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Treasury Review of the Economics of Climate Change

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0. Overview

0.1 This submission first argues that the cap and trade approach embodied in the Kyoto Protocol is seriously inadequate, second demonstrates that it outcome is also seriously sub-optimal, and third examines how this can have come about.

0.2 The demonstration in section 2 is by way of counter-example: a much more effective approach is available, likely having negative costs. Dubbed a 'holistic greenhouse gas management strategy', it addresses the disconnect between scientists concerns about the climate system and what negotiators have been able to agree to do about it, and it treats the whole flux of greenhouse gases into and out of the atmosphere, rather than focusing on reductions of energy sector emissions.

0.3 **The vision** embodied in the holistic strategy is that the polluter pays principle can be turned to a greening of the earth, and to the advancement of those developing countries located in regions of high potential net primary soil productivity, with the process motivated in developed countries by concerns for energy security and by agricultural policy reform, as well as by the need to manage greenhouse gases. In this vision the 'land use change' concept becomes 'land use improvement' yielding multi-dimensional benefits funded through the DFI of major energy sector interests, diverted from investing in unconventional fossil fuels and in nuclear power and mediated as regards sustainability criteria by conditionality applied to such DFI. The reluctance of policymakers to address large-scale global investment in land, as a multi-faceted response to a wide range of environmental concerns, is misplaced.

1. Inadequacy of the 'cap and trade' approach

1.1 We may judge that stabilisation of atmospheric greenhouse gas levels at "2 times CO_2"[1] near the end of this century is about the best that can plausibly be hoped for from successive re-negotiations of Kyoto. Taking account of increased levels of methane (CH_4) etc., equivalent to ~100ppm[2] – it implies stabilising at a CO_2 level around 480ppm.

1.2 However, there is deep uncertainty regarding the ultimate objective of the UNFCCC's Article 2. All signatories are committed to 'stabilization … at a level that would prevent dangerous anthropogenic interference with the climate system' but nobody knows what that

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Department of Applied and International Economics, Massey University, New Zealand. I owe an intellectual debt to Thomas Schelling's 1992 Presidential address to the AEA on 'Some Economics of Global Warming'.

[1] I.e. 580 parts per million (ppm) twice the pre-industrial level of ~290 ppm. Note that this is a social construct having no scientific basis. It was originally adopted to provide a uniform basis for climate model comparisons and gained acceptance as the most ambitious target that analysts judged would be politically feasible, given the very high costs of compliance that were thrown up by early 'top-down' macroeconomic models.

[2] This is on the basis of the global warming equivalence over 100 years that has been evaluated by the IPCC. CH_4 has a half life in atmosphere of around 25 years so that its impact over 100 years is concentrated into the opening decades, whereas CO_2, with a half life around 150 years has a more evenly spread effect over 100 years. The implication of this is that if the threats from climate change are more short term than has generally been supposed, then predicted raised levels of CH_4 need either to be mitigated or compensated by larger reductions of CO_2 levels (i.e. to much lower than 480ppm were "2 times CO_2" to be deemed 'safe' in that short term).

means in quantitative terms. Consequently there is a need for a precautionary approach, that is to say to adopt low cost policies that provide a hedge against a possible need to achieve deep cuts in GHG levels[3, 4] as discussed in Section 2 below.

1.3 The concerns of the scientific community relate to the unstable non-linear dynamics which characterise the climate system, both on *a priori* consideration of its physics and *a posteriori* investigation of its behaviour prior to the benign stability of the last 8,500 years that has enabled settled agriculture, the support of large populations, and the growth of civilizations. The fascinating, and at times beautiful, work of paleo-climatologists to unravel the secrets of pre-historic climate cannot be even outlined here. We can only note a few of the *a priori* aspects, bearing in mind that when dynamic systems are unstable it is because of 'positive feedback', that is to say a situation where the cause of a change is aggravated by its effects, so that the cause is enhanced, and so on, until the effects become so great as to encounter some limit not specified in the initial dynamics.

1a *Positive feedbacks in the climate system*

1a.1 Thefollowing list is likely incomplete

A. Polar warming causes sea-ice to melt, causing more ocean to be exposed, which absorbs rather than reflects sunlight, causing more warming, causing more melting of sea ice, etc, etc.

B. Tundra starts thawing, releasing methane trapped below the surface, causing further enhanced greenhouse effect, more warming and more thawing, etc, etc.

C. Plant-life is stressed due to warmer climate, and absorbs less CO_2, reduced absorption raises CO_2 in the atmosphere, with increased greenhouse effect causing further warming, etc., etc.

D. Warmer oceans melt the frozen 'cork' covering ocean bed 'clathrate' formations[5], releasing methane and causing further enhanced greenhouse effect, more ocean warming, etc, etc.

E. Recently detected tele-connection in the flow of glaciers in Antarctica and Greenland, results in the floating off of ice-shelfs (due to higher ocean levels caused by thermal expansion) leading to acceleration of the glaciers, more floating off, still higher ocean levels, etc, etc.

F. The global thermo-haline circulation that gives rise to the 'Gulf Stream' which keeps North Atlantic regions habitable is known to be unstable, but it is not known whether the feedbacks involved are positive or negative (self-stabilizing) or ambiguous

1a.2 Recent reports from high Northern latitudes suggests that the first two of these may have begun to occur. This may mean that the game is already lost. Or we may be lucky if a slowing of the Gulf Stream[6] leads to a decade or so of hard winters, sufficient to restore polar ice to pre-industrial conditions, after which we will maybe have learned how (with the holistic

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[3] Schelling noted in his Presidential address that the sole economically valid reason for rich countries, largely insulated from the prospective economic impacts of gradual climate change, to take action on GHG's is as insurance against low probability high damage outcomes.

[4] Such cuts in levels cannot be achieved by the zero emissions technologies encouraged by Kyoto: at best such technologies can achieve only an asymptotic approach to the levels of CO2 in the proximate absorbers (the ocean surface layer and the terrestrial biosphere).

[5] Clathrates are poorly understood masses of crystal-like mixtures of ice and methane under the mud on the seabed of the continental shelves. They are stable under the high pressure and low temperature at the sea bed. Warmer oceans may destabilise them, releasing CH_4 to the surface and the atmosphere. Greater pressure may keep them in place (so deeper oceans may have some benefit to compensate for higher costs of coastal defence).

[6] This surmise was drafted some time prior to reports of Dr. Bryden's studies along the 25th parallel and Prof Wadham's research in the Greenland Sea, suggesting a 30 per cent reduction already in the Gulf Stream's flow.

strategy) to avoid sailing quite so close to the wind again. Or we may be unlucky and learn that the only way to prevent the ultimate climatic disaster of slow but inevitable melt-down of the land based ice masses is to return the average ocean temperature to the pre-industrial, requiring the engineering of a phase of global cooling with lower than pre-industrial levels of greenhouse gases – maybe possible, maybe not, with the holistic strategy (see line F in Figure 1 below) but certainly not if we limit policy to capping emissions and accept that the existing warming commitment is irreversible.

1a.3 While we may speculate over these uncertainties, a salient reality[7] is that the climate system is, on the pre-historic record, far less stable than the climate models predict or can back-cast.

> "Climate models provide only a dirty crystal ball in which a range of plausible fortunes may be glimpsed…. At present we are altering the environment faster than we can understand the resulting climate changes. If the trend does not stop, we shall eventually either verify or disprove the climate models – by means of a real global experiment whose consequences we shall not escape." [8]

Since that was written, nearly 20 years ago, the pace of alteration has accelerated and the quality of modelling improved (notably by the linking of atmospheric and oceanic general circulation models to give AOGCM's, the leading edge technique). There has been limited success with integrating C and F above into AOGCM's , but not A and B, the currently most acute causes of concern[6bis]. However, the high ground in providing scientific advice has not been taken by the warnings of paleo-climatologists but by climate modellers whose concern has been to defend the reliability of the projections of their AOGCM's.

1a.4 So transmission of scientific concerns regarding the possible consequences of climate system instabilities has been muddied by a highly publicised search for certainty, pursued by climate modellers trying to replicate accurately the climate track of the last century and challenged by sceptics. Praiseworthy though the modellers' efforts may be, the debate has overshadowed the reality that the appropriate response to uncertainty is not to focus on whether we are 95 or 99 per cent confident that the warming of the last century was anthropogenic[9]. More relevant is to direct policy towards maintaining flexibility of response as scientific appreciation improves of what may happen//is happening in this century. Such flexibility is very far from what can be envisaged from the zero-sum calculus of cap and trade negotiations.

2. Holistic greenhouse gas management

2.1 The holistic strategy has been developed from ideas put forward in my book 'Responding to Global Warming'[10]. Its recent development springs from an expert workshop

[7] At least on this non-climate scientist's reading of as much of the literature as he can cope with.
[8] Stephen Schneider, 'Climate Modelling', Scientific American, May 1987
[9] Indeed, the question of whether it is anthropogenic may seem academic: we would not question rocket engineers efforts to nuke an approaching meteorite by asking if it was man-made or of natural origin.
[10] (Zed Books, 1994) commended by Thomas Schelling as 'A skilled attempt at fashioning policy and a deep foundation for thinking on the subject' and by Michael Grubb as 'This imaginative and challenging book points towards a key strategy… – one that links energy and forestry, North and South'. Wilfred Beckerman's EJ review commented 'a rare and well-balanced mixture of technological and economic analysis ….' but concluded 'Unfortunately the chances of such a logical system … are probably negligible' – as has so far turned out.

held in Paris Sept/Oct 2004 to 'address the policy implications of potential abrupt climate change'[11].

2.2 It addresses climatic uncertainty by a sequential approach, first taking low cost precautionary measures and subsequently, if needed, further actions – possibly high cost actions – enabled by the first stage measures. It achieves potential decadal time-scale control of CO_2 levels (and, in principle, of other greenhouse gases linked to biotic activity, such as CH_4) by modifying the exchange of CO_2, etc., between biosphere and atmosphere, treating energy sector emissions as one outcome rather than the main focus of policy.

2.3 The first stage – consistent with the G8 Action Plan commitment to launch a global bioenergy partnership, and reflecting the conclusion reached by the expert workshop – is to develop a large-scale global bio-energy industry with South-North trade in bio-fuel liquids such as ethanol and bio-diesel. No attempt has yet been made to cost such a development, for which financial viability varies inversely with the uncertain future price of oil. Indeed, within the analytic framework of competing technologies, the notion of cost is somewhat chimerical, with one technology or the other gaining the upper hand under conditions of dynamic economies of scale, due for example to learning by doing with cumulative adoptions, and with no certainty that the resulting equilibrium is globally optimal[12]. This conclusion follows from setting carbon management in the context of the dynamic economics of innovation and of competing technologies rather than the comparative static framework of competitive general equilibrium modelling[13]. Thus the objective of policy that has regard to a market externality is to drive the pattern of technology adoptions towards a (local) optimum that takes the externality into account, rather than put a price on emissions that simply reflects current perceptions of highly uncertain marginal damage costs, and may fail to greatly influence the pattern of technology adoptions.

2.4 However, as regards costs, the workshop noted that ethanol, whether produced from fermenting sugar cane or by advanced techniques for fermenting cellulosic biomass, currently coming on stream on an industrial scale, is financially viable when oil rises above ~35$/bbl (so that 'peak oil' may succeed where Kyoto struggles).

2.5 The second stage in the holistic strategy – possibly high cost and therefore not undertaken unless abrupt climate change is deemed to be imminent – is to link bio-energy to carbon storage, for instance CCS (for CO_2 Capture and Storage, called 'Sequestration' in the USA). Bio-Energy with Carbon Storage (BECS) is a negative emissions energy system in which the biotic production of energy raw material extracts CO_2 from the atmosphere and carbon storage stocks it out of the atmosphere either before or after the biomass is used partially for fuel. It should be noted that neither bio-energy nor carbon storage is 'picking a winning technology' – both are technology types as is fossil fuel a technology type. There are a great many ways of growing and cropping biomass (with some of the most interesting

[11] Funded by the Better World Fund of the United Nations Foundation. Visit www.accstrategy.org/simiti for peer-reviewed articles forthcoming in a Special Issue of *Mitigation and Adaptation Strategies for Global Change*. These and other relevant papers are reviewed in 'Carbon Cycle Management with Biotic Fixation and Long-term Sinks' Chapter 38 of 'Avoiding Dangerous Climate Change', C.U.P. January, 2006.

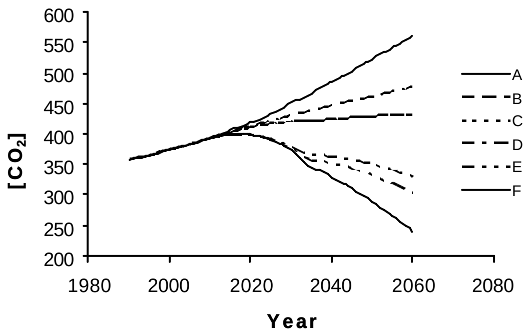
[12] W. Brian Arthur, 1994. (ed.) "Increasing Returns and Path Dependency in the Economy", University of Michigan Press. Also, "Competing Technologies, Increasing Returns, and Lock-In by Historical Small Events", Econ. J. 99, 116 – 31 (1989).

[13] As was noted in the same year as the publication of Baumol and Oates's landmark general equilibrium analysis "The theory of environmental policy" (Prentice-Hall, Inc, 1975), 'In the long run conflicts between environmental values and economic well being are ameliorated by technological change or not at all' (paraphrased) from Kneese A. and C. Schultz, 1975. "*Pollution, Prices and Public Policy*", Brookings Institution, Washington, DC

involving co-production of high value food and fibre) and of converting it to convenient solid, liquid and gas fuels or to electricity. Similarly carbon can be stocked out of the atmosphere before combustion, as standing timber, or after, as with CCS, or through a pyrolysis process to produce bio-char (charcoal) for use as soil amendment in land improvement projects,[14]

2.6 The powerful potential of the holistic strategy is illustrated in Figure 1 where the effect of land improvement over very large areas is shown for three sample technologies:- (line A – line B) the co-production of ethanol and electricity from sugar cane in tropical regions (as is done today in Brazil on a large scale); (B-C) the co-production of cattle-feed protein, ethanol from cellulosic material and electricity from residual ligneous material from

Figure 1: Bio-Energy with Carbon Storage (BECS) – impacts on the level of CO_2 in atmosphere



<u>Legend</u>

A *SRES-A2 business as usual scenario (exceeds '2 times CO2' by 2070)*
B *SRES-A2 with sugar cane land use change activity*
C *SRES-A2 with sugar cane and switch-grass land use change activities*
D *SRES-A2 with sugar cane, switch-grass and forestry land use change activities*
E *SRES-A2 with three land use change activities and low cost capture and storage (CCS) of fermentation CO_2*
F *SRES-A2 with three land use change activities with CCS of fermentation CO_2 and flue gas CO_2*

cropped switch-grass in temperate regions; and (C-D) the co-production of ethanol and electricity from woody biomass[15] along with conventional timber industry products. The importance of storage is apparent in (line C- line D) where the rapidly increasing difference from 2010 to 2035 is mainly due to the growth of a large stock of standing timber in new plantations, extending by 2035 to 1 billion hectares and constituting a strategic reserve stock of biomass fuel to provide assurance of raw material supply for the future large-scale bio-energy market. The contribution of CCS, if needed, is shown as (D-E) representing low cost

[14] Buried charcoal from pre-Columbian Amazonian civilisations (wiped out by smallpox brought by the first explorers, and the origin of the 'El Dorado' myth) is the reason for the occurrence of patches of highly fertile 'terra preta' (Portuguese for black earth) in the otherwise infertile yellow jungle soils. The highly porous bio-char provides a substrate for microbial and fungal species essential to successful rooting activity. One aspect of the holistic strategy could be to promote such soil improvement in the poor soils of much of sub-Saharan Africa, paid for by energy firms in discharge of a carbon storage obligation (see 'policy instruments' below).

[15] Taken from P. Read and A. Parshotam. "Holistic greenhouse gas management" under review with <u>Climatic Change</u>. Related previous work is published in: Read, P., 2005. "Carbon cycle management with biotic fixation and long term sinks", Stabilisation2005 Symposium, Hadley Centre, February, forthcoming Cambridge University Press (see note 11 above); Read, P. and J Lermit, 2005, "Bio-Energy with Carbon Storage (BECS): a Sequential Decision Approach to the threat of Abrupt Climate Change" Presented to International Energy Workshop, Laxenburg, Austria, 2003, revised in <u>Energy</u>, **30**, 2654-2671; Read, P. 2002. "Precautionary climate policy and the somewhat flawed protocol: linking sinks to biofuel and the CDM to the Convention", <u>Climate Policy</u> **2/1**, 89-95; Read, P. 1998a. "Dynamic Interaction of Short Rotation Forestry and Conventional Forestry in Meeting Demand for Bioenergy", <u>Biomass and Bioenergy</u>, **15/1**, 7-15; Read, P. 1997, "Food, fuel, fibre and faces to feed: Simulation studies of land use change for sustainable development in the 21st century", <u>Ecological Economics</u> **23**, 81-93.

CCS, where the fermentation process delivers pure CO_2 at no separation cost, and (E-F) representing high cost CO_2 captured from mixed gases in the smokestack. Because the growing of biomass actively takes CO_2 out of the atmosphere, thereby making it possible to store carbon and to prevent its return to atmosphere, bio-energy differs fundamentally from other forms of renewable energy that do no more than avoid emitting CO_2. And it differs crucially if the climate change problem becomes one of rapid response to imminent abrupt climate change.

2a *Negotiability of the holistic strategy*

2a.1 Rather than engage in speculative cost calculations the holistic strategy has been considered in terms of winners and losers, in particular its benefit to major players involved in its implementation, and thus its negotiability, particularly the negotiability of its first stage. Thus we consider how the creation of a large-scale bio-energy market with world trade, mainly South-North trade, in liquid bio-fuels such as ethanol and bio-diesel, impacts on the various actors involved in the climate change issue. We shall argue that it is less hostile to incumbent energy interests than an emissions cap, is beneficial to a range of land-using interests, and, subject to safeguards, is environmentally benign in diverse ways beyond greenhouse gas management.

2a.2 <u>Energy sector aspects (distinguishing power generation and transportation fuels)</u>

A. *Oil importing countries* will be able to import an increasing flow of bio-fuel substitutes that will eventually limit oil prices to around $35/bbl. Apart from long term insulation from the vagaries of oil prices, available land in the temperate 'North' can, subject to improved vehicle efficiency, supply sufficient liquid bio-fuels to enable these countries to meet essential needs without imports, thus achieving the 'energy security' which is a major concern in the USA, *inter alia*[16].
B. *Oil exporting countries* will – with price fluctuations smoothed by the existence of a credible backstop – miss out on the windfall profits that could otherwise occur occasionally (as in 2005) if needed investments are not made in a timely manner, and as conventional oil 'peaks' (or at least fails to expand as fast as global demand). This would also be the case if the new backstop resulted from timely investments in unconventional oil from tar sands and the like. Whatever the backstop, the main oil exporters will continue to take large profits from their remaining reserves of low-cost oil and (save to the extent they have unconventional reserves themselves, e.g. Venezuela's Orinoco deposits) may welcome the market stability provided by backstop supplies. Once policy achieves long-term credibility they may well seek to diversify into bio-energy investments[17].
C. *Coal* supplies to large-scale users such as power stations have such low short run marginal costs that they can prospectively compete with biomass even if increasingly burdened with a requirement for costly CCS. Thus existing facilities are unlikely to become obsolescent prematurely (so-called 'stranded assets') and the main impact, again given policy credibility, will be reduced investment in new mines and a shift towards investment in supplying biomass in bulk.
D. *Bulk fuel markets* would, under an announced and credible policy for using a rising proportion of bio-fuels, as illustrated in Figure 1, thus see a shift in the pattern of investment into bio-energy supply systems and away from high cost unconventional

[16] Greene, N., F.E. Celik, B. Dale, M. Jackson, K. Jayawardhana, H. Jin, E. Larson, M.Laser, L. Lynd, D. MacKenzie, M. Jason, J. McBride, S. McLaughlin and D. Saccardi, 2004. NRDC Report "<u>Growing Energy: how biofuels can help end America's oil dependence</u>" (December).
[17] Read, P., 1995. "Green Oil: Living with the Berlin mandate" **Opec Review XX/4.**

fossil fuel extraction. ***This shift is the crux of a successful CO_2 mitigation policy***. This is because such fossil fuel extraction, once the costs are sunk, will only with great difficulty – including widespread costly retrofitting of CCS to the historic stock of power stations and other large point source emitters – be prevented from continuing the 'business as usual' transfer of carbon from deep underground into the atmosphere.

E. *Energy sector management* would see such a transition as within the traditions of a sector where shifts in carbon fuels from wood, to coal, to oil, to gas have succeeded each other with minimal disruption. And soon to biomass makes industrial sense in a way that a transition to intermittent sources of electric power, lacking the convenience and storability of carbon-based fuels, does not. Thus policy must strive to create a new vision in energy sector investment that seeks to grow energy rather than mine it – there is no reason to suppose that such a new vision would result in any more costly energy supplies than the current industry vision of exploiting unconventional fossil fuel resources and processing coal to liquid fuels[18]. With well-designed policy instruments, entrepreneurial 'animal spirits' can be enlisted in a competition to win the race to get ahead in the new bio-energy transition, rather than antagonised by emissions constraints that seem to management to be designed to contract their industry.

F. *Flexibility,* needed in response to scientific uncertainty, is inherent in the two-stage approach of the holistic strategy but also derives from the third illustrative technology mentioned above, based on woody biomass of which a strategic stock is created through the 2010-2035 build-up of new plantation forest area (Fig 1 (D-C)). Plantation forestry represents an extremely low-cost way of achieving near term impacts on the level of CO_2 in the atmosphere[19] with its temporal growth and spatial extension compensating for emissions from continued use of fossil fuels in power generation and with the timing of its use adjusted to developing scientific news. If concerns regarding the feed-back processes described in Section 1 prove well founded, the long rotation can be discontinued and short rotation bio-energy cropping (e.g. miscanthus or elephant grass) substituted to yield a more rapid take up of bio-mass raw material in the electricity sector. If the pace of change does not need to be rapid then the plantations can be left standing (growing more slowly, beyond normal harvest age at the end of the rapid growth phase, and continuing to appreciate, unlike most forms of fuel stockpile). If enhanced greenhouse effect turns out to be needed as a defence against the overdue coming of the next ice age (the major concern of climate scientists a generation back) then the continued use of coal can continue, unburdened by any need for CCS, and with the plantations being utilised mainly for traditional timber products (noting that co-production of timber and biomass is inherent in the holistic strategy, with the more highly valued co-product carrying the bulk of plantation harvesting costs).

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[18] For an extremely interesting (but long) article discussing the role of 'vision' in managerial decisions see Fransman, M., 1998. "Information, Knowledge, Vision and Theories of the Firm", 147-191in Dosi, G., D.J. Teece and J. Chitry (Eds) '*Technology, Organization and Competitiveness*' , OUP, Oxford. The classic case is IBM where managerial attachment to the mainframe computer nearly resulted in bankruptcy, despite the fact that IBM had better knowledge than any firm in the world regarding the development of micro-chips and the potential development of personal computers.

[19] This reality led to great resistance to the inclusion of sinks in the Kyoto Protocol from environmental groups focused on prioritising 'domestic action' in developed countries' energy systems. Their 'no pian no gain' concern, that the main thrust of response would be to create new forests, with little energy sector change, went largely unstated. Instead an argument was advanced that forest sinks lack the 'permanence' of reduced energy sector emissions – completely spurious, save for insurable risks of fire, etc. Of course a commercial forest is as permanent as the incentives for growing it, in the present context as permanent as climate policy. And, also of course, fossil fuel left underground can always be extracted later if policy concerns change.

G. *The timing* of energy sector change, the transition to substantial, possibly complete, reliance on biomass raw material for power generation, is thus, by the capacity for carbon storage in standing forest plantations, substantially decoupled from the early impact of the strategy on CO_2 in the atmosphere[20]. Except under conditions of immediate urgency, induced by early and bad scientific news, this temporal flexibility reduces the burden of premature obsolescence in the energy sector, with investment in new, biomass-using plant becoming part of the normal cycle of plant replacement and refurbishment, and with market choices determined by credible long-term policy directions. However, such decoupling does not arise, and is not needed, in relation to the development of bio-based transportation fuels utilising annually cropped plants such as the sugar cane and switch-grass examples that provided data for some of the illustrative calculations for Figure 1 (lines (A-B) and (C-B)). With ethanol and bio-diesel, pressures for energy security may lead to a situation where a new concern would be with the rapid pace of take up, and the sustainability of the land use practices adopted[21], discussed below.

2b ***Improved land use***

A. *Land availability*, and potential competition with food and fibre production, is widely misperceived as a constraint on bio-energy. As detailed in FAO studies[22] the are 2.38 billion hectares of unused potential rain fed arable land world-wide, of which the bulk is in sub-Saharan Africa and South America. *Prima facie*, there is not a shortage of land but of the investment in land that can raise soil net primary productivity and prospectively meet all global demands for food, fibre and fuel, along with the economic aspirations of many rural peoples. Subject to land use controls to shape the pattern of land use change, there is, under the holistic strategy, and again *prima facie*, enough land left over from commercial uses to provide the conservation areas, migration routes, etc., that are needed to sustain remaining global bio-diversity. Securing such environmental benefits depends upon the policy-driven land use improvements employing management practices that reflect sustainable development criteria and upon monitoring systems, possibly involving appropriate NGO's, that are adequate to ensure the criteria are met – the sanction being that bio-fuels that are not produced consistently with the criteria get counted as fossil fuels.

B. *Existing vegetation* in the 2.38Gha of unused potential arable land is mainly tropical savannahs and temperate grasslands, with areas of sparse open woodland that may have been categorised as forests to which may be added degraded forest regions and some currently forested areas prior to success with efforts to stop deforestation, nowadays mainly a tropical forest activity. Noting that forestry, and also possibly intensive grass production, do not require arable quality land, the .43 and .75 billion hectares devoted respectively to sugar cane and switch-grass (in the illustrative calculations on which Figure 1 is based) along with the previously mentioned 1 billion hectares to plantation forestry add up to considerably less than is available.

C. *Farm policy* in developed countries (save for New Zealand) provides subsidies to agricultural crop production that have adverse impacts on developing country

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[20] Read, P.,1996. "Forestry as a Medium Term Buffer Stock of Carbon" paper to World Renewable Energy Conference, Denver, June.

[21] Monbiot, G. 2005. "The most destructive crop on earth is no solution to the energy crisis" Guardian, 6.xii.05, p17, London

[22] Bot, A.J., F.O. Nachtergaele and A. Young, 2000. "Land Resource Potential and Constraints at Regional and Country Levels", Land and Water Division, FAO, Rome, discussed in Moreira, J.R. "Global biomass energy potential", Mitigation and Adaptation Strategies for Global Change , Special Issue, forthcoming – for texts of peer-reviewed articles from the Expert Workshop, Paris, 30th Sept. and 1st Oct, 2004, in author-created format prior to typesetting and proof-reading, see www.accstrategy.org/simiti.

agriculture and which are increasingly under pressure in trade negotiations, being the subject of adverse judgements from the WTO, as regards sugar and cotton so far. Additionally they are an increasing burden on the EU budget as accession states bring in large regions of inefficient farming. Bio-energy can provide an alternative source of income to farmers, sourced from the energy consumer rather than public funds, and sustaining rural livelihoods in WTO compatible ways. The 'smart farmer' in these countries, well accustomed to adjusting production to meet shifts in policy, can be expected to respond quickly to new demands for biomass from the energy sector (as may be needed in relation to the energy security – i.e. liquid fuel – issue discussed above).

D. *Sustainable rural development* in many land-rich but otherwise impoverished countries, where the bulk of available land discussed above is located, is the potential long-run outcome of large-scale bio-energy. Carbon credits from the build-up of the strategic plantation biomass stockpile can provide initial funding and a variety of technologies be employed to suit local conditions and different stages of development – for instance bio-char production for *terra preta* soil improvement and increased crop yields, or as charcoal for healthier cooking and/or a cash earner meeting demands in larger townships or cities. With emergence into the market economy, more sophisticated technology would co-produce rural electricity supplies and liquid fuels for transportation, initially saving oil imports but eventually for export, thus achieving convergence between national plans for sustainable economic growth and project based rural development and income generation.

E. *Synergy with globalisation* arises since, while loan forgiveness is clearly a necessary part of any strategy for poverty alleviation and economic advancement in the least developed countries, they do also need to begin to pay their way with an economic activity that eventually yields export earnings – that is the prospect offered by the holistic strategy. Such rural economic activity will tap into the reserve army of under-employed rural labour and stimulate rapid economic growth under the impact of Keynesian multiplier effects, thus expanding demand for the exports of developed and advanced developing countries (with the developing countries' hard currency needs met by liquid fuel exports), and providing the expansion of effective demand globally that is needed to sustain the continued success of globalisation.

F. *Capacity building*, through the training of local entrepreneurs to develop community driven bio-energy projects in very large numbers, would be needed to ensure that SD criteria such as local control, local environmental benefit and local income generation are met. Large-scale bio-energy would thus come to be supported by very large numbers of community scaled projects rather than a smaller number of the vast mono-cultural plantations which feature in some environmentalist dystopias. To meet the scale of bio-fuel demand implicit in the holistic strategy it would be necessary to train tens of thousands of such local entrepreneurs, to initiate the hundreds of thousands of projects that are needed over the next few decades for the holistic strategy to realise its potential. This could be achieved by a network of local training centres backed by a smaller number of research grade universities, some in developed countries, that would 'train the trainers', and provide problem-solving research backup in response to problems met on the ground with individual projects[23]. The public good nature of such knowledge creation and dissemination makes the funding of such capacity building a natural direction for GEF spending.

[23] Read, P. 2001. "The Role of Plantation Sinks" **Energy and Environment, 12/5&6**, 511-520 – see appendix for a numerical analysis of the capacity building requirement.

2c *Sustainability Issues*

A. Figure 2 illustrates the effect of land use change conducted without regard for sustainability concerns. Lines A and D (the lowest line, involving all land use change activities mentioned in para 2.6, but with no CCS) are as in figure 1, with lines G,H,I demonstrating progressively worse management practice. This diagram amply demonstrates the need for sustainability criteria to be effectively applied to any implementation of the G8 commitment to launch a Global Bio-energy Partnership – a need that is reinforced by noting the ease with which bio-energy systems can be sabotaged by disaffected peasantry equipped with a can of gasoline and a box of matches. Such criteria are not a do-gooding overlay on the success of the holistic strategy but an absolutely core element in responding to the threat that abrupt climate change may come to be seen as imminent, with effective action needed over a few decades rather than centuries.

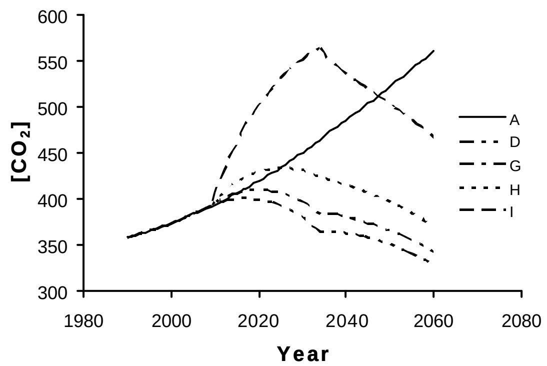

Figure 2: Bio-Energy with CO2 release at time of land use change

A *SRES-A2 business as usual scenario (exceeds '2 times CO2' by 2070)*
D *SRES-A2 with sugar cane, switch-grass and forestry land use change activities*
G *SRES-A2 with three land use change activities and 30 tC per ha released through land use change*
H *SRES-A2 with three land use change activities and 90 tC per ha released through land use change*
I *SRES-A2 with three land use change activities and 300 tC per ha released through land use change*

B. It may be noted that line I roughly reflects current operations in Indonesia where prime natural rainforest is reportedly being burned off to clear land for oil-palm plantations[21bis]. This amply illustrates the need for objective sustainability criteria to be effectively applied, with participation in the 'coalition of the **winning**' (see section 2f below) to involve agreement by participants to the enforcement of such criteria through appropriate monitoring and certification procedures. Commercial pressure for enforcement can come through the nature of any obligation imposed upon energy sector firms (see section 2d below) to use a rising proportion of bio-energy and to support the development of a strategic reserve of biomass in large areas of new plantations – uncertified biofuels count as fossil fuels (or some proportion thereof, depending on the nature of the transgression).

C. An earlier expression of concern on related issues formed the basis of a joint issue of 'Renewable Energy for Development' and 'Renewable Energy Partnerships for Poverty Eradication and Sustainable Development' (visit www.partners4africa.org) presenting a Policy Debate on Global Biofuels Development in which Monbiot's views were reproduced and rebutted in seven expert articles. From these, the need is evident for the Global Bioenergy Partnership's implementation to reflect the key features identified in Sir Nicholas Stern's Munich Lectures, i.e. an active state enforcing contracts and abstaining from obstructive regulation; the stimulation of growth; the encouragement of small and medium sized enterprise (rural enterprise for bio-energy, possibly helping to stem the drift of populations to cities); opportunity to trade, including bio-fuel exports; empowerment of the local communities involved (note the capacity building proposed in 2b.F above and 2f.3G below) and inclusion of females in local ownership and control. It is to be noted that a recent review[24] of CDM projects showed that bio-energy projects were prominent in actually delivering sustainable development on a multi-criterion analysis involving local environmental improvement, local employment and local participation in control.

D. In developing a framework to secure effective sustainability conditionality it is crucial to align commercial interest with the concerns of environmentalists and social advancement through imposing penalties on importers of unsustainably produced bio-fuels into importing countries (mainly in the 'North'). Imported bio-fuels that are not fully certified are treated as fossil fuels and fail to contribute to the obligatory proportion of non-fossil fuel that is imposed as the driver for the development of demand in the market for bio-energy products.

2d *Policy instrument*

A. *The conclusion to be drawn from the preceding discussion* is that the holistic strategy involves driving adoptions of two broad technology types, bio-energy (including the growing of all sorts of crops for co-production of food and fibre with biomass for energy raw material, and also some sole purpose energy cropping, along with a wide range of technologies for converting biomass raw material to useful energy products) and carbon storage (including as compressed CO_2 in a variety of storages, as live carbon biomass in standing forest and as carbon in biochar for *terra preta* style soil improvement).

B. *For a jurisdiction that is not party to an emissions capping regime* such adoptions can be very simply driven by a proportional instrument, such as the Renewable Portfolio Standard, ramped up over time to achieve the desired rate of take up. Thus there may be a requirement on transport fuel suppliers to include a rising proportion of bio-diesel, ethanol, etc in their sales mix. This could be associated by a requirement on vehicle suppliers to include a rising proportion of dual-fuel vehicles (such as are in use in Brazil today) in their vehicle fleet. And power generators could be required to invest in an increasing area of plantation forests (starting with sustaining existing plantations to avoid additionality issues) to create the strategic reserve stock of biomass discussed above under figure 1.

C. *Dynamic efficiency* has been demonstrated[25] for such a proportionate instrument, through internalising the learning externality involved in the innovation process, i.e. the benefit from learning about new technologies that comes from adopting them: new technologies become cheaper over time with experience of using them. Innovation is essentially a supply side activity by specialist firms – consumers are generalists and do not apply what they learn (for instance a consumer may get his house insulated and

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[24] Sutter and Pareno, presentation to workshop "Climate or Development", HWWA, 27-29 Oct, 2005

[25] Read, P. 1999. "Comparative Static Analysis of Proportionate Abatement Obligations (PAO's) – A Market Based Instrument for Responding to Global Warming", **NZ Econ Papers, 33(1)**, 137-147; Read, P. 2000. "An Information Perspective on Dynamic Efficiency in Environmental Policy" **Information Economics and Policy, 12**, March, 47-68; Read, P. 2000. "Asymmetric Learning by Doing and Dynamically Efficient Policy: Implications for Domestic and International Emissions Permit Trading of Allocating Permits Usefully", **Energy and Environment, 11/6**, 665-679; IPCC, 2001. Third Assessment Report, Contribution of Working Group III C.U.P. (Sec. 10.1.2.4.); Read, P., 2005. "Reconciling emissions trading with a technology-based response to potential abrupt climate change" **Mitigation and Adaptation Strategies for Global Change** Forthcoming Special Issue – visit www.accstrategy.org/simiti for peer-reviewed text in author-created format.

learn a lot, but he will not do it twice – it is the specialist contractor who applies the bit more that she learns and supplies better (or cheaper) insulation to the next house she contracts for). Thus dynamically efficient policy requires asymmetry between the penalty on consumption and the reward for policy-desired innovation. Early adoptions yield learning benefits over all future time, later adoptions only over time later. Thus internalising the learning externality means very high incentives for early innovation, declining with time, along with smaller penalties on consumption. That is precisely what is achieved through a gradually ramped up RPS and what mimics the typical behaviour of innovative management – prices on current products are maintained high enough to generate the internal finance needed to launch new lines of business[26].

D. *For jurisdictions that are party to the Kyoto Protocol's cap and trade regime*, an equivalent result can be achieved through a scheme for the initial issue of permits dubbed 'Allocating Permits Usefully' (APU). This is *per contra* allocating the initial issue (i.e. prior to trading) of permits by conventional auctioning or 'grandfathering'. Under APU, project-based credits that embody innovation in desirable technologies are <u>not an offset</u> against the need to hold emissions permits <u>but a currency for getting permits</u>. Firms at the point of policy obligation have to either generate such project-based credits themselves or to buy them on a secondary market for such credits, where the supply comes from specialist renewable energy firms – say insulation contractors – maybe through domestic projects and maybe from overseas projects under JI or the CDM. With such credits, firms at the point of policy obligation can then obtain from the issuer (the Government) a multiple M times as many emissions permits (with M set high initially to provide the high price on project based credits that is needed to overcome barriers to entry and to stimulate early innovation – initially on a small scale – and with M falling later to reflect the declining benefit of learning and also the rising proportion of final demand that needs to be met renewably, as policy commitments increase).

E. *Environmental integrity is enhanced with APU*, vis a vis grandfathering or auctioning, since project credits are not an offset, and are therefore not a potential source of leakage. The emissions permit issue strictly equals actual emissions – if projects are defective then demand to emit exceeds the permit issue and the price rises, choking off demand. Since that is not what industry wants, it has a collective incentive to ensure sound projects and – poacher turned gamekeeper – to participate in a light handed certification and monitoring regime. This reduces transactions costs and could lower one of the major barriers to effective implementation of Kyoto's flexibility mechanisms.

2e *Summary on Negotiability*

2e.1 From the above:

1. Energy sector interests are less sharply impacted, and the energy sector transition much more easily managed under the holistic strategy than under cap and trade. Progressively 'defossilizing' rather than attempting decarbonization, it involves
    - early market penetration of liquid bio-fuels

[26] Of course, if this instrument is dynamically efficient, cap and trade (which establishes an incentive for policy-desirable innovation that is equal to the penalty on emissions) must be inefficient, despite widespread adherence to the idea that the developing carbon market will, when it is mature with globally equalised prices, deliver an efficient outcome. What is needed is two markets, with trades in project based credits that represent innovative actions (e.g. under JI or the CDM, K.P. Arts 6 and 12) fetching a higher price than trades in the market for emissions reductions under Art 17. The price differential should fall over time to reach zero at the policy time horizon, when there is no tomorrow and no benefit from learning (see www.accstrategy.org/simiti pp213-230).

- early initiation of the build-up of the strategic reserve of biomass in new and existing plantations
- progressive take-up of co-firing of biomass in power generation, and eventual development of stand-alone bio-fuel power generation, likely in the context of multi stream bio-refineries producing chemicals, liquid fuels and power
- All the above to be speeded up or slowed (and possibly linked to CCS) depending on bad or good scientific news

2. Oil importers achieve increasing energy security
3. Farm support budgets are reduced, and WTO pressures on farm support policies are relieved, through an alternative source of farm income from carbon credits and from sales of crop residuals and specialised energy crops for bio-energy raw material
4. Many developing countries achieve sustainable rural development and poverty alleviation through benefits of farm support re-orientation, along with economic growth through substitution for oil imports and eventually led by bio-fuel exports
5. Apart from preparedness for imminent abrupt climate change, much more ambitious commitments for the post 2012 period become feasible, including an effective response to the otherwise intractable problem of dispersed emissions from the transportation sector
6. A scheme for initial issue of permits called 'allocating permits usefully' enables the holistic strategy to be implemented in tandem with an emissions cap and, indeed, improves the integrity of the cap, thus making the strategy complementary to the Kyoto Protocol.
7. There is need for a major capacity building programme to facilitate country-driven projects that deliver sustainable rural developments that meet local aspirations.
8. There is need also for an internationally organised certification and monitoring system, possibly involving NGO's, to ensure compliance with internationally agreed standards for sustainable development.

2e.2 Except to those dogmatically attached to the efficacy and sufficiency of cap and trade, it appears that the innovation-oriented holistic strategy confers advantages relative to Kyoto, and in some cases benefits in absolute terms, for many interests involved, both to Parties to the Protocol and to non-Parties amongst developed countries, as well as to many developing countries. For the energy sector it is a relatively painless transition to a low emissions regime. To NGO's falls the need to lobby effectively for socio-economic and environmental safeguards to ensure that this more effective response to the issue (if it is a gradual warming issue) or this only response (if the issue becomes imminent abrupt climate change) is constrained by effective sustainability criteria, certification and monitoring.

2e.2a To the extent the concerns of the 1997 Byrd-Hagel resolution remain current in the US Senate, it may be noted that this approach explicitly involves major developing country emitters, is of minimal or possibly negative cost to the USA (depending on oil price trends), and sidesteps the issue of scientific certainty, challenged by some Senators.

2e.3 Given its capability to deliver benefits to all the major groups that have so far been drawn into conflict by the cap and trade approach, it may be concluded that the latter is deeply sub-optimal and that the holistic strategy may be taken up by the policy process as a low, possibly negative, cost and prospectively negotiable way forward from the near impasse reached in the Kyoto process.

2f *Implementation*

2f.1 The holistic strategy initially requires the rapid build up of a large-scale global bio-energy market. This involves land use improvement over vast areas and must take a long time, given the many millions of stakeholders involved. Therefore there is a need to start soon, which provides the rationale for the two stage strategy, with high cost CCS, if needed, able to be deployed more rapidly later, providing the necessary preparatory work has been done.

2f.2 In order to avoid the delays inherent in securing consensus through the UNFCCC process, the strategy can be implemented initially by a 'coalition of the **winning**' to which new members could be added as its advantages become manifest. Eventually, when the Parties to the Convention invite it, the coalition's agreement would become incorporated into the Convention as a second protocol. In order to avoid redundancy with the Kyoto Protocol, or any need for its renegotiation, this second protocol should hang from Article 3.3, relating (to paraphrase) to 'precautionary action in response to threats of serious or irreversible damage, without waiting for full scientific certainty'. In this way the new protocol, embodying the holistic strategy's response to potential abrupt climate change, would be complementary to Kyoto, leaving its cap and trade approach as the response to the Berlin Mandate's call under Convention Article 4.2 for more demanding commitments.

2f.3 Such a process could involve:

A. Implement the G8 Action Plan for a Global Bioenergy Partnership through a coalition of the **winning** [G8 + rest of EU, China, India, Brazil, S.A., Nigeria, Indonesia, say] agreeing to use an increasing proportion of sustainably produced bio-based fuels over a long-term horizon: 5 % by 2010, 15% by 2015, 30% by 2020, 50% by 2025, 80% by 2030 [a commitment for a moving 10-yrs-ahead period, aspirational thereafter]. Create credible future demand and the supply will follow. Supply can be imported, e.g. from Brazil and South America, increasingly, from sub-Saharan Africa.
B. Institute a sustainable development framework: e.g. NGO's etc to monitor land use improvement practices, with unsustainably produced bio-fuels counting as fossil fuel.
C. Use proportional intruments that create tradable obligations. A renewable portfolio standard would work fine providing the obligation is tradable (if it's hard to burn woodchips in Kansas power stations then they can pay for it to be done in NY; if it's hard for Texaco to source ethanol for their gas stations then they can pay for Shell to do it in theirs).
D. Mandate a rising proportion of dual-fuel vehicles (as being used today in Brazil) to match rising supply of ethanol/bio-diesel.
E. Where countries are in the Kyoto cap-and-trade framework, the proportionality can be driven through the system for 'allocating permits usefully' described above. E.g. issue them in multiple exchange for bio-fuel supply certificates (20 in 2010, 7 in 2015, 3in 2020, 2 in 2025, 1.25 in 2030 to mirror the rising percentages above).
F. Mandate a rising hectarage of plantation forests (new plus old to avoid additionality issues) linked proportionately to bio-fuel supply, to provide a strategic reserve and ensure security of supply of biomass feedstock. This yields co-produced sustainable raw material for timber product industries as well as bio-mass raw material for energy, thus providing an eventual alternative to the destruction of native forests.
G. A GEF program (start up in 2007) to train tens of thousands of bio-energy project entrepreneurs to create the hundreds of thousands of community scaled bio-energy projects needed to realise the sustainable development potential of bio-energy in the least developed countries. About 200 colleges linked to a dozen or so research grade universitites which 'train the trainers' and provide research back-up for trouble

shooting the problems that will arise with individual projects (the G8 action plan also recognises the need for capacity building in relation to bio-energy).

H. Mandate all new power stations and other large fuel burning plant (fossil fuel or bio-fuel) to be designed for retro-fitting CO2 capture (this effectively means use gasification and CCGT technology rather than steam boilers in new power stations)

I. Identify and prove geological CO2 storage sites to match potential flow of CO2 if retro-fitting needs to be implemented.

3 Causes of the negotiating failure

3.1 Unfortunately time constraints have prevented me preparing the properly organised discussion of this aspect that I hoped for. Following below is my response to a journalist who asked for my views on this question.

3.2 Message to a journalist follows:

How did we get into this pickle?

It needs a historian. I think the main problem is the intellectual drive provided by misapplied economic theory. But subsidiary factors are

- the beguiling logical fallacy 'energy emissions are the cause so reduce energy emissions'
- the need for a scapegoat - sock it to the big oil and power boys
- administrative simplicity of focusing on the energy sector
- the convergence of scientific awareness with anti-consumerism, leading to guilt trips and hairshirts greenies, too easily depicted as loonies
- negotiations are highly path dependent - successive rounds are to deal with problems left over from the previous meeting, not to re-open matters that have already been agreed. So nobody wanted to consider alternatives once the Berlin Mandate was interpreted as meaning more aggressive emissions reductions than in the Rio Treaty [absorption into sinks coming late into discussion, and treated as an irritating second best, even though logically more than equivalent, since potentially enabling negative anthropogenic flows, whereas cutting emissions can never do better than zero anthropogenic flows].
- many scientists and economists love the problem and are doing very nicely out of it (for my personal experience, see footnote 2 in my article in the MITI special issue mentioned above, commenting on the references).
- few technologists are interested in bioenergy which is obviously do-able (vide Brazil). Again, there is vested interest in research contracts for blue skies technologies that will solve the problem only if nature waits till 2100. Also US corn farmers lobby against ethanol imports.
- energy interests are happy with blue skies technologies also (for instance the APIECA people consistently downplay bio-energy) which enable them to maintain their vision (see 2a.2D-2E) of a fossil-fuelled future for their current investment planning.

Misapplied economics

Emissions tax concepts are based on a static theory that relates to a flow pollution problem. Thus, in each separate time period, impose a tax that equates the marginal cost of mitigation (say treating effluent better) with its marginal benefit (marginal damage avoided - say reduced fish kill). The theory of competitive general equilibrium (Arrow-Debreu) in which these concepts are grounded is itself deeply flawed, relying on an infeasible information set (Stiglitz) requiring complete probability distributions for all future events into an infinite future, and related contingency - i.e. insurance - markets handled by implausibly hyper-intelligent market agents (Simon) investing in completely described technologies. But in reality climate change presents a stock pollution problem that is inherently dynamic (a one day burst of emissions that would kill all the fish is immaterial to an accumulation over decades) and clouded by uncertainty as regards the FCCC ultimate objective, socio-economic prospects (the SRES scenarios) and technological competition (a fundamentally dynamic and unstable process that confounds all the conventional wisdom of price theory -- the bible is Arthur, W.B., 1994. (ed.) "Increasing Returns and Path Dependency in the Economy", University of Michigan Press.). Uncertainty means we don't have probability distributions and contingency markets can't work. It also invalidates the use of Cost Benefit Analysis, which relies on expected values of risky outcomes for which probability distributions are known. CBA is also invalidated by the global nature of the problem since it relies on an assumption of accepted (politically determined) income distribution, which may be true within the USA, despite Katrina, but is certainly not true as regards, say, the USA and Bangladesh. (Recollect the row over Chapter 6 of the WG3 contribution to the 1995 Second Assessment Report).

We are trying to achieve a technological transformation in the way that C-flows are impacted by human activity. The economics that is relevant is not the constrained optimisation of static competitive general equilibrium theory that gives rise to notions of carbon pricing, but the economics of technological dynamics and a feel for the business behaviour that is going to determine the pattern of investment and the outcome between competing technologies (fossil fuel or renewable as regards energy, sustainable or exploitative as regards land use). The need is to mobilise business in a competition to be first with the technologies of the future, not induce resistance by taxing away the revenues from existing business that are needed to finance a new pattern of investment. As regards energy, we need to do something practicable, not rely on wind that doesn't always blow and sun that doesn't always shine to power essential services and to fuel the transportation fleet. De-carbonising is hugely difficult, de-fossilizing to bio-based hydro-carbons is here and now, practicable, de-centralized and of modest scale and something that new players in the energy markets will exploit if existing players, IBM-like[27], opt out. Furthermore it is quite in line with a long tradititition in energy -- shifting from wood-fuel, to coal, to oil, to natural gas, and now to modern bio-energy presents no great problem, with continued use of the huge convenience of carbon fuels.

In short, economists have brought to the Climate Change problem off-the-shelf tools developed in response to other environmental problems and reliant on a body of theory that is invalidated by the critiques of Stiglitz, Arthur and Simon. Unfortunately economists are very close to governments so that their inputs have been highly damaging to progress with the problem. Nobel prize winner Thomas Schelling commented on my 1994 book "Responding to Global Warming" that it is "a skilled attempt at fashioning policy and a deep foundation for thinking on the subject". It came out at the wrong time, with gathering momentum towards the Berlin Mandate and Kyoto. With Kyoto in a mess, maybe there is hope for new directions, though the Pocantico dialogue does not offer any very striking new ideas.

[27] See footnote 18 – this aspect had been discussed earlier in the correspondence with the journalist.