Building a socio-technical energy research community: theory, practice and impact

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Introduction

It is humbling to be part of a global debate on the role of social studies in energy and the influence they might have on national policy. I am deeply grateful both to the editor and the respondents for taking these ideas, and scrutinising them. I hope we all the better for discussing them.

I want to start off by just being clear what I did *not* want to claim with my original article: My call for more physics was expressly *not* a call for *all* social scientists of energy to use physics *as it is currently deployed* in all (or even some) social studies of energy. My call is for there to be *more* social scientists who work with physics and similar to develop *new approaches to knowing* about energy (in a physical and social sense) from what I'm calling a 'socio-technical research' perspective.

I do not want this to imply that *Energy Research and Social Science* should turn into *Energy and Buildings* – it should remain and build the community it has galvanised. But I do want some interested colleagues, more and more of them to embark on a collective venture that builds a new research paradigm. You are currently out there (including most, if not all of the respondents here) but we need more and we need to build methods and strategies of research.

This last point emphasises an implicit assumption, that socio-technical research is not the same as either just having social and technical researchers in the same research team or in having researchers trained in both disciplinary routes (though both a likely essential precursors). My claim is that we need to negotiate a new set of methods and/or strategies of research that build on new ways of thinking about what exists and how we record what happens with those things. That said, I have little doubt that those trained in both routes are at a distinct advantage in this regard and so should be central to this endeavour.

Also in relation to this, I am not saying that simply doing more research in and of itself will cause more impact. This is a misreading of what I've written. My claim is that by developing a *critical mass* of knowledge that interfaces heavily with engineering perspectives, this research helps engineers of energy *re-describe policy* and therefore *re-describe energy problems* and with it identify new kinds of solutions. It is a strategic rather than tactical move, if you like.

These points also hopefully lay to rest any notion that I am saying the inclusion of more kWh mentions in your articles is a magic bullet towards impact. Absolutely not. Nor of course that social science without physics has no impact, though more on this below.

Impact and impact

Implicit within my original article and those of many of the respondent's (Mallaband, Stern, Mazur, Spreng in particular) is a 'two-types' idea of impact on policy making (where impact on policy making is defined as 'affecting the direction of travel of decisions about policies made by national governments by virtue of conclusions reached on the back of evidence presented'). As a heuristic, we can think of these two types according to the following crude characterisation:

Type 1: 'Accept/amend' impact: this is where social sciences of energy effectively adopt or otherwise do not challenge the standard mainstream way of thinking about or describing the energy system, and so have impact by deflecting the ultimate trajectory of policy. This could include by de-risking delivery through the use of MINDSPACE-style tactics or the assessment of public attitudes regarding particular technologies, in order to then work on more policy derived from the logic of the mainstream techno-economic framework. I would hesitate in calling any social science research in this setting interdisciplinary, or transdisciplinary, since it tends to involve social sciences input being limited to set of predetermined questions. This is not the impact I am focused on here, though that is not to say it has no value.

Type 2: 'Reject/replace' impact: this is where social sciences of energy are implicated in reframing the nature of what an energy system is and generating new kinds of questions and approaches to investigating it. The new framework of course then implies a new set of heuristics and policy goals for officials working in energy policy which lead to further involvement of social science (perhaps accept/amend at that point). This is very much the kind of impact I am interested in and reflects I think the nature of the wider calls in the social sciences for more impact. This of course has echoes of 'mode 2' knowledge production identified by Gibbons et al [1] and thus confirms the link between the way in which research is carried out with the sort of impact it might have.

This bipartite definition of impact is not that new of course – in the UK, researchers on policy impact are often at pains to distinguish between impact in a direct sense (i.e. via a traceable link between research outputs and decision-making) and impact in an indirect sense (i.e. via transforming the framework of thinking in an area). Typically, the latter has a much longer timescale than the former, is incremental and collective as opposed to individual and discrete. This latter type of impact is very much the kind I am aiming for, in the (hopefully widely shared) belief that in so doing, better energy policy may be the outcome.

Having set out my stall on impact, and hopefully clarified my position and the conceptual space it occupies, I feel it is important I address each respondent's piece in turn. I've chosen to do this alphabetically by surname for want of a better ordering heuristic.

Castree and Waitt

Castree and Waitt's [2] forensic review of my paper aims to highlight 'empirical and logical flaws' in my analysis. Below I address each of the points they raise which is as much a chance to rebut, as it is to refine my position, clarify my ideas and accept the need to adapt my position in the face of perspicacious analysis.

Have I relied too much on my personal experience and not used enough empirical research or exploit the literature sufficiently? I can't but concede this point, though one might argue this is true of most conceptual papers such as mine. Of course, I wrote on a highly informed hunch, based in part on my observations and in part on what I read in the relevant literature. I am not the only social scientist to claim a lack of impact but nor am I the first to do so without a sound empirical grounding. I agree with Castree and Waitt's ([2], and Mallaband et al's [3]) call for an empirical study and would gladly collaborate with them or others interested in this (though see below for my preconditions on this). I agree also that I have partially ignored the wider literature on policy impact. In part this is because it is heavily weighted on areas of policy other than energy (e.g [4]) but also because the literature in this area has tended to overlook some of the deep philosophical issues that Castree and Waitt's and other respondents have eloquently highlighted. Gaining useful advice from this area thus requires carefully picking through a crowded field and the respondents here have help directly in this cause.

Have I elided 'conduct of research' with 'communication/knowledge transfer'? Yes, there are new interdisciplinary centres and approaches to influencing policy. But my point is that one may be in danger of having highly effective Type 1 impact when Type 2 is needed. My short reference to the work I've been doing at UCL and the fact I am here is testament to my belief that for Type 2 I needed to move closer to the source of knowledge production in order to effect 'better' knowledge transfer (both more often and with better impact).
Do I think that simply more research equates to more impact? No, it is *not* my belief that the simple volume of socio-technical research will, in and of itself, cause officials to 'take notice' as Castree and Waitt put it. No, indeed it is my belief that officials making energy policy are agnostic about the way of describing the energy system, as long as it adheres to some basic criteria (likely something around it being a commonly agreed way of talking about the system that is likely to help do energy policy effectively). In fact, my strategy, if you like, is for officials *not* to notice socio-technical research but for them simply to adopt what I would hope become mainstream ways of thinking about the energy system. From there, normal policy processes can continue but with the new description of new problems and new options opening-up to address them.

Do I have a 'cognitive and representational' understanding of research policy's role? Yes and no. Insofar as policy research is (I would argue) necessarily cognitive and representational (in account of a need for it to try and represent an invisible space and to do so to inform reasoning about policy action) I agree, there needs to be this kind of socio-technical research. However, I reject the notion that this is the only form or research I hew to. In large part, my realisation about the need for this new kind of research paradigm stems directly from my interactions with interpretivist social science of energy and critical theorists (e.g. Elizabeth Shove, Tom Hargreaves, Dale Southerton, Evelyn Ruppert in the UK). I understood that these ideas could be transported into the realm of policy, and in so doing gave rise to my position in my original paper of this section [5]. I would contend that socio-technical

research should be able to make sense of the interpretivist thinking insofar as it can start to operationalise those ideas in policy-oriented research that must take account of the physical characteristics of the context. Indeed, one might even extend the notion that socio-technical research can serve as a missing interface between social theory and interpretivist approaches with energy policy analysis to say that it may also be the place where physics of energy research and social theory can interact.

Have I used a narrow understanding of the policy arena? Yes, I have – and on purpose. I do focus on national policy making institutions as the core arena. This is mainly due to my own background expertise in them, but also due to the strategic ground they hold. Typically, the central government departments hold significant funds for investing in energy policy area – much more so than any other single actor. As such, affecting their way of seeing the world arguably has the knock-on effect of affecting how other actors in the arena see the world. So the focus is, I argue, a strategic one, not a result of tunnel-vision.

I note that Castree and Waitt [2] point out what might be a parochialism to my analysis – that the use of social practice theory in the Australian policy arena indicates a relative success of this approach in that context. I applaud that work and am eager to understand more of what Strengers and colleagues are doing in that regard. However, I wonder to what extent their success is due to them interacting only with consumer groups outside of the Australian Department of Environment and Energy (DEE)? Is the fact that the example is not with the DEE further (empirical) confirmation of my original proposal?

I wholeheartedly agree with Castree and Waitt's highlighting the need to consider Barry et al's notion of 'ontological logic' [6]. I am very interested in seeing more of this in practice, and finding out about Waitt's work in this area. It is heartening to see work being undertaken: this helps to demonstrate to policy and research colleagues working in other jurisdictions what is possible. Likewise, the notion of 'socio-hydrology' evoked by Castree and Waitt (and distinctly reminiscent of Stern's 'human-environment interactions science' [7]) also represents a space to learn and explore new research practice in related interdisciplinary domains.

Galvin

Galvin's [8] response highlights the deep philosophical questions that underpin the issues at stake when looking to bring physics into social studies of energy. The nature of reality from a physics perspective can be seen to contrast with the nature of social reality: causal logics may differ considerably. I think this is an important area to surface and one that I barely touched on in my original paper, except to say that the underpinning philosophical world view needed to support a socio-technical research enterprise is something like Bhaskar's critical realism [9]. This is a description of the nature of reality that seeks to overcome historical conflicts between logical positivism (and related perspectives) with hermeneutic and interpretivist perspectives. This is achieved by taking a layered description of reality and recognising the role of emergent properties. Crucially, the distinction that Galvin sets out between a mechanistic, deterministic physical world and a spontaneous, non-deterministic social world may not be as clear cut as he seems to presuppose. But that may be an issue to discuss at another time, in another journal.

Perhaps more importantly, Galvin recounts the role and history of social practice theory approaches as they have applied in energy policy settings. From what I read, Galvin is broadly accepting of my main premise that physics can be introduced into studies of energy – and recounts studies where he has undertaken, like Mazur and others studies which talk to my concern. What Galvin doesn't directly address in his analysis – but is perhaps visible in his research is the extent to which the inclusion of physical science in social practice studies has the effect of changing the way in which physical science data are collected? This latter point is something I am keen to explore further with colleagues to understand whether socio-technical research can be executed simply as a well-co-ordinated dance between the two disciplinary streams or whether in considering them in tandem each stream changes the approach of the other? This is the contention at the heart of my paper with Jenny Love [10], but I don't yet know how widely the ideas developed there apply.

One of the challenges that social practice theory faces when looking to impact on policy (of any type) is the degree to which practices are, or may be, perspective dependent. I agree with Galvin in that this may not be too problematic if one sees the approach as lending a new set of heuristics to policy makers that reminds them to consider the inter-relationship between different physical and social elements when looking to appraise options or evaluate an intervention. In essence, I would see this as social practice theory redefining the 'ontological landscape' of energy, and thus giving rise to new units of analysis. These units of analysis can then be seen as the source of where new data can be harvested about what is happening in daily life that gives rise to patterns of energy demand. Of direct interest here then is also the degree to which notions of efficiency within physical systems analysis can adapt to these new system boundaries. This then gives rise to broader questions about how best to appraise policy options, and how such options, rooted in the ontology of policy departments might be constrained or disrupt the ontology of departments or ministries. Often I've raised the idea that perhaps we need a ministry, not of energy but of comfort or convenience – a point that Spreng [11] raises.

Mallaband et al

I was pleased to see Mallaband et al [3] contribution to this topic – theirs is work I have had direct contact with, and has influenced my thinking on this topic. Specifically, a workshop I attended on the social science aspects of the (Build)TEDDI programme they refer to gave me the insights about the nature of 'cross-disciplinary' working (discussed further in [12]) which suggested to me that *interdisciplinary* research might be critical here. The upshot of that thinking is visible in [10] and the extension of those ideas into the importance of such work for Type 2 impact on policy developed in my paper [5]. In many respects, I see myself as an early career researcher like Mallaband and colleagues, (at least in academic years) and so feel their (inter/cross-disciplinary) pain. Nevertheless, my point of departure for addressing some of the issues they raise is to say that perhaps a new endeavour, one that is not marginal but mainstream, is needed. Cross-disciplinary research is, by definition, a kind of no-(wo)man's land. Instead a new territory needs staking out – this is my main claim. With this new territory might come new journals, new career paths and perhaps even disciplines ('physical sociology', anyone?). A new discipline might be necessary if a distinct ontological

and epistemic perspective is required, which I think all of the respondents (and perhaps some not present, [6]) agree to be broadly true.

Mallaband et al [3], like Castree and Waitt's [2] call for more in depth qualitative work to understand how policy-makers access and utilised different forms of evidence. I have already agreed with that, but in so doing am silently also adding specific caveats – there is plenty of research that investigates the use of evidence in policy (e.g. [13]) but very little on the use of specific disciplinary modes within policy institutions where physical science concepts provide what I call an 'necessary vector' for delivering actual policy outcomes (i.e. energy, transport, environment and so on). Critical to any such study would be a deep, likely immanent critique [14] of policy documents, discourses and analytic heuristics built into policy document templates, meeting structures and organograms – alongside interview data. I see the data I provide as a kind of analytic autoethnography [15] which hopefully provides some acceptable evidence in favour of the hypotheses I present (and which I have explored further elsewhere [16]. That is to say, the proposition I outline in my main paper is not completely baseless.

While here, I want to reiterate the points I made at the top, to avoid any further misapprehension about the use of physical science units in the 2-page micro-study I described in my original paper. The point was to use the presence of physical units as a *proxy* for the 'real' treatment of physics. That is, the real treatment of physics has other qualitative elements (such as system boundaries, logic of operations of systems and components) which are not directly captured by a KWh. I simply wanted to show that the presence of physics in social science papers is not as common as in papers which have an ostensible policy impact orientation (proxied by publishing in *Energy Policy*). This relative lack of integration of physics is, to my mind a direct barrier to Type 2 impact. But crucially, the inclusion of physics in social studies of energy is only a necessary component to Type 2 impact. As Mazur [17] demonstrates – if there are too few researchers taking this aspect into account, then mainstream techno-economic perspectives will continue to dominate energy policy thinking. Consequently, we need *more* interdisciplinary research in this area, more Mazurs, Galvins, Mallabands, Stephensons, Sterns and so on, to reach a critical mass of research. Such a critical mass will minimise the risk of Mazur's books only being read by his children (and now me), and maximise the chances of the ideas filtering into the heuristics of energy policy makers. Of course, this is a house of hypothesis cards but it is supported by the way in which engineering and economics ideas dominate energy policy discourses even if engineers and economists (even those embedded within policy ministries) bemoan the degree to which policy officials ignore their advice.

Fundamentally, my goal could be expressed in these terms: we need to get away from or at least develop new and distinct metrics (like Stern, this issue) which have within them concepts from the physics of energy: socio-technical metrics (maybe the 'kilowattever' could be one such – it has my vote). Clearly without such metrics being in wide use I could not use their presence as indicators of impact in my micro study, so I needed to go with what was there. My approach therefore directly contrasts with Mallaband et al's [3] contention that '*how* energy is discussion is not the issue, rather … that it *is* discussed'. The *how* determines what is considered a problem (i.e. carbon-intensive heating systems mean

implementing a programme of insulation and heat-pump installation). An alternative way of discussing energy can open up just the sort of creative solution space that they refer to.

Finally, I also want to lay to rest any notion that I want *all* social scientists either to use more physics or to have more policy impact as Mallaband et al suggest [3]. I don't. I believe, like most of us, that our knowledge is useful for policy and want to set out a strategy for how that impact might best be realised and maximised. This means that some (and quite a lot more than is currently the case) social scientists adopt approaches that are being developed by Mallaband and colleagues, Stephenson, Stern, Galvin, Mazur and other researchers. Others should of course absolutely continue to do social studies of energy as they see fit. Energy Research and Social Science can continue to develop the 'safe space' in this domain.

Mazur

Mazur is broadly right to talk about (and perhaps to) himself. But perhaps more importantly we (social scientists of energy interested in Type 2 policy impact) should talk more to and with him (certainly the least we can do is order his book, as I have now done). Some of the difficulties that Mallaband et al [3] refer to and Stephenson [18] highlights in her imagined conversation are perhaps side-stepped by those carrying dual disciplinarity. But of course, dual disciplinarity is not the same as interdisciplinarity, even if it may be a necessary bedrock for it (or at least some forms of it). The conversations I attempt to have with colleagues who are physical scientists in UCL can bear witness to the difficulty of making progress when both sides of the conversation are not completely able to articulate in the others terms what they find problematic or interesting about the other's perspective. I imagine that if I did a degree in engineering, I would more rapidly identify the points of conflict and complementarity with social science perspectives on energy and therefore might undertake more disruptive research. Mazur's [17] story though is testament to my call for developing a critical mass of research. Part of this is because a critical mass simply creates more visibility for certain kinds of ideas and ways of discussing energy that therefore has greater chance of being taken up by mainstream policy thinking. But also the critical mass implies the generation of a mode of research which others can adopt and extend – which brings a kind of coherence to the picture of the energy system that can challenge the current coherent picture of it painted by systems models like Markal and UK Times. This coherent picture has to work at multiple scales and from a range of perspectives as energy policy operates at the individual level as well as at the national and international level. It works from the perspective of domestic, business, industrial and other perspectives. To cover all these angles requires a large number of researchers and a large volume of research.

Mazur questions whether I would consider per capita consumption of electricity (measured in kilowatt-hours) social or technical data. I would consider it socio-technical data, albeit perhaps a very basic example. The goal I would hope is to move beyond simply dividing KWh by number of people and to embed the social goal into physical units. I've regularly discussed the notion of 'well-being per KWh' with colleagues as a way of illustrating this, but never got worked out how to operationalise it (though Stephenson's approach, this issue, may well have some answers). The lack of relation Mazur found between consumption and quality of life may be a reflection of the lack of validity in combining available data as

discussed in [10] – without detailed discussion on these studies, I can't comment further. I'd consider the average number of blackouts per year in the U.S. Western Interconnection to be technical data, by the way, as it describes the behaviour of the physical system, even if implicitly there are social consequences.

I think I have dealt with Mazur's [17] claim that I am 'looking in the wrong direction' for impact on policy. Having been about as visible as it is to be with (mid-level) policy makers (the one's that actually *do* policy work [19]), and had a job of making social science visible, this easy diagnosis of "they can't see us, that's why they don't listen" doesn't explain my experience. "When they do see us, they can't listen" is my response because the language of our research doesn't fit with the epistemic demands of policy making. One response to that is to go all 'Type 1' policy impact, which I don't advocate personally. The alternative is to undertake a strategic endeavour that addresses not the symptoms of limited impact (lack of visibility, or rather, lack of *appearing* to be seen or heard) and address what I see as the cause (lack of *having reason* to be seen or heard). I of course completely accept that politics 'Trumps' evidence any day of the week. So-called 'alternative facts' can guide decision-making beyond any corpus of widely accepted high-quality research (social, physical or socio-physical). I agree that getting high-profile in front of senior politicians is important, but it is also a high-risk strategy that lacks long term resilience. Changing the nature of the way policy officials think about energy, as engineers and economists have done, is clearly more effective in this regard.

Spreng

Spreng [11] is close to the mark when he wonders if my approach has within it "a smart method to measure the transdisciplinary nature of social studies". Certainly, I would hope that one implication of my approach is not "a call for disregarding all that populated the huge dark room around traditional knowledge." I might go so far as to say that the idea is that physics probably can shed light on the rest of the room if physicists just cared enough to look at that dark area, the area that social scientists arguably are interested in. This is to some extent implicit in the approach described by the other respondents here, who have sought to integrate physics concepts in social studies with revealing insights.

Likewise, Spreng is broadly right in saying that "the Department for Energy and Climate Change… are more interested in machines and kilowatts than in, for instance, company structures because they prefer to work in a domain, where they are independent of sister departments?". There is certainly a natural tendency to silo-mentality in national government ministries. However, at the same time, there was significant interest in developing a knowledge base around how companies function, albeit one based on the MINDSPACE idea which draws from social and cognitive research on individuals. In the DECC-branded document I co-authored with fellow civil servants setting out the research priorities for DECC [20], I helped ensure that business models were up front. But I could only do that if such a position were widely held by policy officials in DECC with responsibility for those areas (p.14). But certainly, the framing that Spreng gives these issues, which touch on big political questions would certainly not be seen as DECC's domain of activity. It is for those reasons that we can think of the recent shift from DECC to BEIS (Department for Business, Energy and Industrial Strategy) as potentially a positive move in this regard.

Further, I wholeheartedly endorse Spreng's analysis of my paper as a call for more transdisciplinarity. This means including engineers of energy in the equation because they are a necessary part of the evolution of energy systems. Without their collaboration in this enterprise, policy making will continue along the same path, serving the same epistemic interests. Since policy officials rely – not exclusively, but significantly – on engineers advising on how to think of the energy system, it makes sense to first transform engineering thinking as part of a strategy to change policy thinking.

Stephenson

Stephenson's [18] eloquent dialogue between a social scientist and a physical scientist. One that I (and no doubt my colleagues in the UCL Energy Institute) would certainly recognise. I think I could write a similar dialogue between an energy engineer and a social scientist, such as those I was party to when helping the UK Energy Technologies Institute develop its research call for a Smart Systems and Heat, Consumer Response and Behaviour programme[1]. My bugbear in this space is the degree to which the human and social elements tend to be treated in what might be called one- or two-dimensional terms. People are often seen as static recipients of energy services, they have 'requirements' to be met. While there is a certain truth in this, the over-extension of this idea tends to mean that engineering thinking forgets the dynamics and diversity and responsiveness of humans to their physical environment. Likewise, there are physical scientists I've encountered in policy environments who appear to believe that the execution of social science is so easy, they can do it independently of social scientists' advice. These kinds of barriers (similar to Mallaband et al's experiences [3]) are often a hurdle to the sorts of interdisciplinary conversation that Stephenson so rightly highlights as important.

What is also extremely important and underpins Stephenson's vignette is that while there is an openness and humility (mainly on the part of the social scientist learning some physics) on both sides, there is also a socio-technical theory that provides a platform for interdisciplinary research. Stephenson's 'energy cultures' approach presents what I have elsewhere proposed as a necessary aspect in the development of socio-technical – as opposed to social and technical – research [10]. What Stephenson so helpfully provides then is both a model for conversations and interactions across disciplinary streams and a theoretic framework that may help researchers progress further and more rapidly along this track. This sits alongside other approaches that might be considered in this area, such as Galvin's use of social practice theory, or even the adaptive thermal comfort model [21]. Stephenson et al's [22] framework is perhaps particularly promising though for its incorporation of systems thinking in an explicit attempt to avoid modelling the system "as a melange of co-produced outcomes" (p.6121). This for me, represents a crucial aspect in theorising socio-technical systems for policy and about the idea of drawing knowledge intelligently across the domains of physics and social science including Latour's Actor Network Theory [23] and is therefore among the most promising of socio-technical approaches.

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[1] See: http://www.eti.co.uk/programmes/smart-systems-heat/consumer-behaviour-study . Accessed 31 January 2017.

Stern

Stern [7] sets out situations when physical units are or are not central in generating energy policy impact. I would take issue with the notion that "social science energy research can make useful contributions to policy… without needing to reference physical energy units" as being contrary to my argument. I did originally state that social science *sans* physics can and does have impact – albeit Type 1 impact. The tendency is to use social science as a means of deploying a variation of the original 'Decide, Announce Defend' strategy to 'Decide, Announce, Persuade' as many others have noted. In the UK for example, despite ground-breaking work on NIMBYism by Patrick Devine-Wright [24] and despite Patrick being on the DECC 'Social Science Expert Panel' and me having direct conversations with the national policy lead for energy infrastructure planning about the upshot of Patrick's work for them, no visible policy change in infrastructure planning has ensued. There are myriad reasons for this that are likely not to do with the use of physics in social sciences, but the persistent doubt in my mind is that those working on large-scale infrastructure policy just don't see social sciences as relevant to their work. This causes me to think that either you change the social science so it is more relevant (i.e. do social acceptance surveys or run deliberative workshops as forms of consultation to potentially persuade communities about agreed policy) or change the way of thinking of officials. I am reminded of the Director of Strategy in the UK's Nuclear Decommissioning Agency giving a talk at DECC one afternoon proclaiming that the problems he faces are not where or how big to dig the hole, but how to deal with the communities affected by it. He needed sociologists more than physicists or engineers he said. When I asked how many they employed, he answered 'none'. There is something missing when good social science is clearly in front of the right energy policy making officials and yet it is not taken on board in any meaningful way. This is completely consistent with Stern's experience [7].

Stern identifies two rules for increasing influence that I tend to agree with: i) identify physical energy savings and target the biggest impact; ii) identifying how the 'behavioural plasticity' can be maximised. However, the danger of using just those two rules is that the social science becomes trapped in the techno-economic ontological landscape: the peaks of greatest energy use are commonly defined in these terms. Part of the goal of a new interdisciplinary approach is to define new peaks in this landscape – ones that are important both to people and to the energy system. For instance, in Stern's terms the technical potential of a specific action might be small indicating limited reason to address it. But if this technical potential is counted in a way that conforms to standard techno-economic thinking (e.g. the small spike of energy use when making a cup of tea) then the broader socio-technical potential of the practice is missed – millions of teas made almost simultaneously according to synchronised practices of television watching is one example that illustrates this – possibly Galvin's plant pots and windows another. Indeed research on lifestyle analysis of household carbon emissions suggests that such a reframed ontological landscape is an essential first step (see for example [25 p.2079, figure 9], though this particular example clearly suffers from trying to layer a sociological approach onto techno-economic data using complex modelling techniques. Put another way, should we focus on how much electricity a kettle consumes or how much tea-making consumes or how much relaxation and socialisation practices draw on (or not) different types of energy. My preference is to go

for the latter (two), whereas technical energy research sucks the unsuspecting social scientist into the former, by virtue of what's easiest to measure and what's most obvious in energy engineering terms.

Perhaps the most important aspect of Stern's response is his highlighting of the 'reasonably achievable emissions reductions' RAER unit as a 'physical-social unit'. The only pause for thought this gives me is a classic critical realist one: 'reasonably achievable' for whom? Under what circumstances? This is not to play down the importance of concepts like the RAER but to open them up to scrutiny and build on them so that robust, defensible units that do reflect multiple and dynamic socio-technical realities can be captured just well enough to aid better energy policy making.

Despite some misgivings about the underpinning psychology offered up, I generally agree with Stern's analysis. I'd rather compare the social (psychology) scientists to attractive and productive bees (rather than drunks) searching for answers only in flowers and not considering other plants or other materials important to their area of interest (and livelihood). An analogy that I hope not only illustrates my position but also helps endear me to the wider community. I'm both a social and sociable scientist, after all.

Concluding comments

I've clearly not been able to do full justice to all the responses to my original article. But I hope we have all been able to do justice to an important issue within the social studies of energy. The overlapping territories of impact and interdisciplinarity – especially as they intersect with the borders of social and physical sciences – we encounter all kinds of strange and wonderful sights. I am just one explorer among the group, and not in the vanguard either. I have been enriched by taking part in this debate here, and I hope the others have too. If I can use my experience and expertise to augment the work of so many others in this field, I will. And I hope many of you who are new to this will join in too.

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