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ENGINEERING AND SUSTAINABILITY:
control and care in unfoldings of modernity

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Biographical Note

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Abstract

This chapter explores some underlying issues bearing on relationships between engineering and Sustainability. It aims to help point towards ways in which engineering practice might avoid some of the dangers associated with pressures and rhetorics of justification and legitimation, such as to become more robustly aligned with authentic values and interests of Sustainability. Key to this is to recognise some deep resonances around the central preoccupations of much instrumental-style engineering with attempted performances of control. For it is similar imaginations of control that characterise the presently globalising 'infraculture' of Modernity itself. And it is to the associated problems of failed efforts at control, that the Sustainability movement is a reaction. In order practically to resist the associated fixations, fallacies and fantasies of control both in engineering and Modernity more widely, it is suggested that a starting point lies in enacting a distinction between control and care. A number of examples are explored – for instance around current responses to 'climate change' and visions of 'the Anthropocene' – where controlling imaginations are aggravating progressive values and where more caring practices would be more supportive of Sustainability. At the end, the chapter critiques visions of transitions to Sustainability as relatively technical expert-led challenges of controlling progress in particular notionally singular, depoliticised directions. It is argued instead, that a more caring approach might recognise the inherently diverse, political nature of Sustainability. Here, engineering is more about collective action than instrumental policy intervention – as just one among many ways to care for more plural, open-ended transformations.

Acknowledgements [1]

Keywords

engineering; sustainability; transition; transformation; care; control; Anthropocene; environmental authoritarianism; murmurations; democratic struggle

1. Sustainability, Engineering and Control

Sustainability is about reversing the negative impacts of contemporary Modernity on social equity, human wellbeing and ecological integrity (Brundtland, 1987) (Holden, Linnerud and Banister, 2014). Here, engineering of many kinds has undoubtedly helped enable many material (and some wider) benefits. But it remains a driving concern of Sustainability [2] (Stirling, 2009), that diverse kinds of technological, environmental and institutional engineering have also interacted with other factors to bring a host of (ostensibly unintended) adverse social and ecological consequences (Holling and Meffe, 1996). Accordingly, the Sustainable Development Goals (UN, 2015) offer a crucial contribution in contemporary high-level global governance, towards actions to address the resulting compelling imperatives around inequality (Piketty, 2014), oppression (UN, 2014), climate disruption (IPCC_WGII, 2014), ecological destruction (UNEP, 2014), toxic pollution (Harremoës *et al.*, 2002), nuclear risks (UNSCEAR, 2016) and the perennial scourge of war (Mueller, 2001).

As such, Sustainability addresses an '*Achilles' heel*' at the core of Modernity – the vulnerability of engineering cultures and practices to so many kinds of fixations, fallacies and failures of *control* (Stirling, 2019). Depending on political perspective, examples might include fossil fuel dependencies (Unruh, 2000), high-input agriculture (Mollinga, 2010), pharmaceutical based healthcare (Sally C Davies, 2011) (GFHR, 2004), automobile-based transport infrastructures (Arthur, 1989), high-rise housing (Ward, 1976), technocratic urban design (Cecla, 2012), top-down development programmes (Parfitt, 2017), agrarian collectivisation (Viola, 1996), re-engineering of rivers (Zavialov, 2005), large hydro-electric schemes (McCully, 2001), nuclear power (Collingridge, 1983), nuclear weapons (Stirling, 2014), and the litany of repeatedly disastrous preparations for war (Wilson, 2007) (Kaysen *et al.*, 2002) (Goodson, 2001) (Belasco, 2011) (Seymour, 2015) (Braithwaite, 2012) (Kaldor, Karl and Said, 2007). Historically, all these infrastructures have privileged instrumental-style engineering thinking and expert technical interventions involving various kinds of control rhetoric (Jasanoff, 2005)(Stirling, 2015). In each field, claims are routinely made that engineered 'solutions' offer means of control, by

which to achieve declared aims. But again and again, though these narratives and performances of control persist, the successful realisation of control remains elusive.

So, a lens of control offers a potentially useful means to examine relations between Sustainability and engineering. For, engineering is not only deeply implicated *empirically* in so many of the persistent social and environmental problems that Sustainability seeks to address. In a "*traditional*" view (Allenby, 2005), engineering is also seen quite fundamentally in its own right to embody – indeed, be shaped and driven by – the underlying formative aspirations and assertions of Modernity itself: to control nature and society. So it is in this sense that Sustainability movements find themselves also wrestling with some of the deepest commitments of Modernity in the constituting *ideologies* of engineering around control (Millar and Mitchell, 2017).

Associated dilemmas have long been well recognised. For instance, Heidegger explored the tragic paradox that the instrumental engineering vision of technology as an ostensibly consummate "*means to an end*", should itself be so evasive of human "*mastery*" (Mumford, 1934)(Ellul, 1964)(Winner, 1977)(Feenberg, 1999)(Verbeek, 2007). In wrestling with this, many contrasting modalities of control have since been distinguished around engineering – for instance distinguishing diverse gradations of '*hard*' or '*soft*' '*mastery*' (Williams and Edge, 1996). Associated implications are variously viewed in favourable (Wolpert, 1992) or unfavourable (Wynne, 1993) ways. But across the enormous resulting scope for debate and ambiguity, the fundamental aspirations of engineering are again frequently held to coalesce around different kinds and contexts of *control* over society and nature (Ison, 2010)(Fuller and Collier, 2004)(Aronowitz, 1988).

Accordingly contrastingly-conceived detailed notions of control are also central preoccupations in technical discussions more specifically in the *philosophy* of engineering. Indeed, discussing "*ideals for engineering*" in a recent key text in this field (Michelfelder, Newberry and Zhu, 2017), Pirtle and Szajnfarber envisage a quite existentially controlling role for engineering in that "[h]*umanity's ability to exist in the long-run will depend on our being able to continue controlling and influencing ourselves,*

our environment, and the systems which we have embedded into it" (Pirtle and Szajnfarber). It is hardly surprising then, that various principles around control feature prominently in many contemporary specific contributions to this field [Floridi in (RAEng, 2011)](Demir, 2012). Control forms a defining focus in philosophical examinations of systems engineering (Ottens) (Poel *et al.*, 2010). Likewise, control is especially salient in understandings of responsibility in engineering [(Coeckelbergh, Pols) also (Fischer and Ravizza 1998) (Poel *et al.*, 2010)(Govert, this volume). In different senses, notions of control remain central discussions in the philosophy of engineering over "*social control*" (Collingridge) and "*rational acceptance*" Houkes and Pols in (Goldberg *et al.*, 2008) of technology.

So, before considering in detail the implications of all this for relationships between engineering and Sustainability, it is worth asking (for present purposes) exactly '*what is control*?' (Stanovich *et al.*, 2014)? For such an apparently simple and familiar idea, notions of control are actually quite tricky to define (Leigh, 2004). How do they differ, for instance, from related ideas concerning contrasting degrees and modalities for the exercise of agency over a given process of change – variously by 'influencing', 'effecting', 'impacting', 'modifying', 'conditioning' or 'managing' formative processes (Bandura, 1989)? Here, a typical dictionary gloss of the distinctive colloquial meaning of 'control' refers to a capacity to "*exercise power or authority … to determine … behaviour or action*" (OED, 2013). So, a crucial ingredient is the reference to the rather ambitious aim of '*determination*'. But if such a strong aspiration is to hold, then associated agency needs to be both *effective* and *specific* in quite demanding ways (Stirling, 2018).

In these terms, then, 'control' implies an *efficacy* of agency in a given context, sufficient fully to realise the particular aim(s) in view (rather than achieving this only partially or conditionally). And this of course, also implies a faith that it is possible to resolve and aggregate such a requisitely precise definition of purpose in the first place. If an intervention succeeds in effecting large-scale consequences, but these are not aligned with any original purpose, then what has occurred is more like 'impact' than 'control'. So, the idea of control also implies a high degree of *specificity* in the extent

to which the available instrumental means are held to make it possible to avoid inadvertent side-effects beyond given intended ends. This means that those outcomes that are realised are restricted only to ends that were initially intended, as distinct from other possible alternative or collateral consequences. After all, the wider and deeper the unintended consequences, the less any given intervention can properly be held to involve control (rather than some other kind of intervention). So, in their most idealised form then, any aims or claims involving control (disaggregated as appropriate with respect to specific ends), inherently require *realising fully and solely, a prior set of intended end(s), with no unintended effects*.

Although demanding, there is no shortage of examples of situations in which this strict concept of control can be recognised to be workably appropriate. A simple paradigmatic instance of control in this precise sense, might be recognised in many aspects of the everyday exercise of agency through a mechanical device such as an automobile. Among the multiple immediate aims in play in this kind of confined setting, are various aspects of the process of moving from one location to another. In one such aspect of agency, the normal practice of steering (for instance) involves an experience of moving in one particular direction at any given moment – and only in this way. Wobbling between orientations (even if the average remains around the intended orientation), would not properly count as control. Similarly, the modulation of speed, must – to be held as control – result in a precise rate of movement and not some kind of lurching fast and slow around this rate. Likewise, control over other functions like windscreen wipers or heating, should not interfere with other aspects of control, nor result in unintended results like engines cutting out or wheels falling off.

What is striking about general relationships between engineering and Sustainability, then, is the extension of this familiar (when operational) experience of control *within* a given *engineered system*, to control *by* engineering interventions of wider *encompassing circumstances*. But as depths, degrees and dimensionalities of nonlinear complexity extend beyond circumscribed domains of mechanical linearity, ideas of control in this instrumental engineering sense quickly become highly questionable.

And there are, as we have seen, plenty of other possible concepts than 'control', for addressing the kinds of formative relationships that actually pertain between entire engineered infrastructures or technological systems and the plural social contexts and operational environments within which these are located (Hommels, Mesman and Bijker, 2014).

In efforts to achieve (for example) provision of food, shelter, energy, livelihoods, mobility, communications or security, Sustainability debates teach an important lesson. Engineering interventions in such contexts cannot typically reasonably be held fully to deliver on the more hubristic aims or claims of 'control'. In areas like these, too much policy discourse around engineering takes the form of 'solutionist' promises, emphasising supposedly singular and complete 'magic bullet' responses to global challenges (Strebhardt and Ullrich, 2013). Rather than these kinds of controlling visions, what the considerable potentialities of engineering can instead be relied upon to achieve, is more modestly to 'influence', 'affect', 'impact', 'modify', 'condition' or 'modulate' the realisation of some part of the intended ends. What is required, then, is a degree of *humility* around conventional modernist instrumental imaginations of control.

For if the function of engineering were distinctively to count as *control* (rather than some other among these more modest kinds of formative relation), then delivery of stated aims would not incur any of the many adverse collateral impacts that it is the defining purpose of Sustainability to address. It is the totalising self-confidence of idealised imaginations of control – and associated propensities to sideline emerging criticism or concern – that serve as much as the material workings of the engineered systems, to exacerbate the negative impacts of so many instrumental engineering interventions. And it is the resulting mismatch between modernist idealisations of control and the messy practical actualities of engineering responses to real-world challenges, that dominates the negative side of relations between engineering and Sustainability.

This problematic mismatch is further exacerbated, when it is considered that formal frameworks like the Sustainable Development Goals represent a rather incomplete and idiosyncratic – if not downright

misleading (Farley and Smith, 2013) – reflection of the actual interests, values and drivers that really tend to motivate large scale institutional and infrastructural interventions around the world (Stirling, 2009). Governance discourse around Sustainability involves powerful actors ostensibly subscribing exclusively to values advancing human wellbeing, social equity and ecological integrity (Voss, Bauknecht and Kemp, 2006). But that these declared aims of Sustainability are so prominent in elite discourse, does nothing to diminish the hard realities of the actual purposes that are typically far more influential in shaping and driving large-scale engineering endeavours around the world (Parkinson and Spedding, 2001). Despite the undoubted efforts, commitments and integrity of individual engineers, it implies no cynicism to observe that the most formatively important forces shaping the configuration and orientation of much of the world's engineering more often lie in values like individual careers, disciplinary reputation, private profit, sectional privilege, commercial interest, national prestige or military domination (Stirling, 2018). None of these highly formative drivers of engineering appear anywhere in the SDGs. Whilst isolated serendipitous alignments with wider aims of Sustainability can occur under favourable circumstances, it would be eccentric simply to assume these. So, recognising these further uncomfortable realities underlying the driving purposes of efforts at control, puts relations between engineering and Sustainability in an even more fraught light.

2. Modernity, Control and Care

So far, attention has focused on failures in conventional large scale engineering-style efforts at control. Maybe the 'solution' lies within engineering professions, institutions and cultures themselves (see this volume: Chapters 44; 45 and 46)? If engineering practice were to reform within its wider social context, in ways that make it more 'ethical', or 'responsible', perhaps these negative syndromes might be solved? Such impulses may be understandable and positive as human reactions. But great caution is required over any idea that such circumscribed interventions alone might in themselves constitute a fully satisfactory response to the dilemma. For there are sadly many deeper dimensions to the

encompassing modernist culture of control, which arguably render such programmes themselves, often to be little more than naïvely instrumental 'solutionism'. If these dimensions are not also addressed, then efforts at alleviation that are too restricted in scope, may actually inadvertently exacerbate the problems.

It is also across this deeper-seated, more pervasive and longstanding 'infraculture' of Modernity as a whole then (Hoffman, 2015) (rather than merely inside the more visible but circumscribed cultures around particular existing practices, disciplines or institutions), that the real challenge lies for resolving relations between engineering and Sustainability. For it is centrally around refractions of this same impulse to control, that the entire condition of Modernity – in all its worldwide forms (Eisenstadt, 2000)(Mignolo, 2007)(Seth, 2016)(Kiely, 2005)(Santos, 2002) – has itself been arguably most deeply constituted for several hundred years. In foundational analyses like that of Condorcet (Condorcet, 1979), for instance, particular '*enlightenment*' notions of Modernity (see Chapter 7 in this volume) have since their inception centred around "*the belief that technological progress will give humanity increasing control over nature*" (Inglehart and Welzel, 2005) (see also this volume, chapter 7). Likewise, at least since Weber (Scott, 2006), Modernity has been deeply associated in philosophies of society, politics, culture and history, with a range of contrastingly-diagnosed modalities of control (Gregory *et al.*, 2009). Primarily, these include: rationalization, individualization, capitalization, industrialization, nation-forming, bureaucratization, democratization and disenchantment from tradition (Stirling, forthcoming). It is in these terms, that Modernity in itself and as a whole across its many diverse forms and aspects, might be characterised in quite deep general terms as an 'infraculture', a more generally formative cultural configuration lying beneath and beyond otherwise disparate manifestations across cultures – and conditioning their evolution over long time periods (Hoffman, 2015). If so, the most prominent single feature of this underlying 'infraculture' of Modernity, might be identified to be maginations of control. Unless this pervasive constituting characteristic of the encompassing infraculture of Modernity is not addressed, then it must be expected that little that can be done by interventions implicating engineering alone.

This point may warrant some slight elaboration, for it may not be immediately obvious, how so many of the widest and deepest constituting foundations of Modernity itself, are so centrally about romanticisations of control (Beck, Giddens and Lash, 1994). To take each of the above widely discussed aspects in turn, then: *rationalization* (for instance), involves aspired control over legitimate ways of understanding the world (in science) (Hegel, 1974) and justifying action (in public affairs) (Habermas, 1985). *Individualization* is about imaginations of greater control by individuals over the course of their own lives (Durkheim, 1984) – disembedding from constraining traditional norms (Comte, 2009). *Capitalism* involves efforts by particular political-economic interests to concentrate control over wider means of production (Marx, 1976). *Industrialization* (socialist or capitalist) involves attempts at enhanced control over productive activities (Arendt, 1959). *Nation-forming* was notionally about more clearly demarcating particular geographical domains of political control (Gellner, 1983) – or (as in more contemporary 'Brexit' parlance) "*taking back control*" (VLC, 2016). *Bureaucratization* involves the performance of tightened control over organisational processes (Weber, 1947). Many varying notions of *democratization* (for all their flaws) centre around ideas of more distributed social control over unfolding politics (Tocqueville, 2003).

Yet even this formidable list of the constituting control dynamics of Modernity as identified in conventional academic accounts, is still arguably seriously incomplete. Further to these familiar deeply-structured processes, there is an important additional way in which aspirations to control have exercised formative effects on prevailing cultures and infrastructures of engineering. This concerns the profoundly shaping effects of ever-present cross-cultural forces of *coloniality* (Mignolo, 2007)(Quijano, 2007). Also arguably present before and outside Modernity (Dietler, 2010)(Halperin, 2007)(Deringil, 2003)(Buzon, 2008)(Latvus, 2006)(Larsen, 1974)(Barrett, 2003) this most pervasive and intractable modality for the hegemonic entrenchment of power has taken especially devastating forms in successive waves of European *colonialism* that attended the advent of Modernity (Trigger and Washburn, 1996)(Mignolo, 1995)(Said, 1994) (as well as their various non-European eddy currents (Chen, 1970)(Mwangi, 2001)(Halperin, 2007)(Gladney, 2004)(Yi-chong, 2014)). Involving particularly

extensive and acute forms of violence (Churchill, 2002)(Jacobs, 2009), Euro-American colonialism has proven arguably more important than any other single factor in shaping the underlying infrastructures and imaginations that condition engineering around the world (Grove, 1997)(Churchill, 2002)(Hudson, 1972)(Harvey, 2003)(Ahmad, 2004).

Currently entrenching globalised architectures for production, investment, trade, mobility, innovation, knowledge accreditation and military domination were all originally engineered under intense pressures of coloniality – and continue to reproduce these conditions today (Bukharin, 1917)(Wallerstein, 2006). Interacting with all the other aspects of Modernity discussed above, these each display their own fixations, fallacies and failures of control. Behind well-meaning individual motivations and justificatory rhetorics, then, the hierarchical structures and centralised orderings underlying all these engineered systems and their embedded artefacts, continue (despite countervailing intentions among some embedded actors) to facilitate various kinds of global extraction and appropriation (Hildyard, 2016). So, perhaps more than any other among the conventionally-recognised constitutive dynamics of Modernity, it is arguably the under-acknowledged relations and processes of coloniality that most drive cumulative challenges of social inequality and environmental degradation at the heart of relations between engineering and Sustainability (see also Chapter 52 in this volume).

As if this were not enough, the picture so far has still only centred on the more material expressions in Modernity of this deep-seated 'infraculture' of what Nehru called "controlism" (Jones, 2010). Underlying and shaped by these constituting practices, there is also the dimension of ideology and imagination. For control is also central to the engineering of the distinctive *ways of knowing* the world, that are variously seen to characterise contemporary global Modernity (Misa, Brey and Feenberg, 2003)(Stirling, 2015). Recognising that "*knowledge itself is power*", Francis Bacon famously articulated in the seventeenth century a defining theme in the then-erupting coloniality of the European Enlightenment (McGovern, 2005). He went on to urge that, in order to achieve '*progress*', science

must "*put nature on the rack and torture her secrets out of her*" (Keller, 1984). Especially significantly, Bacon anticipated an "*empire of man over nature*" (Morgenthau, 1947). There could hardly be a more graphic expression in the foundational empiricism of the ostensibly neutral world of science, showing how the controlism of Modernity entangles with the distinctive violence of coloniality.

In all these ways, instrumental-style engineering imaginations pervade not only the material structures of globalisation, but also their driving imaginations and ways of knowing (see chapter 10 in this volume). Bodies like the World Bank, World Trade Organisation, International Monetary Fund, UN development frameworks and multilateral networks for regulating global environmental and security issues – as well as numerous transnational corporations – are as intrinsic to the controlling orientation of contemporary engineering, as the disciplines and cultures of engineering itself as a discipline. All alike reproduce Baconian efforts to: reduce complexities; standardise disparities; aggregate variabilities; integrate ambiguities; homogenise pluralities; domesticate risks; externalise uncertainties and deny indeterminacies – and so discipline (if not "*torture*") diversity and change (Jasanoff, 2004). In seeking to address relations between engineering and Sustainability, then, it is again essential to go beyond claims-making about professional ethics or responsibility *within* disciplinary cultures, to also challenge the constituting controlling obsessions of Modernity itself.

So what is the alternative? Amidst so much deeply embedded complexity, what can be the practical implications for relations between engineering and Sustainability? It is here that there comes most strongly to the fore once again, the human and environmental values of longstanding Sustainability movements. For, as set out by Brundtland and detailed further in the carefully-negotiated global aims encoded in and Sustainable Development Goals (SDGs), Sustainability presents arguably the most important general challenge to the encompassing *controlling* ambitions of Modernity. It does this at a level that is appropriately much deeper than purely expert interventions or technical reforms in or by particular disciplines or institutions. Fulfilling ambitious aims around social equity, ecological integrity and human wellbeing require overtly political engagements addressing the most general

arenas ofinternational governance – in the most central traditions of progressive social movements, addressing the most entrenched forms of global power. For all the many serious flaws, compromises and *civilising hypocrasies* (Elster, 1999) in the present form of the SDGs themselves, then, it is this explicit framework of diverse normativities that helps shift attention away from the closed, instrumentalised technocratic idealisations of *control* towards a more openly political and potentially empowering idiom of *caring* – for the neglected unintended consequences of just this kind of control for: people, societies, ecologies and the future of the world (Bellacasa, 2017)(Robinson, 2011)(see also Chapter 53 in this volume).

Whether in terms of the Brundtland values of human wellbeing, social equity and ecological integrity then, or the many more specific (if often compromised) Sustainable Development Goals, the crucial contribution made by this more 'caring' style of Sustainability discourse and practice, is to help open up narrow, vertical, technical notions of control (in which driving ends remain instrumentally invisible) (Preston and Wickson, 2016). It is in the resulting onward political, cultural and discursive contexts that emerge, that more opportunities can arise for currently-conventional controlling styles of engineering to be balanced with wider and more horizontal – more overtly political (and so accountable) – ideas and practices of care (Wickson *et al.*, 2017). In this way, the driving imperatives of governance around engineering can deepen and expand from narrow expert wrangles over asking merely "*how fast?*"; "*what risk?*"; or "*who leads?*" in some presumed single trajectory controlled in each sector by incumbents as 'inevitable' (Andy Stirling, 2014b). In ways elaborated below, when the pluralities of these more caring values and dispositions of Sustainability are taken seriously, far more plural and fundamental questions may emerge for engineering over "*which way?*"; "*who says?*" or "*why?"* (Stirling, 2008).

But this prompts difficult questions. What then characterises more concretely and exactly, this contrast between care and control in relationships between engineering and Sustainability? It is here that longstanding feminist literatures around the ethics and politics of care, offer many practical

insights over how to shift attention away from the deeply embedded modernist imaginations of control (Plumwood, 1993). Of course, some strands of feminism display their own fixations with control (Cuboniks, 2015). And much formative thinking about care has also gone on outside feminism (Pellizzoni, 2004)(Hamilton, 2013)(Groves, 2015)(Schweitzer, 1947)(Pope_Francis, 2015). But it is in deep engagements with the comprehensive subalternities of gender, race and other intersectionalities (May, 2015), that some of the hardest thinking has been done about the kinds of enhancements of social agency that Sustainability is striving for, which feature more as 'matters of *care*' (Bellacasa, 2017)(Fisher and Tronto, 1991) than as aspiring control. And it is only at this level of political-cultural depth and pervasiveness, that the most intractably hardwired effects of coloniality on engineering can arguably be addressed.

It is due to feminism, for instance, that a further analogy may be helpful in illuminating the control/care distinction advanced here (see also Chapter 50 in this volume). To focus on this distinction should not be taken to imply the kinds of hierarchical binaries so well critiqued in a related strand of feminist thought (Taylor, Hines and Casey, no date). To contrast one idea with another, rather than merely assert a single (ostensibly disembodied) notion on its own is, after all, a way to be more explicit and accountable – caring for the enabling of critique. So, in relation to the example of driving an automobile given earlier, then, a contrasting analogy might focus on society's relationships with children (Gilligan, 1993)(Held, 2005). After all, many different kinds of societies all care very much about the ways in which children develop. But (however it may manifest in some settings), this concern is typically only very poorly (arguably dysfunctionally) describable as ambitions to *control*.

Key in the example of child-rearing (as in Sustainability), is that care is typically greatly more flexible, open and plural than is captured by the idea of control (Gilligan, 1993)(Held, 2005). Intentions and ends at issue are generally more diverse and carefully deliberated between subjects and objects of care. The means are more mutualistic than deterministic. There is a more relational than categorical stance, with greater humility and reflexivity over complexities, uncertainties, and other (third) loci of

agency. Deeper precaution is adopted towards adverse effects, than is captured in controlling notions of 'trade-offs'. It is these kinds of differences that lead efforts to exert general controlling relationships over children (for instance) to be widely regarded (across different societies) as a pathology. So, it is distinctions like these that make both relations with children (like the concerns of Sustainability) better envisaged to be more about '*care*' than '*control*' (Davies, 2012)(Arora, 2017)(Groves, 2013). It is on this basis that the implications of Sustainability can be considered, for the development of a kind of engineering that is more caring, than controlling.

3. From Control to Care in Engineering for Sustainability

So what might be the practical lessons for relations between engineering and Sustainability, of this analysis of the contrast between control and care in response to challenges of Modernity? Before turning to more specific repercussions for engineering, it is worth reflecting on some important general implications for discourse and practice around Sustainability itself. For the deep-seated hegemonies of control discussed earlier, have not remained inactive in the face of Sustainability challenges. On issues like heavy metals, chlorine chemicals, ionising radiation, pesticides, carcinogens and toxic wastes, decades of values-based environmental campaigning achieved repeated successes through applications of values-based – 'caring' – a actions, contrasting markedly with the more controlling imaginations of government, business and mainstream academia (Harremoës and European Environment, 2001; EEA, 2013).

In the face of unrelenting scientistic expert-led 'risk-based' 'no alternatives' rhetorics from elite institutions, this struggle involved broad political mobilisations emphasising uncertainties and alternative political visions (Grove-White, 2001). But these earlier articulations of Sustainability are now under pressure. On high profile issues like climate change, for instance, a main emphasis is now on exactly the kinds of control rhetoric that were in the past deployed *against* Sustainability concerns. Scientistic analysis increasingly substitutes for explicitly values-based arguments (Hulme, 2009). Policy

debates become dependent on complex risk-based modelling (Shackley and Wynne, 1996). Primary agency is afforded to exactly the kinds of incumbent science and policy interests that in the past most resisted Sustainability concerns (Wynne, 2010).

And in struggles to protect the Earth's climate from rising emissions of climate-forcing gases, there is an especially disturbing way in which a modernistic infraculture of control is warping what were originally the more caring sensibilities of environmentalism (Bloom, 2003)(Lannoo, 2010)(Yearley, 2005)(Pepper, 1996). Under a controlling imagination, this challenge is undertaken in a very different way to previous successful environmental struggles to curb uncontrolled ecological impacts (Harremoës *et al.*, 2001)(EEA, 2013). Instead of hope-driven, values-based actions, what increasingly hold sway are fear-laden, expert-defined visions of control over the Earth's climate as a whole – modulating mean temperature within pre-set model-defined limits.

Under the burgeoning instrumentalism of this planetary engineering imagination, it is as if the 'natural' state of the climate were somehow static; that this condition is self-evidently desirable; that it is '*change*' itself that is negative; and that what should be controlled for are the '*optimal Holocene conditions*' of a '*stabilized earth*' (Sterner *et al.*, 2019)(Steffen *et al.*, 2018). In other words, the aim shifts from protecting other – largely unknown – kinds of agency on Earth, to asserting with renewed vigour, the particular controlling singularity of agency associated with exactly the presumptively all-knowing modernity that is causing the problem in the first place (Stirling, 2019).

A caring approach to the Earth's climate, by contrast, might be about more politically curbing '*climate disruption*', than technically controlling '*climate change*' (Pidgeon *et al.*, 2016). Driven by acknowledged uncertainties over uncontrolled impacts, rather than asserted certainties towards planetary control, this would focus not so much on controlling global temperature, but more directly on substituting the polluting practices. And a caring approach would recognise that the problem is caused not indiscriminately '*anthropogenically*' by humanity *per se*, but by particular *modernistic* kinds

of society (Lövbrand *et al.*, 2015). Indeed, it is this very possibility of political alternatives in ways of being human, that makes any struggle worth pursuing at all.

This pattern reflects a wider shift in many other areas of environmental struggles, as these impinge on high level governance processes around the world. With the caring multiplicities of Sustainability decried as 'Stupid Development Goals' (Economist, 2015), repeated efforts are made to control the focus of attention down to a supposedly singular and more technical 'nexus' (Beddington, 2009) of far narrower 'grand challenges' (CEC, 2009). A growing mood of '*environmental authoritarianism*' (Beeson, 2010) argues that the democratic arenas on which environmental struggles of the past depended so much, might actually be seen as an '*enemy of nature*' (Euractive, 2010). Leading environmentalists proclaim that "*it may be necessary to put democracy on hold for a while*" (Hickman, 2010). Attempts are made to reduce the vibrant political arena of Sustainability into an inaccessible technical discourse around a narrow set of '*planetary boundaries*' as "*control variables*" (Rockström *et al.*, 2009) about which "non-negotiable" expert pronouncements brook "*no uncertainty*" (Rockström, 2010).

All this is especially relevant to engineering, because momentum is accelerated by a new wave of unprecedentedly ambitious new infrastructures promising planetary-scale control (Cairns and Stirling, 2014). A host of emerging 'geoengineering' technologies help drive the momentum (Shepherd *et al.*, 2009), in which current global political – and especially military (Brzoska *et al.*, 2012) – incumbencies openly position themselves for a mission of 'planetary management' (Newton, 1999). So powerful has this modernist control-delusion become, that a demonstrably massive failure on the part of Modernity even to be able to control itself, has been spun into an even more inflated (self-appointed) mandate to control the whole 'earth system' (Lövbrand, Stripple and Wiman, 2009). In an oddly under-discussed confusion of 'impacts' with 'control', a newly burgeoning ideology of '*the Anthropocene*' (Economist, 2011) hubristically mis-names a fleeting geological instant of destruction as a presumed entire new prospective epoch of notional human control. As foundational scientific texts put it, the Anthropocene

is a coming epoch in which "*a self-conscious control force that has conquered the planet*" (Schellnhuber, 1999), with a homogenized and depoliticized humanity "*taking control of nature's realm*" (Crutzen and Schwagerl, 2011). Just as diagnoses burgeon of the possible end of Modernity, so Modernity hysterically intensifies the prescriptions that so helped make the problem in the first place: impelling in the name of Sustainability itself, a new wave of fixations, fallacies (and inevitable further failures) of control.

So, how to defend past hard-fought political gains by Sustainability from this currently resurgent modernist hegemony? How to reverse erosions of scope for democratic struggle? How to resist wider authoritarian appropriations of the institutions and practices of Sustainability itself and their subversion to technical agendas of control, rather than more emancipatory politics of care? Central as it is to visions of Anthropocene geoengineering, the engineering community arguably has a particular responsibility (see Chapter 46 in this volume).

A start might lie in reaffirming where Sustainability movements came from in the first place – and the nature of the political forces that have most supported them. In keeping with Brundtland's emphasis on themes of participation and democratic struggle (Brundtland, 1987), Sustainability discourse was historically pressured onto high level international agendas (like the World Commission on Environment and Development) through emergent waves of collective action and "uninvited" public engagements in pursuit of social justice and environmental protection (de Saille, 2014). Just as in other earlier movements for the emancipation of subjugated classes, ethnicities, slaves, workers, colonies, women, young and disabled people and diverse sexualities – Sustainability was only pressured to become a focus for bodies like the Brundtland Commission, through diverse, protracted, radically-challenging and overtly-political agonistic struggles by subaltern social movements (Mouffe 1999).

Mediated often in new musical and artistic forms, these movements acted through the deepest and broadest political spaces of culture as a whole. These unruly processes were a far cry from the kinds of expert-led 'integrated assessment' or 'evidence-based' control highlighted in contemporary elite

planetary management. Far removed from the 'cockpitism' of transitions processes like that so unsuccessfully presided over by the IPCC, transformations of this kind are more about a mutually-choreographed rhizomic 'culturings' of change. Here knowledge and action are not forced into vertical separation by elite institutional etiquettes and divisions of labour, but are freely combined, with new configurations of practice, identity, values and interests horizontally shaping each other. And it is mainly by such means, after all (rather than by more controlling interventions), that other great progressive gains of history have also been achieved – against slavery (Davis, 2014) and serfdom (Carol S. Leonard, 2011); oppressed labour (E. P. Thompson, 1966) and colonised people (Fanon, 1967); subjugated women (Paletschek and Pietrow-Ennker, 2004) and disabled people (Block *et al.*, 2016); and minority ethnicities (Sudbury, 1998) and sexualities (Giffney and O'Rourke, 2009).

In keeping with the aphorism that '*the medium is the message*', then, these ways in which Sustainability movements came into being and have thrived so long, also strongly resonate with their normative content (Stirling, 2016). Again, this key strand of Sustainability arose historically more through a messy mutualistic politics of care, than by orderly engineering of hierarchical instruments of control. Take, for instance the development of issues around occupational hazards, resource degradation, consumer chemicals, ionising radiation, atmospheric pollution, water contamination and climate change (Gee et al, 2001; EEA, 2013). All were typically pioneered by subaltern communities of workers or affected people, then picked up by the social movements who cared for these interests. In each case, it was caring recognition of uncertainties that most strongly advanced progressive causes, not the controlling assertions of 'uncompromising', 'non-negotiable' certainties now redolent of controlling Anthropocene discourse.

Indeed, these imperatives were at each stage strongly contested by precisely the authoritarian controlling language of risk, now used by mainstream science and engineering and high-level governance institutions seeking to champion the reframing of Sustainability as 'planetary management'. The kinds of control-style aggregating analysis, optimising models and categorical

boundaries that now structure '*global assessments*', for '*earth systems governance*', were – like earlier notions of '*assimilative capacities*' – all used in efforts to resist Sustainability movements. The formative kinds of concrete action that most grew momentum around Sustainability issues, were less about quantitative expert control of risks, and more about qualitative values of care for fellow people and their environments.

Turning from the motivating problems to aspiring engineering 'solutions', similar general patterns can be seen. Innovations such as wind turbines, ecological farming, super-efficient buildings, and green chemistry all owed their pioneering origins and early development to subaltern social movements (Garud and Karnøe, 2003; Smith, Fressoli and Thomas, 2013). All were systematically marginalized (if not actively suppressed), by incumbent interests in science, government and industry. And again, these transformative responses were nurtured not by controlling management, but by mutualistic – caring – struggle. That so many of these innovations have now become central elements in prospective transformations to Sustainability, is despite – rather than because of – 'sound scientific', 'evidence based' elite policy discourse. Again, it was the politics of care, that brought these presently-growing signs for hope from engineering into being, far more than the currently-celebrated technical imaginations of control.

So at the end, we come to the question of how engineering can best assist in struggles towards Sustainability: to rebalance modernist technical fixations with control, by helping in the culturing of a newly vibrant mutualistic politics of care (Andrew Stirling, 2014). And here for the purpose of drawing practical conclusions, it might be useful to think as a heuristic, about two ideal-typical imaginations of radical social change that pervade current global policy debates around the implications of Sustainability (Stirling, 2011).

On the one hand, are what might called '***sustainable transitions***' (Markard, 2017)(Rotmans, Kemp and Asselt, 2001)(Schot and Kanger, 2018)(Geels, 2005): directed under incumbent structures by means of orderly management according to tightly-disciplined technical expertise and technology-based

innovations (Shove and Walker, 2007)(Meadowcroft, 2009)(Smith and Stirling, 2010)(Stirling, 2011). Often driven especially by fear, these focus largely on presumptively well-known and singular means, with details of the wider driving ends remaining relatively less questioned. Notionally rigid categories are emphasised over inconveniently open relations. This typically emphasizes integrated multidisciplinary science directed at controlling management through formal procedures in hierarchical organizations centred around technical infrastructures sponsored by the convening power of government. Exemplified in a range of currently widely-propounded frameworks, this is the mode of change most characteristic of instrumental-style engineering under modernist hegemonies of control.

On the other hand, there are '***transformations to Sustainability***' (Stirling, 2011)(Brand *et al.*, 2013)(Temper *et al.*, 2018)(Andy Stirling, 2014a)(Hölscher, Wittmayer and Loorbach, 2018): involving more diverse, emergent and unruly political alignments. Best driven more by hope than by fear, these reflect less disciplined (incommensurable, tacit and embodied) knowledges and social (more than technical) innovation (Scoones, Newell and Leach, 2015). They involve pursuit of contending (sometimes even presently unknown) means towards contrasting ends that remain hotly contested. The focus is on open-ended relations rather than supposedly fixed categories. So, in this more political mode, space opens up for subaltern interests, social movements and civil society to struggle for in ambiguous (sometimes invisible) ways to orient the broader normative and cultural climates in which all explicit structures are set. Challenging incumbent interests associated with the modernist hegemony of control, this idea is more congruent with the mutualistic pluralism of caring imaginations of Sustainability. It is these features that might help characterise a more caring style of engineering.

Although taking contrasting forms in different contexts, it is arguably the more caring dynamics of ***transformation*** (more than controlling transition in these senses), that are most in keeping with the original driving values and practices of the collective action movements that brought the Brundtland Report into being. And it is associated qualities described here as care for (rather than control of) fellow people and the Earth, that feature most strongly (for all their flaws) in frameworks like the

SDGs. These kinds of social change are not best enacted through rigidly categorical hierarchies of deterministic cause and effect. They do not depend on incumbent interests commissioning justificatory 'evidence' or 'research' from elite institutions of academic or policy actions. They thrive instead in myriad ostensibly small-scale mutually-shaping actions, flowing together in 'murmurations' that condition transformative social change not through rigid hierarchies of control, but through more dynamic and mutualistic relations of culture.

Referring to the often rapid changes of direction seen in flocking behaviours in nature, the idea of murmurations shows how ambitious social transformations are arguably only truly achieved through horizontal relations of care, rather than the vertical structures of control. Interestingly, the colloquial English word for such processes – murmurations – refers both to the sense of unstructured mutual co-ordination and subaltern critical dissent (Stirling, 2016). Here, knowledge and action need not be treated as separate and sequential as prescribed in the rigid controlling protocols of 'evidence-based policy' discussed earlier. Instead, they can be recognised to be deeply-entangled and mutually shaping – into multiple kinds of '*knowing doings*' of kinds that shaped the culturing of Sustainability movements themselves (Stirling 2014a; 2014b).

Choreographed in this way more by distributed autonomous normative compasses than by centralised instrumentally coercive grids, this kind of politics of transformation defies not only any prior controlling orchestration, but also the imposition of such expedient storylines after the fact. Formative phenomena are not neatly nested, but rhizomically entangled across all 'phases', 'scales' and 'levels'. Key generative processes eschew the conveniently tractable logistic curves so beloved of expert diagrams, instead surging to and fro in non-monotonic waves, where it may be unclear throughout, exactly which is the direction of change.

If it is to become more aligned to these potential caring dynamics of transformation, as distinct from the more controlling hierarchies of control, then engineering needs to engage more with these more relational, processual, nonlinear and rhizomic forms of understanding and action. First, of course,

there are the well known values of responsibility (see Chapters 46 and 47 in this volume). And in the spirit of 'first do no harm', there are obvious implications for some of the most self-evidently unsustainable applications of engineering – for instance in the military (Barry, 2012). Beyond this, emphasis might shift from technical means to political ends – with the latter addressed more directly and in ways not seen through such instrumental lenses (Stirling, 2016). This means recognition for the irreducible ambiguities and pluralities of politics – such that even the idea of a singular engineering 'solution' in any given context, is acknowledged to be untenable – and even such ambitions as downright damaging (Morozov, 2013). Where engineering communities find themselves – as is often the case in international affairs – sitting at the "top tables" of global governance, they might try harder to avoid not only the assertion of narrow institutional agendas, but also the frequently somewhat wishful conceit of representing uninvited interests (Felt *et al.*, 2008). More caring efforts might be directed towards opening up of political space, such that these other voices can speak directly for themselves (Stirling, 2008). In short, engineering imaginations should accept the role of servant, rather than master – in the service of democratic struggles rather than seeking to control these.

Either way, the point of this distinction between 'transition' and 'transformation' is not to insist on terminology. These words are often entirely-reasonably used in interchangeable ways. Nor is the point to argue that only one dynamic can be historically effective. In reality, any major political change will require interactions between each. Nor is the message that one is always more positive under a progressive view or the other necessarily negative. These are dynamics for radical social change of any normative orientation. So real-world diversities and complexities give many examples where either process spans the political spectrum. What is argued instead, are the following three – simple but potentially crucial – points.

First, it is practically useful to distinguish these two processes. Exclusion of this distinction, or failures to make it in particular settings (with whatever words), will likely lead to a default situation in which vulnerabilities are reinforced to the modernist fixation with control discussed in this chapter. On the

basis of evidence documented here, this powerful current hegemony can reasonably be expected to respond to Sustainability pressures by emphasising expedient technical mechanisms of transition and sidelining the inconvenient (more care-focused) politics of transformation. Even without any countering bias, simply making the distinction is a precondition for rebalancing this political pressure.

Second, there is the point made in this section, that it is the caring politics of transformation (rather than the more controlling management of transition), that has proven more crucially formative in the histories of emancipatory movements that have always driven Sustainability. This remains so, despite mixes of both processes being salient in different stages of complex real-world histories (and each dynamic being potentially regressive as well progressive). This history is important, in reminding how the unruly generative vibrancy of care presents a direct challenge to more controlling environmental authoritarianism currently consolidating around initiatives like '*the Anthropocene*', '*the nexus*', as well as manipulative '*nudge*' strategies and '*planetary management*'. Under these incumbent pressures, 'transition' processes thus tend to look after themselves. Serious progressive actions towards Sustainability should therefore emphasise complementary processes of 'transformation'.

Third, there is the point that process matters. Although either political dynamic can lead to different normative ends, they are not simply 'plug and play'. Just as means are not entirely divorced from ends, so the contrasting attributes of each kind of process may be expected to leave sticky imprints on the consequences towards which they lead. No matter how well-intended they may be as means to challenge particular forms of control, interventions that are also controlling in different ways will likely reinforce this shared hegemony. Perhaps details will be reoriented. But underlying cultures of control remain intact. An extreme case is especially pertinent to historical use of controlling violence as a means towards 'revolutionary' visions of transformative change. No matter how progressive the revolutionary visions, such controlling violence can easily serve merely to perpetuate (in new modes) the oppressive relations it was ostensibly intended to control. Reflecting longstanding recognition for

this point in subaltern progressive social movements, this is why Brundtland emphasised the caring imperatives of participatory process and democratic struggle.

And if all this seems quite abstract and conceptual, it is not hard to see the practical salience of these contrasting faces of transformation for current high-stakes Sustainability politics. Consider, for example, the radically contrasting orientations of early moves (in alternative potential forms of Sustainability 'transitions' or 'transformations') currently underway in different sectors around the world. Entirely plausibly imaginable worldwide transformations to low-input care-intensive agroecology may be sidelined by transitions to high-technology synthetic biology driven intensive industrial agriculture. Transformations towards distributed community-based renewable energy and interactive energy services will be suppressed by transitions highlighting centralised grids for 'small modular' nuclear power reactors, interlinked with military propulsion and weapons infrastructures. Climate disruption may be alleviated by transformative improvements in political economy, resource efficiency and lifestyle change, or by transitions to global climate management using geoengineering technologies and their associated institutions of planetary control.

Each of these radically contrasting possibilities – and many more – are currently loudly propounded under different political views as (sometimes the 'only') possible means to find Sustainable resolutions to particular challenges in different sectors. In terms of their material feasibility, each is equally plausibly realisable in an appropriate economic context. But commitments in one direction foreclose chances of realising the other. Many well-known processes of lock-in help shape single track 'race-like' modernist visions for technology, infrastructure and institutional change . As time goes on, path-dependencies increasingly do their job and entirely feasible alternative possibilities find themselves crowded out. Although these examples are stylised and diverse permutations are possible in this picture, the stakes between transition and transformation are clearly very high.

4. Practical Implications for Sustainability and Engineering

In order to draw practical conclusions, the key themes of this analysis are readily summarised. For all its progressive aspects, Modernity continues to shape and condition engineering of many kinds through a range of fixations, fallacies and failures of control. Despite specific gains under particular conditions and notions of social advance, these syndromes tend to impact unacceptably on prevailing levels of inequality, injustice and environmental degradation. Against this backdrop, Sustainability can (by contrast) be seen to be about caring for these neglected harms to people, societies, nature – and their implications for the future of the world. This compels that radical improvements must be sustained in human wellbeing, social equity and ecological integrity. If engineering is to assist in this, it must not only be reformed in its own practices and priorities, but play its part in aiding the wider necessary political transformations.

Here is not the place to detail the diversity of practical actions that engineers themselves have conceived and undertaken, broadly (if not explicitly) away from controlling transitions and towards more caring transformations to Sustainability. In particular, engineers repeatedly join scientists and other technical specialists around the world, variously organising in favour of '*sustainable engineering*' (Davidson *et al.*, 2010)(Jonker and Harmsen, 2012) or related efforts at '*engineering without borders*' (Helgesson, 2006) or for '*global responsibility*' (INES, 2019) or striving for particular visions for engineering that are (for instance) '*ethical*' (Bown, 2009), '*humanitarian*' (Mitcham and Munoz, 2010), '*responsible*' (Woodhouse, 2001), '*holistic*' (Buch, 2016) or even '*caring*' (Lucena, 2013).

Beyond the influence of these kinds of initiatives, further effects may also be exercised by prospective engineers '*voting with their feet*' – or more accurately, their career choices (Parkinson and Spedding, 2001). This is an especially important dynamic in areas of engineering which ethical or sustainability values most obviously disfavour – like the military or nuclear industries (Blue, Levine and Nieusma, 2014)(Langley, 2005). Frequent lamentations in such areas over the challenges presented by a "*skills gap*" (HoC, 2009) is an illuminating reflection of the ways in which the prevailing orientations for

engineering as conditioned by incumbent structures of Modernity may sometimes be in tension with everyday normativities of ordinary people (and prospective engineering students). Mismatched "*prosocial motivations*" of many otherwise would-be engineers (especially women), is often observed to be a key reason for the large rates with which prospective students choose other courses (Miller *et al.*, 2000) – or accredited engineers actually leave the profession (Rulifson and Bielefeldt, 2017). Were movements towards a greater emphasis on Sustainability to be successful in rebalancing patterns of engineering activity away from areas like military and nuclear and towards (say) renewable energy or closed cycle production (CAAT, 2014), then such impacts on the engineering profession might be expected to be lessened. To this extent, it is arguable that the 'murmurating' effect of cumulative career choices may be one among many cultural factors exercising convivial pressures for moves away from control to more caring engineering for Sustainability.

The implication here is not that initiatives confined to disciplines and institutions of engineering – no matter how ambitious – can completely eliminate the controlling hegemony of Modernity. Indeed, such ambitions would be ironically self-refuting in their own controlling aims. The vision is, that relatively circumscribed technical movements within and around the engineering professions must, to be successful, be accompanied by parallel action in wider public arenas – including (indeed, especially) by engineers. Synergising with movements within engineering disciplines, such complementary outside action can challenge the overarching imaginations and structures of control, within which the instrumentalised practices and institutions of engineering are continuously reproduced.

And even here, the aim cannot be eradication of all notions of control within engineering. As has been discussed, these do retain more circumscribed and conditional applicabilities in spatially and temporally confined operational contexts *within* (rather than *around*) engineered systems. The aim of the present analysis is rather towards a more nuanced and re-balancing of attention to caring and controlling idioms in engineering, reflexively countering the inherent biases of encompassing

modernist cultures. And (in multiple ostensibly minor forms) this kind of effort in everyday practice can, in itself, be an example of the murmurating dynamics of transformation. Even (perhaps especially) if they are below the radar of established canons of practice, such 'political jujitsu' or 'Trojan horse' moves can *broaden out* apprehensions within engineering of the different values, understandings and possibilities that constitute the emancipatory core of Sustainability (Stirling, 2016).

When articulated by engineers towards patrons and sponsors of wider infrastructures (or in horizontal actions that are uninvited and unauthorized by incumbents), there is much potential for such moves. They can help *open up* wider political appreciations in society at large, for the multiplicity of alternative pathways that exist around the world for realising – iteratively and carefully – concrete moves towards Sustainability in particular settings. And the cumulative effect of such moves even within the traditional heartland of engineering cultures and practices, may help in processes of eroding the overbearing hegemony of Modernity itself – aiding in the vital process of *letting go* – to subvert, dissolve and pivot prevailing idioms of control, without reproducing them in self-negating attempts at countervailing domination.

If global societies are serious about enabling people to care better for each other and for the Earth, then it these kinds of actions (not countervailing efforts at control) that may most help in murmurating away from the fixations, fallacies and failures of controlling Modernity. And in seeking to advance this imperative for transformative struggles towards more caring possibilities of Sustainability, arguably no community is more important (nor their actions potentially more influential) than the professions, institutions and practices of engineering.

Further reading

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Jasanoff, S. (ed.) (2004) *States of Knowledge: the co-production of science and social order*. London: Routledge. (A useful outline in the broad spirit of the present analysis, concerning how political economy, state politics and the politics of knowledge are all entangled)

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Related topics

Chapter 7 Philosophy of engineering and technology (Diane Michelfelder); Chapter 10 Presctipive engineering knowledge (Sjoerd Zwart); Chapter 27 Sustainable design (Steven Moore); Chapter 54 Engineering and environmental justice (Benjamin Cohen); Chapter 44 Standards in engineering (Paul Thomspon); Chapter 45 Professional ethics (Michael Davis); Chapter 46 Public-professional societies (Joseph Herkert and Jason Borenstein); Chapter 47 Engineering as a political practice (Govert Valkenburg); Chapter 50 Feminist engineering (Donna Riley); Chapter 52 Engineering and social justice (Carolyn Baillie); Chaprter 53 Humanitarian engineering (George Catalano).

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[1] Especially in relation to the discussion here of coloniality – but also ranging far more widely – I owe a great debt to my SPRU colleague (former engineer and extraordinary scholar) Saurabh Arora.

[2] Later in this chapter, a series of serious political pressures will be discussed, that act to appropriate and subvert Sustainability institutions and discourse in order to legitimize unrelated values or interests. The fact that the verb 'sustain' can be applied in principle in English to refer to any imaginable object, value or interest, further exacerbates vulnerability to these political pressures. To help resist such misuse, reasons are elaborated in (Stirling, 2009) for using a capital 'S' when using the term **S**ustainability in relation to the *particular* publicly-deliberated values and interests around human wellbeing, social equity and ecological integrity made explicit and accountable in **S**ustainable Development processes since Brundtland (Brundtland, 1987) and on through the **S**ustainable Development Goals (UN, 2015). The capacity to maintain any *unspecified* (even entirely undeclared) object, value or interest, can then be referred to as sustainability with a small 's'.

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