

Energy Innovation Policy Must Enhance Energy System Coherence and Adaptability

Submission to the Garnaut Review concerning [Issues Paper 4: Research and Development: Low Emissions Energy Technologies](#).

Summary

“Issues Paper 4: Research and Development” is focused on providing the public policy framework that is most appropriate for stimulating ultimately market driven innovation and commercial deployment of low emission technologies [LETs] suitable for timely mitigation of climate change.

We argue that such a framework will only function satisfactorily if it is underwritten by, and the design of its economic instruments adapted to pursuing, the goal of energy system coherence and the instruments furthermore ought to aim to ameliorate societal risk to energy supply security and costs.

Achieving these goals cannot be left to the purely economically regulated market (cf. p.4) because it is weak at achieving global coordination of these kinds, nor can it be left to private firms because of their multiple limitations, in knowledge, resources, risk-taking capacity, etc. Thus **pursuing these goals requires substantive energy-specific technical knowledge and planning tools complementary to the general economic tools currently contemplated by Paper 4**, and it also requires appropriate institutionalisation of the planning capacity they afford.

More specifically, the design of subsequent economic instruments and regulatory processes governing LET innovation and development should take as indirect goal that of sustaining suitable future access to a *sufficiently diverse but adaptably interrelated suite of coherent energy pathways*. This can be achieved through do-a-little-and-learn adaptive strategies - where the level of access to a pathway is relative to its risk and promise and the desired adaptability is specifically to the key energy sector uncertainties of resource availability, technological development, skills availability, and demand.

Appropriate characterisations of energy system-coherence and adaptability and a method for the substantive construction of portfolio-based, energy-specific adaptive strategies for societal energy risk amelioration are provided in recent work by Brinsmead and Hooker for the Cooperative Research Centre for Coal in Sustainable Development. Thus the work offers a methodological basis for putting the recommended approach into practice.

There must be a coherent, articulated interrelationship between the planning structure and the economic instruments so that the economic instruments support the adaptive strategy . The foci of competition, for example, should derive from those energy pathways evaluated as most promising and socially desirable (ie not necessarily merely short term profitable), and the form of activity accord to their development stage, including fostered international cooperation.

Note that this position does not in general mandate single specific technologies as 'correct' or 'winners', but neither is it indifferent to technological specifics; rather, the significance of specific technologies will depend upon both their physical characteristics as expressed in their roles within coherent, adaptable energy system designs and their risk-weighted promise. The situation is analogous to medical advice given by a doctor to a presenting patient that avoids both prescribing a single 'magic bullet' treatment (a 'winner') and offering only random experimentation (a 'neutral' treatment strategy), instead identifying a suite of preferred next tests and medication trials based on likely causes (cf. likely technological development possibilities) and risks of error, with learning directed toward resilient health (cf energy system physical coherence and economic resilience) as ultimate goal.

Brief Exposition

Adequate energy system management requires substantive energy-specific planning tools focused on the goals of energy system coherence and societal risk amelioration.

Energy system coherence. Energy provision has a larger systemic organisation that ultimately rationalises individual technologies. *First*, energy technologies make physical (and economic) sense only in appropriate pathways – for example, hydrogen fuel cell technology for transport remains an orphan until embedded in a pathway that begins with a commercial-scale supply of hydrogen, including its storage and transport, and concludes in its use in functional electric vehicles. Thus, policy measures should “join up”, not just across the stages of an innovation chain, (Issues paper 4, p4), but also all the way along an energy supply chain pathway.

Second, pathways show important mutual synergies and dysergies that affect energy (and wider economic) system performance – for example, co-generation and solar boosting of carbon capture of emissions (synergies) and agricultural biofuel production versus carbon bio-sequestration (dysergy). Solar photovoltaic manufacturing would be compatible with a semi-conductor electronics industry but synthetic liquid fuels would be compatible with chemicals production. These pathway-wide and pathway interaction effects on overall energy (and industrial) system (short run) performance are market externalities that are not directly addressed by carbon-emission focussed economic policy instruments (cf. Issues Paper, p3).

Societal risk amelioration. A *third* pathway design feature concerns technology interrelations that affect not just energy system performance, but key energy system (long run) adaptabilities, the ability for energy system infrastructure (both physical and social) to flexibly adapt to changing circumstances. For example, the disparities between oil-fuelled technologies for transport demand and nuclear electricity for stationary demand result in few adaptive interrelations between them. This is in contrast to biofuel technologies for transport demand and coal-gasified and photolytic hydrogen for stationary demand, where hydrogen gas-shifting, fuel cells, and a number of other technologies support adaptive shifts among resources, pathways and end-use technologies. These are only two of a set of systematic contrasts of this kind.

Design adaptability of this kind (or its lack) is an inherent feature of any energy system, but it needs specific enhancement in the present circumstances because of the unprecedented and fundamental uncertainties currently facing the energy system.

Crudely, these uncertainties fall into two classes. (I) Developmental uncertainties of energy technologies: almost all low-carbon technologies are still under development, their future maturational time, physical and economic performance all uncertain in significant respects, yet recent studies indicate that for most or all their mature output cost of energy will converge into the range \$50-100/MWh equiv., in the period 2015-25.¹ This produces a ‘decision bottleneck’ for conventional planning, since it is impossible to ‘pick winners’ by forecast methods. (II) Uncertainties in the larger environment of the energy sector: these include uncertainties in scarcity and price of

¹ See Wibberley, Louis, Aaron Cottrell, Doug Palfreyman, Peter Scaife and Phil Brown (2006), *Techno-Economic Assessment of Power Generation Options for Australia*, CRC for Coal in Sustainable Development, Technology Assessment Report 52, www.ccsd.biz

major resources, especially oil, gas and uranium; in the pace and impacts of climate change; in demand, from population pressure, rapid industrialisation and socio-political attitude formation; and in geo-political responses to all these given emerging new powers.

Finally, there is currently mounting conflict between the delay for learning required by the maturational uncertainties (I) and the need for immediate action engendered by the environmental uncertainties (II). This emphasises the difficult, often ‘knife-edge’ balanced, mix of opportunities and dangers inherent in the present decision environment (cf. balancing learning benefits, Issues Paper 4, p5).

As Issues Paper 4 recognises, the appropriate response to these uncertainties is to ensure risk/promise-weighted investment across an appropriate portfolio of options (combined with some form of learning and updating strategy). But these options must themselves amount to coherent designs if they are to serve their purpose, and they also must result in an adaptable energy system. If the flexibility potential promised by a portfolio is to be realised, there must be support for the possible timely expansion (or contraction) of its various components.

Unhappily, the competitive market is correlatively and inherently weak at ensuring global, long timescale, strategic coordination of this kind, and particularly weak at maintaining diverse “standing” development capacity in a portfolio of technology alternatives, under regulation solely for efficiency. (Consider, for example, the fact that the MRET has primarily boosted the demand for wind generators, a relatively mature renewable technology, but has had limited impact on the encouragement of other low emissions technologies.)

Nor would it be efficient or sufficient (and mostly not even feasible) to instead require individual private firms to invest in whole pathways or whole systems, principally because of their multiple limits – in knowledge, resources, risk-taking capacity, their rational reluctance to share information and skills, and so on – and the undermining market monopolies and premature technology entrenchment that would result should they anyway succeed.

Nor is Australia any longer in the position it once was to provide adequate institutional support for such planning. Where once planning was the assumed in-house function of large centralised public utilities, these have been broken up into competing fragments, often privatised, and they and other private firms have largely been stripped of technical and planning skills, and reduced to short-term decision horizons, in order to maximise immediate competitive efficiency. None of these consequences demonstrates error in these developments; nevertheless, it is essential that institutional support for the technically based planning capacity described here be created.

Because energy provision is fundamental to societal functioning and industrial development, it is thus in the national (and state) interest to ensure (i) that energy technology innovation and development options are pathway coherent and also (ii) that the collection of supported pathways has sufficient adaptive capacity to respond adequately to the key strategic uncertainties currently characterising the energy sector, thus representing a coherent risk-ameliorating strategy. Here responding adequately means utilising adaptive flexibility to maintain societal functionality through change while also taking full advantage of the industrial innovation and export opportunities that looming technological transformation offers.

It also means, conversely, being able to resist the natural market tendency to premature entrenchment of technologies in their then-current pathways through economies of scale, consumer habit and regulatory and political inertia (see Section 4.3, p6 of the Issues Paper), a tendency which discourages the maintenance of a portfolio. Instead, the public interest lies in continuing (though not necessarily large scale) support for adaptable access to a sufficiently broad portfolio of options as to fully capture the long term, post-transitional benefits of a high performance energy system.² Thus, the deliberate maintenance of an *appropriately diverse* portfolio requires a framework for characterising the appropriate range of portfolio option categories, specifically, they should be uncertainty relevant (across categories) as well as being pathway coherent (within them).

Moreover, energy businesses themselves require such a framework before they are able to properly plan operations, especially capital expenditure. It is not sufficient to provide only general economic incentives, because this leaves them without any assurances that their necessarily specific technological investments will fit into a usable, high performance, adaptable system, especially when the technologies are sufficiently long-lived that later asset stranding is a risk.

This planning framework represents a substantive (ie technology cognisant), complementary emendation to the framework contemplated in Issues Paper 4.

Issues Paper 4 is focused on the issue of providing the public framework that is most appropriate for stimulating ultimately market driven innovation and commercial deployment of low emission technologies [LETs] suitable for timely mitigation of climate change.

Aware of the dangers of trying to ‘pick winners’ among prospective energy technologies and of the general difficulties of government trying to operate an energy business successfully in complex conditions, Issues Paper 4 focuses on the design of tax incentive structures and other ‘2nd order’ regulatory economic features (cf. p4) that in themselves are intended to be ‘technology neutral’ in the sense of constituting a framework of measures that permits leaving all of the technology-specific decisions to the free operation of the market. An adequate system of such regulatory instruments is clearly crucial and in both public and private interests to achieve.

However, the preceding section has provided an argument that, left to themselves, these instruments will be inherently unable to sufficiently guide the development of the energy system so as to adequately satisfy either public or private interests. Rather, it is essential that any purely economic framework of technology neutral instruments should be complemented by substantive energy-specific planning tools capable of ensuring energy system coherence and societal risk amelioration. And the associated economic instruments should be adapted to supporting in this task.

In particular, economic instruments should be targeted insofar as ensuring that the portfolio of options encouraged has coherence, resulting in a) complete energy supply chain pathways and supporting infrastructure, and b) pathways that are sufficiently adaptably interrelated to result in flexibility of access to their timely expansion.

² The foregoing considerations make it clear that the Commission’s goal of long run cost minimisation (p.2) is a potentially poor one unless it is carefully formulated within an appropriate coherency and risk amelioration context, as indicated below, requiring something like the adaptive resilience methodology (cf. p.4, including at institutional level), advocated here.

Conversely however, the portfolio of options should also be appropriately diverse so as to support *pathway diversity* that enables availability of responses across the likely uncertainty range. This requires measures that are technology specific to some degree, since the relevant uncertainties include both future (technology conditional) resource availability and developments in (specific) interrelated technologies. Ensuring the existence of a diversity of energy supply pathways (including even some that are not currently commercial) at appropriate scales (including pre-commercial demonstration and/or pure research) represents a form of insurance at the society-wide scale. However, some degree of efficiency can be encouraged - and accountability maintained – by promoting competition *within* pathways and groups of pathways as they are developed. Accountability of the overall strategy (ie choices *among* pathways) could be supported by some degree of public involvement in shaping that strategy.

An energy policy methodology is now available that appropriately characterises energy system-coherence and adaptability, and outlines the substantive construction of portfolio-based, energy-specific adaptive strategies for societal energy risk amelioration.

To our knowledge a methodology of this sort has hitherto not been widely used by energy policy planners; recent work by Brinsmead and Hooker for the Cooperative Research Centre for Coal in Sustainable Development [CCSD] aims to correct this deficiency by providing the methodological tools for putting this approach into practice.

These tools aim to be technology and resource neutral or unbiased in the sense that they provide appropriate planning tools irrespective of the kinds of energy resources and transform technologies considered. However, because energy resources and transform technologies differ widely in their physical properties, these tools do not, and should not, treat them all in the same substantive way; rather, the tools aim to treat all resources and technologies solely on their inherent technical characters and merits.

The tools are set out in five papers available on the CCSD website www.ccsd.biz (see below).

The overall approach is to employ scenario backcasting (Hooker and Brinsmead 2007a) to identify a range of potentially acceptable future scenarios. This captures the full range of possibilities for later use in risk amelioration, including off-trend options not accessible to forecasting. Scenarios themselves need to be systematically structured from a firm basis. To this end, Brinsmead and Hooker (2007a) provide a systematic framework for categorising technological options by energy system function and physical operating principle, a framework that also reveals the key design constraints on functioning energy systems, while Brinsmead and Hooker (2007b) provide a method for ensuring systematically wide coverage in the creation of suitably adaptable scenarios for risk amelioration. Hooker and Brinsmead (2007b) explore the construction and evolution of a risk-ameliorating portfolio of technologies that span the selected scenarios and the conditions that enable key pathway elements of each scenario to be accessible to prospective realisation. Brinsmead and Hooker

2008, forthcoming, provides an initial application of the combined ideas, to energy policy for Queensland.³

Simultaneous maintenance of many pathways reduces both (a) reliance on ‘winner selection’ (Issues Paper p5), and (b) institutional biases (not just isolation, cf. ‘lock-in’ p6) to correlated risks (e.g. only carbon sequestration) (p5). Ensuring that technology development policy is derived from a consideration of energy pathways rather than component technologies, and deriving economic incentives that are compatible with a coherent, but malleable strategy that is increasingly specifically defined over time, reduces (c) research coordination failure (large – especially for firms and states – categories not listed at p10 of the Issues Paper), and (d) barriers and unfairness (p6) while (f) capturing support sector spillovers (p7). Making public the information on energy developments, compiled in order to support the adaptation of the energy policy strategy as identified above, would reduce (e) general investment information asymmetry (p12).

A coherent, articulated interrelationship between the planning structure and the economic instruments is required that permits adapting the latter to the former in key respects.

As a first step, for each energy pathway option desired to be kept open, the technological development strategy would involve encouraging at least a minimum scale of investment and operational activity, appropriate to the developmental status of the technologies involved. Instruments for this purpose may include any mix of grants, rebates, tax incentives, procurement policy, low interest loans, research and development funding, mandatory sales percentages, infrastructure provision and support for technology development consortia, with the precise mix chosen so as to balance the competing requirements of adapting them to the local idiosyncrasies of each specific pathway and supporting system-wide coherence, fairness and efficiency.

Competition may be focused on providing alternative realisations of strategically important pathways, whether these pathways be specific (e.g. a wood alcohol-to-transport pathway) and the competition be focused down on provision of each of its particular technologies, or more generic (e.g. a biofuels-to-transport link), comprehending several different specific pathways that may then become the locus of competition. It may instead be expedient on occasion to support research focussed on a particular fuel, say hydrogen, across its pathway involvements that would include consideration of its storage and distribution as well as of its production and final uses.

Since learning effectively about new technologies often requires long time scales (particularly those requiring changes in consumer practices) it is important that any public policy support for such technologies should be guaranteed for a reasonably long duration, although not necessarily at a large quantitative scale, perhaps with well established mechanisms for optional increases or decreases in support level over intermediate time scales. In some circumstances, guarantees of public access to relevant performance information resulting from publicly supported demonstration projects may be warranted in exchange for that support.

Such an approach would require the regular provision of updated information on energy market and technology developments, based on the systematic (‘disciplined’,

³ The analysis is qualitative but detailed; adding quantitative analysis demands data and analytic resources beyond the scope of the current project.

see Issues Paper 4, p7) analysis of options and impacts, and their systems importance. Publicly available technical information (e.g. performance and learning curve data) underwrites both public planning and private research and development efforts. One effective approach may be to propose modest funding for a suitable institution to collate, assess and make publicly available such information (e.g. CSIRO, cf. n.1). Also a triennial national strategy assessment meeting to debate and agree upon data priorities and pathway development strategies may be productive.

Brinsmead TS and CA Hooker (2007a), *Physical Constraints and Options in Energy Policy*, CRC for Coal in Sustainable Development, Brisbane, RR78, www.ccsd.biz.

Brinsmead TS and CA Hooker (2007b), *A Framework for Energy Policy Scenario Construction*, CRC for Coal in Sustainable Development, RR 79, www.ccsd.biz.

Brinsmead TS and CA Hooker (2008, forthcoming), *An Adaptive Energy Policy for Queensland*, CRC for Coal in Sustainable Development, Brisbane.

Hooker CA and TS Brinsmead (2007a), *Adaptive Backcasting - the method of possibility and design for planning the future*, CRC for Coal in Sustainable Development, Discussion 8, www.ccsd.biz

Hooker CA and TS Brinsmead (2007b), *Adaptive Analysis for Energy Policy*, CRC for Coal in Sustainable Development, Discussion 9, www.ccsd.biz

[NB: A summary presentation of this work is found in Hooker's address to the CCSD Annual Conference, 3/4 April 2008, at <http://www.ccsd.biz/calendar.cfm?Calid=326>]