Responding to the Millennium Project's Energy Challenge: A Futurist's Perspective

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Abstract

The Millennium Project poses the question "How can growing energy demand be met safely and efficiently?" From a perspective grounded in critical and epistemological futures inquiry, this subsumes three further questions: 1) what is the nature of our changing energy demand; 2) what might it mean to meet this 'safely'; and 3) what might it mean to meet our demand 'efficiently'? These issues must be grappled with if we wish to address the framing question comprehensively. This leads beyond an instrumental approach to our energetic challenges focused on energy sources and conversion technologies, by sweeping these within a higher-order approach based on developing the institutions through which we mediate between human aspirations and energy use. From this institutional viewpoint, we may well serve our collective interests better by making the design principles of safety and efficiency subsidiary to those of resilience and sufficiency.

Keywords: Millennium project, state of the future, energy demand, energy use, epistemological futures study, contradictory certainties, participatory process, institutional development, World Energy Outlook, unconventional gas, peak oil, EROI, resilience, sufficiency, efficiency, rebound effect, environmental benignity.

Introduction

This article is based on a contribution to the joint submission from the Australasian Node of the Millennium Project for the 2011 State of the Future report. It responds to the 2010 report's section on Challenge 13 that poses the question "How can growing energy demand be met safely and efficiently?" While the Millennium Project draws contributions for its annual *State of the Future* report from a broad range of disciplines, the report itself is presented principally as *futures research*. This sets the overarching disciplinary context within which we should make sense of the initiative's research questions and its findings. Slaughter's (1999) four-level model for locating futures work, running from *pop futurism* (level one) through *problem-focused futures study* (level two) to *critical futures study* (level three) and finally to *epistemological futures study* (level four), provides a widely-recognised set of benchmarks that can aid such sense-making. The utility of the model extends well beyond this also—by providing a basis for evaluating responses to questions such as the one posed in Challenge 13. Perhaps most importantly though, it can act as a guide to the *formulation* of high-quality responses in the first place, by helping circumvent futures work "*which misses the shaping significance of socio-cultural foundations,* [and that hence] *will be seen, increasingly, as naïve and superficial*," thereby missing "the richest opportunities for problem-solving, reconceptualisation and cultural renewal – a renewal that cannot be identified merely by changes in surface structures" (Slaughter, 1999, p.145). Describing in greater detail the model's utility, Slaughter (1999, p.146) provides a sense of how it might be applied in the present context:

> As one moves from level one to level four, so an increasingly rich array of options present themselves. At the most superficial level, one remains imprisoned by unregarded 'givens' and unstated assumptions. It is true that the deeper one goes, the more demanding the work. But, equally, greater scope exists to look freshly upon assumptions and meanings, which appear natural and inevitable, but, in fact, are not so. At the epistemological level, futures work merges imperceptibly into the kind of fundamental re-thinking which is clearly philosophical in character and orientation; one of the key bridges between futures work and the older, better-established disciplines.
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> These are welcome developments. For it is here, in the foundations of culture, that all 'world problems' have their origins. Equally, 'solutions' will not emerge from ill-founded analysis or superficial tinkering: they will not grow from media hype or pop futurism; they will not result from empirical/analytical work which ignores the foundations of the social order. *Effective solutions will involve deep-seated shifts of perception, value and understanding, at the deeper levels.*

Taking Slaughter's model as our benchmark then, it's apparent that a high quality response to the Challenge 13 question entails engagement at the level of critical and epistemological futures inquiry. In practice, this must commence by considering the assumptions—and the knowledge systems within which these are established—underlying the question itself. With this in mind, the headline question subsumes at least three further questions that we would need to come to terms with in formulating an adequate response: 1) what is the *nature* of our changing energy demand; 2) what might it mean to meet this 'safely'; and 3) what might it mean to meet our demand 'efficiently'?

These questions are interconnected—they can be regarded as constituting a system of mutual influences. What we might consider as an adequate response to any one of them has consequences for the adequacy of our responses to the other two. Moreover, what counts as adequate is very much a matter of the perspective we bring to the questions and their interpretation. These are not just technical questions with a convergent problem-solution structure; they are questions with ethical and aesthetic dimensions: our responses should not only be technically feasible, but aesthetically desirable and ethically defensible (Bawden, 2000), if they are to have systemic integrity. Grasping comprehensively the situation to which the questions relate requires that we embrace that situation's multi-perspectival character—the way in which our perception of the situation depends on how we look at it. In light of this it's clear that a *comprehensive* response to Challenge 13 in the Australian context—one that does justice to the Challenge's very significant nature—is beyond the scope of an article from a single author. I offer here instead a brief discussion of the matters that require exploration in greater depth on the way to offering a response to the framing question that might be considered adequately comprehensive.

Before proceeding with this though, I note that the question of how such exploration might be conducted opens up a new way of interpreting the Challenge 13 question itself. At first glance, the question "*How* can growing energy demand be met safely and efficiently?" seems to invite a response in *instrumental* terms. Indeed the 2010 State of the Future report, with its principal focus on speculative primary energy sources and conversion technologies, suggests that such an instrumental worldview might be close to the one from which the authors themselves write. An alternative interpretation, however, entails approaching the *how* question in *institutional* terms, in a manner similar to that found efficacious by Thompson and Warburton (1985) in grappling with environmental problems in the Himalayas—and of a 'Himalayan scale'.

Thompson and Warburton found that it was literally impossible to establish in an overarching way the physical facts about the environmental condition of the Himalayas. Expert estimates in relation to given key indicators differed by such large factors that no meaningful overall assessment could be made. The researchers were dealing with what they termed *contradictory certainties*, arising from a situation in which "each organisation has its own definition of the problem: one that contradicts all the others and…is increasingly thrown into contention" (Thompson & Warburton, 1985, p.4) and where "the problem is to know that the problem is" (p.33). Their response to this was to embrace the situation. Recognising the institutional limitations to the success of top-down development *projects* focused on technology transfer, they attended instead to bottom-up development *process*. This involved working out how to allow "diversity, redundancy, duplication and overlap," the institutional enablers for "learning, flexibility and opportunistic adaptation," within an intra-agency environment that sought to avoid these sources of uncertainty through high-level integration and coordination (Thompson & Warburton, 1985, p.31). A similar approach to interpreting the Challenge 13 question opens up the opportunity to bring the present emphasis on *techniques for manipulating matter and energy* within an encompassing approach that prioritises development of *participatory techniques and institutional capacities for negotiating the relationships between our present values, future aspirations and the social, economic and natural capitals available to us*.

The Nature of Our Changing Energy Demand

The convention of considering energy use associated with our economic arrangements and the ways of life they enable in terms of 'energy demand' and 'energy supply' often leads to these being treated as if they are effectively independent phenomena. Energy supply and demand can be more effectively understood as two aspects of a *duality* (Ison, 2010). One advantage of maintaining awareness of the duality is that 'energy demand' need not necessarily be addressed through 'energy supply' alone—after all, from a human existential perspective, rather than an industrial economic one, it is the quality of life benefits enabled by our energy use that we 'need', not energy use per se.

Living in ways that demand less energy use has a particularly important role to play in affluent countries such as Australia (Wilhite & Nørgård, 2004). In fact, in many instances this provides the most direct path for addressing the concern for safe and efficient responses. As I'll discuss a little further on, comparing the safety and efficiency of different energy supply technologies can be a fraught endeavour. Making the case for environmental benignity and resource efficiency of conservation measures, on the other hand, is less prone to controversy.

This entails thinking about future energy demand *in the context of* future energy supply. Traditionally we have tended to go about this in the reverse: we consider supply in the context of demand (Nørgård, 2000). For instance, we forecast demand and then plan supply systems on the basis of those forecasts. Available supply options (or those supply options that we prefer, for example on environmental grounds) have important implications for what we should expect in terms of energy availability, and hence the demands that we should reasonably make on our energy systems. This is not just a matter of technology—the characteristics of our primary energy sources are critically important here.

Current demand patterns have evolved in the context of particular primary sources and associated conversion technologies—we tend to assume though that it is reasonable to expect the same demand patterns to be met by alternative primary sources and conversion technologies. That is, we treat our demand patterns as given or inherent, rather than as a matter of contingent social (and techno-economic) construction. Industrial civilisation's evolution in the context of cheap, convenient and energy-dense fossil fuels means that our established expectations have their own historical path dependence. But our demand patterns, as social and techno-economic constructs, are subject to evolutionary change. To date, this evolution has largely taken the form of gradually increasing magnitude. This historical pattern need not necessarily determine future evolution of demand. While it may presently be politically unpopular to discuss moderating our demand, or changing our expectations to fit better with, for example, availability of renewable energy sources, this is not inherently precluded.

Moreover, growth in energy demand presupposes general growth in economic activity—and growth in economic activity is dependent on appropriate resource availability, especially energy resources. So questions related to meeting growing energy demand are inextricably interconnected with questions of resource availability. A global energy system founded primarily on non-renewable primary energy sources that are subject to depletion has critical implications here—these conventional energy sources are themselves necessary for developing the safe and efficient energy infrastructure that Challenge 13 is seeking. In parallel with this, a resilient global economic and financial system is required—large financial investments are needed, and so capital must be available. The ongoing vulnerability of global financial health, stemming primarily from poorly regulated public and private sector debt expansion (Keen, 2011) but also including that associated with high and increasing oil prices, has important implications here.

A best-practice futures approach would entail questioning the assumption of *inevitable* long-term growth in energy demand. Instead, as futurists we should ask questions such as 'under what circumstances might energy demand continue to increase?' and 'under what circumstances might energy demand decrease?' The variable circumstances to be considered here would necessarily include the particular time horizons in which we're interested—for instance, whether we envisage demand increase or demand decrease might depend on whether we view two years or 200 years as the appropriate timescale on which to consider matters of this nature. We need to understand the systemic influences on energy demand, and we need to appreciate the associated uncertainties. This leads to thinking in terms of multiple possible and plausible futures—doing so would provide a robust response to Challenge 13.

The perspective on future energy demand presented in the 2010 State of the Future report draws on scenarios developed by the International Energy Agency (IEA) and published in its World Energy Outlook (WEO). Scenarios are intended to illustrate a range of plausible futures, rather than predicting precisely what will unfold. Given this, in order to properly understand how the IEA authors perceive the uncertainties associated with their forward view, we would need to see the full scenario set. Abstracting individual figures from a single scenario and using these in isolation is problematic—the background context within which the figures were originally developed is critical to making sense of what the originators had in mind.

The practice of considering multiple possible futures is of course relevant to all dimensions of global change that we might consider significant. For instance, the relationship between energy use and population magnitude is highly relevant to future human prospects (Smil, 2010). Accounting adequately for the relationship between population size and energy demand requires that we treat the relationship systemically. That is, while on the surface it may appear that energy demand would be a relatively straightforward function of population size, population scale is itself subject to the nature and scale of available energy sources. Useful population projections thus need to take into account energy resource availability, and associated limits—as illustrated for instance by the *Limits to Growth (LtG)* study (Meadows, Randers, & Meadows, 2005). As the *LtG* authors made clear, while resource abundance can support population growth and hence growth in energy *demanders*, overshoot of resource limits leads to commensurate population declines. While *LtG* looked at the prospects for contemporary human society and is therefore subject to the caveats of all such model-based futures research, the general findings are consistent with those of Tainter's study (1990) into the historical decline of complex societies that provides many precedents for the overall behaviour anticipated by *LtG*, should we continue on our present path.

Moreover, as Smil has demonstrated (1994; 2010), understanding the relationship between population and energy demand requires that we consider not only overall population size, but the extreme variability in *per capita* energy use. For similar outcomes on a range of measures for both quality of life and standard of living, the differences in average energy use between residents of contemporary Japan and Europe on the one hand and the USA on the other are telling in this respect, with a factor of as much as two separating them. That is, to appreciate the relationship between the number of energy *demanders* and overall energy *demand*, we need to know about much more than gross population numbers: we need to know who those people are. The differences in per capita energy use amongst contemporary societies demonstrate that there may well be greater scope for variation in global aggregate energy demand on the basis of ways of life than on the basis of population size alone. It is just this sort of context-sensitive consideration that the discussion I've presented here is intended to encourage.

At this point—and again reflecting good futures practice—it seems prudent to note more generally the dangers of relying exclusively on 'official' data sources as the basis for thinking about future energy supply and demand. To appreciate this, we need only to consider the controversy surrounding Saudi Arabia's apparent overstatement of its crude oil reserves (see for instance Tverberg, 2011). While the IEA is widely treated as the default source for energy-related data, there is no particular basis for treating it as having *ultimate* authority in this area (Friedrichs, 2011). Critique of the 2010 WEO published at The Oil Drum highlights the limitations of what might be termed 'the IEA worldview' (Tverberg, 2010). One clear technical gap with the IEA's work is the way in which it treats different primary energy sources as equivalent on the basis of gross heating value, without acknowledging that net end use energy available after energy costs of production, conversion etc are taken into account differs markedly between sources, conversion technologies and supply systems. While the IEA is not alone in aggregating data in this way, the scope of its influence means that blind spots in this area could have very significant adverse implications. This alone is a strong reason for subjecting its data to critical scrutiny.

The pitfalls of assuming equivalence and interchangeability of physically distinct energy sources are well illustrated in relation to the increasing global attention to unconventional natural gas (primarily shale gas and coal seam gas). In its Golden Age of Gas Scenario in the 2011 World Energy Outlook, the IEA projects global primary energy share from natural gas rising to 25 percent in 2035, with 25 percent of this coming from unconventional sources (International Energy Agency, 2011). Total natural gas supply is presented by simple aggregation of conventional and unconventional production. In the 127 page report, there is no mention of either net energy or the related measure, Energy Return on Energy Invested (EROI)—no distinction is made between gas produced from different source media on the basis of the relative amounts of energy required for production, and of what this therefore implies for available end use energy. Yet recent EROI research indicates unconventional natural gas in the United States is several times as costly to produce in energy terms as is conventional gas (Sell, Murphy, & Hall, 2011). This has profound implications for the prospect that unconventional gas might in the longer term substitute for conventional gas's role in fuelling complex industrial societies. For unconventional gas to replace depleting conventional gas, many more wells are required, with the attendant infrastructural and institutional complexity that this implies. Even in the event that global recoverable reserves reflect anything like the '100 year-supply' recently touted for the United States—and this appears highly uncertain, if not outright contentious (Nelder, 2011; Sell, Murphy, & Hall, 2011; Urbina, 2011)—depletion rates for each well exceed those for the conventional wells that they might replace, while demanding an increasing proportion of the overall energy provided in order to maintain a given net supply. It's worth noting that Sell, Murphy and Hall's 2011 analysis in relation to production costs of unconventional gas in the United States seems out of step with current low gas prices in that market—one might assume that higher production costs relative to conventional gas from mature fields would require higher gas prices to be economic. On this basis, it seems that the work of Sell and colleagues might support the view that the recent flood of investment in unconventional gas represents a speculative bubble, with holders of shale gas rights subsidising supply of gas below cost in order to satisfy market and regulatory production schedule requirements (Urbina, 2011).

The implications of this for any suggestion that unconventional natural gas might have a significant role to play in mitigating the impacts of peaking conventional *oil* production—and therefore postponing attendant declines in levels of social complexity that can be maintained (Tainter, 1995)—will hopefully be apparent. While the unique characteristics of our principal primary energy sources mentioned earlier—

low cost, convenience, high energy density—apply in degrees to all fossil fuels, it is its convenience that marks conventional crude oil as especially important, and that differentiates it in functional terms from coal and gas. In practical terms, this convenience manifests in the ease and relative safety with which conventional oil can be stored, transported and transformed into useful products, including the fuels upon which the vast majority of our transport infrastructure depends. It is in relation to the global transportation task that this convenience finds its most significant expression. The enormous infrastructural legacy supporting our transport expectations could not be shifted to a different fuel without commensurately large reinvestment in new physical capital. This has major energy demand implications. Consider, for instance, what would be required to fuel a significant proportion of this transport task with natural gas: either a) the prime movers (along with their fuel distribution infrastructure) would need to be modified or replaced in order to run directly on compressed or liquefied natural gas; or b) massive new gas-to-liquids processing capacity would be required, in concert with changes to prime movers to allow operation with such fuel. Either way, net fuel energy at point of use would be significantly less than gross primary energy associated with actual gas production, and it seems reasonable to expect that the proportional difference would be substantially greater than for present transport fuels. With this in mind, we might do well to move beyond simply conducting energy-related discourse in terms of the more abstract concept of overall *energy* demand, considering our situation instead in terms of specific *fuel* demands. By continuing to account for primary energy sources in terms of gross energy content, we obscure all of these critically important nuances.

Limitations associated with failure to account for such nuances notwithstanding, the IEA's outlook does continue to evolve, recognising for instance in its Key Graphs for the 2010 WEO the peaking of conventional crude oil in 2006 (International Energy Agency, 2010, p.7). Even here though, contestable assumptions about production rates such as those used in its earlier WEO 2008 (Aleklett et al., 2010) mean that the value of the analysis is very much dependent on the degree of critical scepticism that a reader brings to its interpretation. IEA Chief Economist Fatih Birol's more recent expression of concern about the absence of response from governments to the peaking of global conventional oil production (Newby, 2011) is particularly noteworthy given that the 2010 State of the Future report makes no reference to depletion of non-renewable resources—conventional crude oil in particular—in discussing Challenge 13. This clearly has fundamental implications for global capacity to support present energy demand, let alone future growth in energy demand. The implications for our ability to replace fossil fuel-based infrastructure with renewable energy infrastructure might be regarded as even more alarming: the declining EROI accompanying the depletion of our easily-accessible crude oil continues to erode the net energy surplus upon which such a transition depends (Hall, Balogh, & Murphy, 2009).

What Might it Mean to Meet Our Energy Demand 'Safely'?

In the 2010 State of the Future report we read that "Challenge 13 will have been addressed seriously when the total energy production from environmentally benign processes surpasses other sources for five years in a row and when atmospheric CO_2 additions drop for at least five years." So two criteria are provided for what is considered 'safe' in the context of the Challenge: the first relating to 'environmental benignity' in general; the second specifically based on CO_2 emissions associated with meeting energy demand.

The report refers elsewhere to estimated financial investment associated with keeping CO_2 concentration below 450 ppm. It's not immediately clear though that satisfying the report's second safety criterion would lead to stabilisation of the total atmospheric CO_2 stock at such a level—for this we would need to consider target aggregate emission rates, not just the direction and duration of changes in these rates. Moreover, dissensus rules in relation to the atmospheric CO_2 stock that might be considered 'safe'. Consider for instance arguments advanced by Rockström and colleagues for reducing atmospheric CO_2 from the present level to below 350 ppm (Rockström et al., 2009). Not only is this question of safety subject to differences in perspectives between particular individuals or groups, these perspectives are themselves subject to change in the face of evolving knowledge systems. An example of such evolution with particular relevance to how we might understand conceptions of safety can perhaps be seen in the questions raised by analysis from Alkelett and colleagues (Höök, Sivertsson, & Aleklett, 2010) regarding the validity of fossil fuel production expectations upon which the fourth IPCC assessment's emissions scenarios are based. Add to this the fact that energy conversion and use is only one domain contributing to anthropogenic GHG emissions, and the uncertainty relating to notions of 'safety' is further amplified.

The criterion of 'environmental benignity' also invites close scrutiny. All energy conversions entail environmental impacts—it isn't apparent that *any* of these could necessarily be considered 'benign' for all possible indicators (Fisher, 2004). On the other hand, alternative systems for providing a given end-use energy supply *can* be compared against one another on a range of specific life-cycle impacts. By arriving at some agreement for the impacts that should be considered, and the weightings of different impacts, it is certainly possible to arrive at an opinion on the *relative* benignity of various systems. The critical question here though relates to how such *agreements* should be arrived at in the first place—it is *these* agreements (agreements about agreement) that are often the most challenging to reach. Agreeing on the actual impact levels may be the least contentious part of the process. As with CO_2, making sense of 'benignity' seems likely to be characterised by dissensus.

The scope for dissensus in relation to 'meeting energy demand safely' seems to support well a view that the strength of our participatory decision making processes and our capacity for dealing together with both risk *and* uncertainty is just as important in responding to Challenge 13 as the particular technologies that might be employed.

What Might it Mean to Meet Our Energy Demand 'Efficiently'?

The 2010 State of the Future report doesn't specify criteria for assessing 'efficient' satisfaction of energy demand. What we mean by efficiency isn't a trivial matter: the way that we understand it has profound implications for energy use and hence for the demands placed on associated resources. For instance, efficiency conceptualised in terms of minimising the primary energy use needed to meet acceptable quality of life conditions at the national or even humanity-wide scale is very different from efficiency conceptualised in terms of minimising end-use energy for providing some desired service at the personal scale. Efforts to pursue efficiency in the latter sense do not necessarily translate into desirable outcomes in the former sense. A critical factor in this is the influence of rebound effects. These are often dismissed in relation to specific situations such as the overall fuel use associated with introduction of more fuel efficient motor vehicle designs. At the aggregate level though, increasing economic productivity of energy use enables expanding economic activity overall and with it increasing use of primary energy sources (Alcott, 2005, 2010; Brookes, 2000; Herring, 1999, 2006; Madlener & Alcott, 2009; Nørgård, 2006; Smil, 2010). This is particularly significant for highly industrialised countries such as Australia where our energy use already exceeds what is required to live well (Smil, 2003, 2010). Despite continually increasing energy efficiency of individual end-use devices over many decades, the proliferation of energy use applications that this enables is accompanied by ever increasing primary energy use.

With this comes rising pressure on the health of our natural systems, with all that this entails for meeting our safety criteria. If we are to meet energy demand both safely and efficiently, we will need to pay very close attention to the way that these aspirations interact. While on the surface safety and efficiency might appear complementary, this seems to depend on how we understand the two concepts in the first place.

In light of this, it would be valuable to consider other ways of characterising the desirability and ethical defensibility of energy systems. If a narrow focus on energy *efficiency*, without sufficient attention to the broader contexts in which this is pursued, can lead to the exploitation of our primary energy sources at higher rates overall, thus depleting non-renewable resources faster and increasing stress on biological systems, then perhaps we would be better off thinking about how to achieve energy *sufficiency* (Wilhite & Nørgård, 2004). Such an approach would recognise limits both to resource availability and to environmental capacity for coping with the consequences of resource use, and would involve establishing bio-physical boundaries within which the human pursuit of happiness might proceed. From a futures perspective in which the temporal dimension of planetary-scale wellbeing is particularly valued, this on its own may be a necessary but insufficient design criterion. To the sufficiency criterion we should perhaps add that of meeting our energy demand *resiliently*—that is, in ways that favour persistence, adaptiveness, variability and greater capacity to accommodate unpredictability (Gunderson & Holling, 2002).

Conclusion

In advocating for such a revised perspective on the energetics of human society, I'm mindful that the Challenge 13 question was originally drafted in the mid nineteen nineties, and is now more than a decade and a half old. The Millennium Project tracks via its annual report the evolution of *responses* to each of its Challenge questions. Given the Project's longevity, perhaps there would be value in allowing the questions themselves to evolve in response to changing circumstances. After all, the global context in which the original questions were formulated was significantly different to that which we find ourselves facing today. For instance, at that time Laherrère and Campbell's Scientific American article (1998) that brought into popular awareness the phenomenon of peak oil, previously little known beyond the ranks of petroleum geologists despite its clear empirical demonstration in various territories, including most significantly the USA, was still some years away. With the IEA now recognising the global peak in conventional crude oil production to have occurred in 2006, we are clearly living in different times to those envisaged when the Challenge 13 question was formulated.

As I have outlined in this article, adopting design principles for our energy systems based on *sufficiency* and *resilience* would help to enable responses to our global challenges well aligned with Slaughter's criteria for effective solutions. This does not mean abandoning principles of efficiency and safety. Rather, it recognises that, if our approaches to dealing with society's energy challenges are to serve the higher order end of long term human wellbeing, then searching for technical means that provide safety and efficiency will need to become subsidiary to developing institutional means for sufficiency and resilience. The Millennium Project could play an important role in building appreciation for such higher order design principles, by reflecting them in its own research agenda. Doing so would help to ensure the continuing relevance of the State of the Future reports in a world characterised by challenges that themselves are subject to continuous change.

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