless relatively easy compared to opening a space where people want to come to: to take ownership over and feel and make it their own, and see it as a vital focus for the neighborhood. There is a strong need for high quality community development skills to help: articulate aspirations and needs; facilitate community-building; manage conflict; and enable the co-designing with ordinary people of new kinds of infrastructure that work for them. These are all part and parcel of any successful infrastructure for grassroots innovation.

5.3 Training and skills

Grassroots innovation and innovation democracy have important implications for training and skills acquisition at all levels in society. They require the rethinking of current ways in which training is organized, supported, and practiced. Here, the discussion above suggests that actions might most productively aim at enabling skills to be acquired in more interdisciplinary and problem-oriented ways; combining intellectual and practical skills and reducing barriers between trades and professions.

Others are better placed to detail these kinds of suggestions than we are. However, in our own experience as university researchers we do appreciate the imperative for training to become much more action-oriented. There are insights, methods and ways of working in the tradition of action-research that could be brought much more systematically into research institutions (Fals-Borda & Rahman, 1991). We notice, for instance, that there are many novel forms of citizen science that are opening up rapidly alongside grassroots innovation activities. Similarly, initiatives for lifelong education rooted in principles of popular education offer potential. But university institutions are currently ill-suited to respond to (or support) these as fully as would appear central to an innovation democracy.

5.4 Investment

Grassroots contributions to innovation democracy could be facilitated greatly by redesigning the way society invests in innovation and looks at new ways of supporting a wider diversity of sites of innovation activity. Some grassroots groups have been quite effective in turning to opportunities presented by crowd-funding platforms. Crowd-funding allows initiatives to appeal for finance from beyond their immediate community, and can at the same time serve to publicize an activity. Certainly this form of support merits greater attention. A consideration here is the extent to which such funds are able to support development beyond prototyping. Moving from a neat single initiative or proof of concept towards a marketable product or development program requires considerable funds and institutional support. Moreover, crowd-

funding may only appeal to certain kinds of issue and be accessible to groups able to present themselves in fundable ways.

More systematic mechanisms for investing in grassroots innovation are also required. Such investment need not always focus on commercialization for private and public markets. It can be sufficient to recognize the social value in some of the less obvious, more dispersed and cultural benefits of widespread grassroots innovation activity (Table 1). It is noticeable, for example, that justification for public funding of the Ateneus de Fabricació Digital in Barcelona (i.e. public makerspaces) included valuing them as new public infrastructure for the twenty-first century, joining education, parks, libraries, and other social goods and infrastructure recognized in earlier municipalism. New investment models require a more open-minded recognition of the social value of grassroots innovation.

Currently, the most common approach to supporting innovation is understood in terms of the scaling up of some promising individual initiative. Scaling-up is typically framed as proceeding through successively more ambitious measures to formalize and commercialize the grassroots innovation. In this way, the facilities and tools of conventional innovation systems are brought to the service of promising grassroots innovators and their innovations, through the investment of research, development and demonstration; assistance with standards procedures; and help securing intellectual property (Hilgartner, 2009). Investment and marketing assistance is also offered. By such means, the grassroots furnishes prototypes for entrepreneurs and investors; and these are then in turn adapted to goods and services for scaling up – principally by expanding markets, but also through more conventional development programs. This is a framing under which it is assumed there is an obvious particular risk-taking innovator (analogous to an entrepreneurial firm or inventor) on whom support and rewards can be focused; and it presumes the innovation is of a form that can be turned into a proprietary object for marketing.

There is nothing inherently wrong with this approach. Indeed, it can help considerably to improve those innovations that can more readily be marketed. And, given the way policy and business interest in grassroots innovation is organized towards this end, it is a dynamic that we can expect to have considerable momentum. But while doing that well, such investment approaches neglect the more democratic possibilities in grassroots innovation. Because often, grassroots innovation is not motivated by existing commercial logics and business models, but rather by the expressing of different values and the exploring of alternative social and economic relations (Bhaduri & Kumar, 2011). Grassroots innovation movements pioneer new and additional social relationships, organizational forms and purposes that operate beyond and beneath entrepreneurship and markets. These relationships build the capacities

for people to organize at grassroots level and to contribute and steer innovation along development pathways particular to their contexts.

Grassroots innovators want to be involved in the breadth of the relevant decisions, from prioritizing and framing the development issue, to making design choices and decisions about evaluative criteria, as well as evaluating “success” and undertaking further development and production. This includes deciding how investments are made, having a stake in the way value is realized, captured and distributed into wider community developments and livelihoods. There can be broad and irreducible social good in grassroots innovation, and that is difficult to enclose within a discrete package with isolable returns. Support and investment is required that recognizes and cultivates these more diffuse goods.

5.5 Openness

The question of innovation democracy is not new. The need for public oversight and the right to intervene and control innovation processes for social good has been a constant accompaniment to modernity. Innovation activities, and their consequences, are often overseen to some degree by states and if necessary subject to regulation. The state provides legal frameworks, such as for intellectual property, central to innovation, and indeed funds research and trains scientists and engineers. The state creates regulatory agencies, for health and safety, environment, and consumers, which shape and induces innovation (Mazzucato, 2011). In the domains of military, health and other areas the state is a big customer whose demands also shape innovation.

However, state oversight, accountability, and regulation is imperfect. Even though it remains necessary and important, it has limitations (van Zwanenberg et al., 2011). Different arms of the state can develop their own interests, which contrast with those they notionally serve. Regulatory processes can be susceptible to capture by vested interests (including those who are supposedly regulated). Parliamentary attention is limited. Conflicts of interest exist within the state at many levels. And contradictions and tensions between state functions and responsibilities can reduce state control to a rather clumsy mechanism for social deliberation on innovation.

Over recent years, there has been growth in new forms of public engagement in science and technology as a means to improve public anticipation and responsiveness to innovation (Callon et al., 2009). A variety of participatory methods have been developed for including citizens in public decisions about research agendas, investments in new and emerging technologies, and gathering views on the social and regulatory implications and requirements of certain innovations. Exercises such as citizen’s juries, focus groups, deliberative panels, and much more are orchestrated by a variety of public and private organizations, sometimes merely for reasons of window-dressing

(Levidow, 1998), but other times genuinely in order to solicit views and inputs to the deliberations of those organizations. Deep participation is engendering a more sophisticated understanding of research and innovation; and an emerging perspective that sees innovation as co-produced between experts and diverse publics in complex processes over extended periods of time (Chilvers & Kearnes, 2016; Selin et al., 2016). Whether these practices are in line with moves to innovation democracy, rather than constricting them, depends on whether they “open up” space for wider accountabilities, or close them down (Stirling, 2008). So an important area for action is to resist pressures for consensus and closure in overly-designed or standardized “engagement” activities. Diversity, unruliness and open-endedness are some of the most important qualities in public engagement.

Protest and other forms of “uninvited” contestations of particular innovations are also seen in a constructive light by more farsighted bodies, and valued for their contribution to bringing marginalized issues to the fore, and expanding the ways in which society shapes innovation (Rip, 1986; Hess, 2007; Jamison, 2003). An example of a current institutional conflict is that between open and closed (commons-based and proprietary) approaches to knowledge. International legal regimes have been developed over many years to protect intellectual property. But the wider social benefits of these structures are ambiguous. Such institutions increasingly jar with an emerging culture that views knowledge as a commons that should be open to all. In contrast with the proprietary view (which sees profitable and exclusive rights to knowledge as a spur to innovation), the commons-based view sees openness as beneficial to wider involvement and greater sharing in knowledge production processes – and sees this as leading to more and better innovation (Benkler, 2016; Kostakis & Bauwens, 2015). Many grassroots innovation activists (though not all), are inclined towards commons-based approaches (Smith et al., 2016).

Each of these moves in society can open up space for progress towards more expansive and deeper forms of innovation democracy. All are necessary. However, as we have seen above with grassroots practices and networks, the picture is complicated and wonderfully messy. It is clear though, that grassroots innovation can and does contribute in many ways to innovation democracy. And a vital avenue for continuing this work is to better link grassroots innovation into changes in conventional processes such as those in the preceding paragraphs.

Our suggestion for openness is to view grassroots innovation as one of a variety of sources of critical knowledge and experience on which wider protagonists for innovation can draw – and as a field of activity that can be involved in other innovation democracy processes. This thought returns us to the suggestion made above about infrastructure and training, as both facilities

and processes need to be opened up to allow these encounters to happen and the resulting possibilities to be followed up.

6. Conclusions

Innovation is increasingly recognized as a key activity for sustainable development. But the way we go about innovation for sustainability will have a big bearing on who wins, who loses, who is included and excluded, and what life is like in the sustainable societies of tomorrow. And whatever the outcomes, we can be sure that future innovation will continue to be just as political as today.

In this paper we have argued that imperatives for social justice and democracy are as important around innovation, as in other areas of public life. If innovation is to be truly effective in addressing the needs of society, then it must be democratic in the senses we outline here. We have also pointed to the many different ways in which a wealth of grassroots innovation experience – past, present and future – can contribute to innovation democracy. In conclusion, we want to emphasize the diversity, plurality and agonistic qualities of grassroots innovation. Innovation often feeds off more subversive cultures, and grassroots innovations contribute spaces for being subversive. By this we mean providing opportunities to challenge dominant visions and values, to suggest other arrangements that are counter to the prevailing institutional orders, and to disrupt particular patterns of authority and domination in society.

It would be unfortunate (and counterproductive) if attempts to better articulate grassroots innovation with new institutions for innovation democracy resulted in a closing down of spaces for subversion. Interestingly, all these moves are dependent upon the others. Without the radical idealists, the appropriable novelties available to institutionally constrained business would be fewer; and without problematic co-options within the mainstream, the idealists would have no “other” against which to innovate.

Crucial here is the importance of diverse values and approaches in innovation (operating, of course, within the principled parameters of sustainable development). The search for good models and best practices in innovation needs to be subordinate to a need to look at interactions, flows and contestations between different approaches to innovation, including grassroots innovation. Here, thinking about the institutional changes required to restructure relations between these various forms of innovation helps us approach the deeper challenges of transforming social, economic and political power. Without this, neither sustainable development nor democracy is tenable.

Acknowledgements

The views expressed in this working paper draw upon various strands of research we have undertaken with colleagues at the STEPS Centre, SPRU and TRANSIT (Transformative Social Innovation) project. We are grateful to them for creating such a convivial environment in which to work. The relevant projects received funding from the Economic and Social Research Council and the European Commission.

NOTE

1. An earlier version of this paper appeared originally as a “thinkpiece” for Big Ideas initiative of Friends of the Earth, and as a working paper for the STEPS Centre (Smith & Stirling, 2016).

REFERENCES

- Abramsky, K. (2010). *Sparkling a Worldwide Energy Revolution*. Edinburgh: AK Press.
- Agyeman, J. (2013). *Introducing Just Sustainabilities: Policy, Planning and Practice*. London: Zed Books.
- Akrich, M. (1992). “The De-Description of Technical Objects,” in W. L. Bijker (ed.), *Shaping Technology/Building Society: Studies in Sociotechnological Change*. Cambridge, MA: MIT Press, 205–224.
- Arblaster, A. (2002). *Democracy*. Philadelphia, PA: Open University Press.
- Asaro, P. M. (2000). “Transforming Society by Transforming Technology: The Science and Politics of Participatory Design,” *Accounting Management and Information Technology* 10: 257–290.
- Bell, M. (1979). “The Exploitation of Indigenous Knowledge, or the Indigenous Exploitation of Knowledge: What Use of What for What?,” *IDS Bulletin* 10(2): 44–50.
- Benkler, Y. (2017). “Peer Production, the Commons, and the Future of the Firm,” *Strategic Organization* 15(2): 264–274.
- Bhaduri, S., & H. Kumar (2011). “Extrinsic and Intrinsic Motivations to Innovate: Tracing the Motivation of ‘Grassroot’ Innovators in India,” *Mind & Society* 10(1): 27–55.
- Bijker, W. E. (1995). *Of Bicycles, Bakelites, and Bulbs*. Cambridge, MA: MIT Press.
- Bohmann, J., & W. Rehg (eds.) (1997). *Deliberative Democracy: Essays on Reason and Politics*. Cambridge, MA: MIT Press.
- Byrne, J., C. Martinez, & C. Ruggero (2009). “Relocating Energy in the Social Commons: Ideas for Sustainable Energy Utility,” *Bulletin of Science, Technology & Society* 29(2): 81–94.
- Callon, M., P. Lascoumes, & Y. Barthe (2001). *Acting in an Uncertain World*. Cambridge, MA: MIT Press.
- Chilvers, J., & M. Kearnes (eds.) (2016). *Remaking Participation*. Abingdon: Routledge.

- Cooley, M. (1987). *Architect or Bee? The Human Price of Technology*. London: Hogarth Press.
- Davies, S. R. et al. (2012). "Citizen Engagement and Urban Change: Three Case Studies of Material Deliberation," *Cities* 29(6): 351–357.
- de Laet, M., & A. Mol (2000). "The Zimbabwe Bush Pump: Mechanics of a Fluid Technology," *Social Studies of Science* 30(2): 225–263.
- Ehn, P. (1988). *Work-Oriented Design of Computer Artifacts*. Stockholm: Arbetslivscentrum.
- Ely, A., A. Smith, A. Stirling, M. Leach, & I. Scoones (2013). "Innovation Politics Post-Rio+20: Hybrid Pathways to Sustainability?," *Environment and Planning C: Politics and Space* 31(6): 1063–1081.
- Ely, A., P. Van Zwanenberg, & A. Stirling (2010). "New Models of Technology Assessment for Development," Working Paper, STEPS Centre.
- Fals-Borda, O., & M. A. Rahman (1991). *Action and Knowledge*. London: Intermediate Technology Publications.
- Feenberg, A. (1999). *Questioning Technology*. London: Routledge.
- Fraser, N., & A. Honneth (2003). *Redistribution or Recognition: A Political Philosophical Exchange*. London: Verso.
- Freeman, C. (1991). "Technology, Progress and the Quality of Life," *Science and Public Policy* 18(6): 407–418.
- Fressoli, M., E. Arond, D. Abrol, A. Smith, A. Ely, & R. Dias (2014). "When Grassroots Innovation Movements Encounter Mainstream Institutions: Implications for Models of Inclusive Innovation," *Innovation and Development* 4(2): 277–292.
- Geels, F. W. (2014). "Regime Resistance against Low-Carbon Transitions: Introducing Politics and Power into the Multi-Level Perspective," *Theory, Culture & Society* 31(5): 21–40.
- Geels, F. W., M. P. Hekkert, & S. Jacobsson (2008). "The Dynamics of Sustainable Innovation Journeys," *Technology Analysis & Strategic Management* 20(5): 521–536.
- Gupta, A. K. et al. (2003). "Mobilizing Grassroots' Technological Innovations and Traditional Knowledge, Values and Institutions: Articulating Social and Ethical Capital," *Futures* 35(9): 975–987.
- Hargreaves, T., S. Hielscher, G. Seyfang, & A. Smith (2013). "Grassroots Innovations in Community Energy: The Role of Intermediaries in Niche Development," *Global Environmental Change* 23(5): 868–880.
- Hess, D. (2007). *Alternative Pathways in Science and Industry*. Cambridge, MA: MIT Press.
- Hielscher, S., & A. Smith (2014). "Community-based Digital Fabrication Workshops: A Review of the Research Literature," Working Paper, University of Sussex, Brighton.
- Hilgartner, S. (2009). "Intellectual Property and the Politics of Emerging Technology: Inventors, Citizens, and Powers to Shape the Future," *Chicago-Kent Law Review* 81(1): 197–224.
- Hommels, A. (2005). "Studying Obduracy in the City: Toward a Productive Fusion between Technology Studies and Urban Studies," *Science, Technology & Human Values* 30(3): 323–351.

- Jacobs, M. (1999). "Sustainable Development as a Contested Concept," in A. Dobson, (ed.), *Fairness and Futurity*. Oxford: Oxford University Press, 21–45.
- Jamison, A. (2003). "The Making of Green Knowledge: The Contribution of Activism," *Futures* 35: 703–716.
- Johnson, V., & S. Hall (2014). "Community Energy and Equity: The Distributional Implications of a Transition to a Decentralised Electricity System," *People, Place and Policy* 8(3): 149–167.
- Jordan, T. (2015). *Information Politics: Liberation and Exploitation in the Digital Society*. London: Pluto Press.
- Jorgensen, U., & P. Karnoe (1995). "The Danish Wind-Turbine Story: Technical Solutions to Political Visions?," in A. Rip, T. J. Misa, & J. Scott (eds.), *Managing Technology in Society: The Approach of Constructive Technology Assessment*. London: Pinter, 57–82.
- Kohtala, C. (2016). *Making Sustainability: How Fab Labs Address Environmental Issues*. Ph.D. diss., Aalto University, Helsinki.
- Kostakis, V., & M. Bauwens (2015). *Network Society and Future Scenarios for a Collaborative Economy*. Basingstoke: Palgrave Macmillan.
- Kraft, P., & J. Bansler (1994). "The Collective Resource Approach: The Scandinavian Experience," *Scandinavian Journal of Information Systems* 6(1): 71–84.
- Kumar, H., & S. Bhaduri (2014). "Jugaad to Grassroot Innovations: Understanding the Landscape of the Informal Sector Innovations in India," *African Journal of Science, Technology, Innovation and Development* 6(1): 13–22.
- Latour, B. (2005). *Re-assembling the Social: An Introduction to Actor-Network Theory*. Oxford: Oxford University Press.
- Leach, M. et al. (2012). "Transforming Innovation for Sustainability," *Ecology and Society* 17(2): 11.
- Levidow, L. (1998). "Democratizing Technology – Or Technologizing Democracy? Regulating Agricultural Biotechnology in Europe," *Technology in Society* 20(2): 211–226.
- Light, A. (2014). "Citizen Innovation: ActiveEnergy and the Quest for Sustainable Design," in M. Ratto & M. Boler (eds.), *DIY Citizenship: Critical Making and Social Media*. Cambridge, MA: MIT Press, 259–268.
- Marres, N. (2012). *Material Participation: Technology, the Environment and Everyday Publics*. Basingstoke: Palgrave Macmillan.
- Marres, N. (2005). *No Issue, No Public: Democratic Deficits after the Displacement of Politics*. Ph.D. diss., University of Amsterdam.
- Martin, B. R. (2013). "Twenty Challenges for Innovation Studies," Working Paper No. 443, Centre for Business Research, University of Cambridge.
- Mazzucato, M. (2011). *The Entrepreneurial State*. London: Demos.
- Middlemiss, L., & B. D. Parrish (2010). "Building Capacity for Low-Carbon Communities: The Role of Grassroots Initiatives," *Energy Policy* 38(12): 7559–7566.
- Miranda, I., M. Lopez, & M. C. C. Soares (2011). "Social Technology Network: Paths for Sustainability," *Innovation and Development* 1(1): 151–152.
- Murphy, J., & A. Smith (2013). "Understanding Transition–Periphery Dynamics: Renewable Energy in the Highlands and Islands of Scotland," *Environment and Planning A* 45(3): 691–709.

- Newell, P., & D. Mulvaney (2013). "The Political Economy of the 'Just Transition,'" *The Geographical Journal* 179(2): 132–140.
- OECD (2015). *Innovation Policies for Inclusive Development: Scaling Up Inclusive Innovations*. Paris.
- OECD (2010). *The OECD Innovation Strategy: Getting a Head Start on Tomorrow*. Paris.
- Rasmussen, L. B. (2007). "From Human-Centred to Human-Context Centred Approach: Looking Back over 'the Hills,' What Has Been Gained and Lost?," *AI & Society* 21(4): 471–495.
- Ratto, M., & M. Boler (2014). *DIY Citizenship: Critical Making and Social Media*. Cambridge, MA: MIT Press.
- Rip, A. (1986). "Controversies as Informal Technology Assessment," *Knowledge* 8(2): 349–371.
- Schumacher, F. W. (1973). *Small Is Beautiful*. London: Blond and Briggs.
- Sclove, R. E. (1995). *Democracy and Technology*. New York: Guildford Press.
- Scoones, I., M. Leach, & P. Newell (eds.) (2015). *The Politics of Green Transformations*. London: Earthscan Routledge.
- Selin, C., et al. (2016). "Experiments in Engagement: Designing Public Engagement with Science and Technology for Capacity Building," *Public Understanding of Science*. <https://doi.org/10.1177/0963662515620970>
- Sen, A. (ed.) (1999). *Development as Freedom*. Oxford: Oxford University Press.
- Seyfang, G., S. Hielscher, T. Hargreaves, M. Martiskainen, & A. Smith (2014). "A Grassroots Sustainable Energy Niche? Reflections on Community Energy in the UK," *Environmental Innovation and Societal Transitions* 13: 21–44.
- Seyfang, G., J. Jin, & A. Smith (2013). "A Thousand Flowers Blooming? An Examination of Community Energy in the UK," *Energy Policy* 61: 977–989.
- Seyfang, G., & A. Smith (2007). "Grassroots Innovations for Sustainable Development: Towards a New Research and Policy Agenda," *Environmental Politics* 16(4): 584–603.
- Shapiro, I., & C. Hacker-Cordon (eds.) (1999). *Democracy's Edges*. Cambridge: Cambridge University Press.
- Simcock, N. (2016). "Land Use Policy Procedural Justice and the Implementation of Community Wind Energy Projects: A Case Study from South Yorkshire, UK," *Land Use Policy* 59: 467–477.
- Smith, A. (2004). "Alternative Technology Niches and Sustainable Development," *Innovation: Management, Policy and Practice* 6(2): 220–235.
- Smith, A. (2016). "Alternative Technology Niches and Sustainable Development: 12 Years On," *Innovation: Management, Policy and Practice* 18(4): 468–484.
- Smith, A., M. Fressoli, D. Abrol, E. Arond, & A. Ely (2017). *Grassroots Innovation Movements*. London: Routledge Earthscan.
- Smith, A. (2006). "Green Niches in Sustainable Development: The Case of Organic Food in the United Kingdom," *Environment and Planning C: Government and Policy* 24(3): 439–458.
- Smith, A., T. Hargreaves, S. Hielscher, M. Martiskainen, & G. Seyfang (2015). "Making the Most of Community Energies: Three Perspectives on Grassroots Innovation," *Environment and Planning A* 48(2): 407–432.

- Smith, A. (2017). "Social Innovation, Democracy and Makerspaces," SPRU Working Paper, University of Sussex, June.
- Smith, A. (2013). "Socially Useful Production," STEPS Centre, Institute of Development Studies and SPRU Science and Technology Policy Research, the University of Sussex, November.
- Smith, A. (2014). "Technology Networks for Socially Useful Production," *Journal of Peer Production* 5: 1–9.
- Smith, A. (2015). "Tooling Up: Civic Visions, FabLabs, and Grassroots Activism," *The Guardian*, April 4.
- Smith, A. (2007). "Translating Sustainabilities between Green Niches and Socio-Technical Regimes," *Technology Analysis & Strategic Management* 19(4): 427–450.
- Smith, A., M. Fressoli, & H. Thomas (2014). "Grassroots Innovation Movements: Challenges and Contributions," *Journal of Cleaner Production* 63: 114–124.
- Smith, A., & A. Light (2016). "How to Cultivate Sustainable Developments in Makerspaces," CIED Working Paper, Brighton.
- Smith, A., & A. Stirling (2016). "Grassroots Innovation & Innovation Democracy," Working Paper, STEPS Centre, University of Sussex, Brighton.
- Smith, A., A. Stirling, & F. Berkhout (2005). "The Governance of Sustainable Socio-Technical Transitions," *Research Policy* 34(10): 1491–1510.
- Smith, A., J.-P. Voß, & J. Grin (2010). "Innovation Studies and Sustainability Transitions: The Allure of the Multi-Level Perspective and Its Challenges," *Research Policy* 39(4): 435–448.
- Stirling, A. (2014). "Emancipating Transformations: From the Controlling 'the Transition' to Culturing Plural Radical Progress," Working Paper, STEPS Centre, University of Sussex, Brighton.
- Stirling, A. (2016). "Knowing Doing Governing: Realizing Heterodyne Democracies," in J.-P. Voß & R. Freeman (eds.), *Knowing Governance: The Epistemic Construction of Political Order*. Basingstoke: Palgrave Macmillan, 259–289.
- Stirling, A. (2008). "'Opening Up' and 'Closing Down': Power, Participation, and Pluralism in the Social Appraisal of Technology," *Science, Technology & Human Values* 33(2): 262–294.
- Stirling, A. (2014a). "Towards Innovation Democracy? Participation, Responsibility and Precaution in Innovation Governance," Working Paper, STEPS Centre, University of Sussex, Brighton.
- Stirling, A. (2014b). "Transforming Power: Social Science and the Politics of Energy Choices," *Energy Research & Social Science* 1: 83–95.
- Teixeira, A.A.C. (ed.) (2012). *Technological Change*. Rijeka: InTech.
- Thackara, J. (2015). *How to Thrive in the Next Economy*. London: Thames & Hudson.
- Truffer, B. (2003). "User-led Innovation Processes: The Development of Professional Car Sharing by Environmentally Concerned Citizens," *Innovation: The European Journal of Social Science Research* 16(2): 139–154.
- Veak, T. J. (ed.) (2006). *Democratizing Technology: Andrew Feenberg's Critical Theory of Technology*. Albany, NY: State University of New York Press.
- Wainwright, H., & D. Elliott (1982). *The Lucas Plan. A New Trade Unionism in the Making?* London: Allison & Busby.

- Wakeford, T. (2001). "A Selection of Methods Used in Deliberative and Inclusionary Processes," *PLA Notes* 40: 29–31.
- Wakeford, T. (2004). "Democratising Technology: Reclaiming Science for Sustainable Development," ITDG Discussion Paper, Rugby.
- Winner, L. (1977). *Autonomous Technology: Technics-out-of-Control*. Cambridge, MA: MIT Press.
- Winner, L. (ed.) (1992). *Democracy in a Technological Society*. Dordrecht: Springer.
- World Bank (2012). *Inclusive Green Growth: The Pathway to a Sustainable World*. Washington, DC.
- World Commission on Environment and Development (1987). *Our Common Future*. Oxford: Oxford University Press.
- Wynne, B. (2007). "Public Participation in Science and Technology: Performing and Obscuring a Political–Conceptual Category Mistake," *East Asian Science, Technology and Society: An International Journal* 1(1): 99–110.
- van Zwanenberg, P., A. Ely, & A. Smith (2011). *Regulating Technology: International Harmonisation and Local Realities*. London: Routledge.