Is it time to Limit Fossil Fuel Production?

Climate Control: a proposal for controlling global greenhouse gas emissions

Raf Manji[1]

[1] © Raf Manji, Director, Sustento Institute, 8 Bealey Avenue, Christchurch, 8014, New Zealand.

Abstract:

Global warming is considered to be one of the great eco-societal challenges facing mankind. A continuation of this trend is likely to have adverse societal consequences on a global scale. To date international agreement on the way to deal with this has not been achieved due to the complexity of the proposals and inequitable distribution of costs. This paper proposes a new approach which centres on the integration of the world energy market with a global climate model. Following the approach of the Montreal Protocol by directly addressing the source of greenhouse gas emissions, namely the producers of fossil fuels and relating that to changes in land-surface areas, a more efficient and successful outcome may be achieved.

Keywords: Greenhouse gas emissions, global warming, fossil fuels, climate change, energy, OPEC, IEA, Montreal Protocol.

I. Introduction

Global warming is well established in scientific circles as a serious event. Global average temperatures have risen by 0.6ºC over the last century (King 2004) and if the current trend is maintained, this could add between 1.5º and 5ºC over the next 100 years (Meyer 2000). The impact of this could be catastrophic in both economic and social terms with the global insurer Munich Re forecasting annual costs of $300bln due to climatic changes[2]. In 2004, the UK Prime Minister, Tony Blair, pronounced climate change as "the world's greatest environmental challenge"[3]. More recently the head of climate research at NASA, Dr Jim Hansen stated that the tipping point for global climate change is perhaps 10 years away[4]. The main cause cited for the occurrence of global warming is human activity. This activity has resulted in an increase in levels of carbon in the atmosphere, which has led to an overall warming effect, although this is still disputed in some areas (Lomborg 2001). The increase in carbon levels is a result of increased greenhouse gas emissions from fossil fuel extraction and combustion, land use changes and other natural outputs (IPCC 2001).

There has been a great deal of debate over how to deal with this issue and given the complexity and uncertainty around the outcomes, it is no surprise that national self-interest has come to the fore with no full scale major global agreement in place (Bartlett and Hickman 2001) . The arguments against a strong response to the problem are generally split into two camps: the first notes that economic growth is dependent on the

[2] See http://www.unep.org/Documents/Default.asp?DocumentID=192&ArticleID=2758
[3] Speech given to Prince of Wales Business & Environment Programme, 14th September 2004.
[4] http://www.cbsnews.com/stories/2006/03/17/60minutes/main1415985.shtml

use of fossil fuels and that any attempt to cut emissions will lead to lower economic growth, an outcome that is not acceptable to some politicians who are focused on shorter term electoral considerations. This group also contains some who are sceptics on the issue of global warming; the second camp postulates the view that although global warming may be happening and is a serious issue, the costs of dealing with it outweigh the benefits and the focus should be on adaptation policies (Lomborg 2001).

In section II, I will look at the issues surrounding global warming and examine the solutions proposed so far. I will summarize the current difficulties with the proposals and look at some of the key requirements for a successful international agreement. In section III, I will propose a new and simple theoretical framework for managing the global climate by integrating the global energy market with a global carbon inventory model. In section IV, I will look at whether this would work in practice by examining whether the global energy market can in fact be "managed". In section V, I will draw my conclusions and argue that the only way to guarantee carbon outputs is to manage carbon inputs by limiting annual fossil fuel use.

II. Global Warming

At the annual meeting of the British Association for the Advancement of Science in September 2004, Professor Mike Pilling claimed that "millions of people across the globe are set to die early due to extreme weather events"[5]. A report in the U.S., commissioned by the Pentagon, also noted that the impact of global warming "could be a significant drop in the human carrying capacity of the Earth's environment" (Randall and Schwartz 2003). These comments by two contrasting institutions have an air of doom about them. They state that global warming is indeed a very serious threat to mankind and one that needs to be addressed sooner rather than later. Whilst the issue has been on the global policy radar for some time (Young 1989) no full global agreement has come into force, although the Kyoto Protocol to the 1992 United Nations Framework Convention on Climate Change (UNFCCC) has come close to fruition (see Baumert et al. 2002, Faure et al. 2003).

However, as noted above, there is a general consensus that global warming is a problem emphasised in a joint declaration by the heads of eleven major scientific academies in the US National Academy of Sciences[6]. Although the U.S. government has so far not joined any international agreement it has called for further research (King 2004) as well as instituting its own policy, the Climate Change Initiative. This approach is technical in nature concentrating on improving the carbon intensity of the US economy, which measures the total greenhouse gas emissions per unit of total gross domestic product

[5] See http://www.forests.org/articles/reader.asp?linkid=34754
[6] http://nationalacademies.org/onpi/06072005.pdf

(GDP). The US government feels that its targets, although voluntary, will match those of the Kyoto Protocol (Christiansen 2003).

In general, the proposals for addressing global warming have been developed around three main policy instruments: emissions trading, carbon taxes and technological improvements. The US proposal would fall into the latter. In July 2005 this approach was further reinforced by the establishment of the Asia Pacific Partnership on Clean Development and Climate[7] involving the US, Australia, China, Japan, India and South Korea. This block represents 50% of world output and potentially will be influential in developing policy post Kyoto. It is interesting to note that the National Academy of Science in the US, China, India and Japan were all signatories to the 2005 Statement.

There has been a fair amount of analysis of the proposals to date (see Aldy, Barrett and Stavins 2003, Helm 2003), from which there has been no stand out solution. The Kyoto Protocol has also been the subject of a wide range of literature (see Meyer 2000, Lomborg 2001, Baurmert 2002, McKibbin and Wilcoxen 2002, Bohringer 2003, Faure et al 2003, Aldy et al 2003). The consensus is that Kyoto is a good start but not the final solution. As Bohringer notes Kyoto "provides a valuable starting point for efficient climate policies in the future". However, McKibbin and Wilcoxen take the view that the Kyoto Protocol is "completely ineffective in practice" and "doomed". It is likely that the post-2012 framework will look very different if not completely reworked (Biermann 2005).

[7] http://www.foreignminister.gov.au/releases/2005/js_cdc.html

The main flaws of Kyoto and many of the other proposals are the issues of compliance, enforcement, complexity, equity and costs (Aldy et al. 2003, McKibbin and Wilcoxen 2003). These issues have been examined empirically and found to be key planks of any successful international environmental agreement (Young 1989, Helm and Sprinz 2000, Mitchell 2003). The best known successful global environmental agreement is the Montreal Protocol on Substances that Deplete the Ozone Layer in 1987[8]. The success of this agreement was based on the approach to the problem and the actors involved.

The problem, namely a growing hole in the protective ozone layer, was identified and easily understood. The simple nature of the problem enabled a simple solution to be found: Chlorofluorocarbons (CFCs) were causing a hole in the ozone and production needed to be curtailed. As the CFC market was small, it was easier to negotiate an equitable across the board cut in production and also easy to monitor compliance (Young 1989). As Young further notes this is not the case with greenhouse gas emissions (GHGs) given that the sources of GHGs "are numerous and widely dispersed".

This is where I depart from the current mix of proposals. Young notes the wide dispersal of GHG emitters and this is evidenced by the attendance of 160 "national free riders" at COP 6, the Sixth Session of the Parties to the Climate Control Convention at the Hague in November 2000 (Bartlett and Hickman 2001). There was a similar spread of CFC users as well yet the focus was on the producers not the consumers. My proposal also concentrates on the producers of the GHG problem, namely fossil fuel companies. The Montreal Protocol did not target users of CFCs in air conditioners and fridges and offer

[8] See http://www.unep.org/ozone/index.asp

abatement processes, CFC emission permits or taxes on CFCs. They simply reduced the possible output, via production, to the required level.

I believe that the lack of a successful agreement to reduce GHGs is due to policies being developed to deal with actual emissions once they have been released as opposed to before they have been created. I will expand on this seemingly innocuous difference and propose that a similar approach to the one taken by the “dynamic and flexible” Montreal Protocol may yield better results (Benedick 1998).

III. A New Approach

Global warming is considered to be caused by the forcing effect of increasing carbon dioxide[9] in the atmosphere (IPCC 2001). Whilst the focus has been on fossil fuel consumption, changes in the atmosphere are also caused by other processes: land surface changes, methane hydrates, concrete production and other natural processes. The importance of land surface changes should not be underestimated and so far "climate mitigation policies do not generally incorporate the effects of these changes in the land surface on the surface albedo, the fluxes of sensible and latent heat to the atmosphere, and the distribution of energy within the climate system" (Marland et al. 2003).

The interaction between human activity and the ecosystem is extremely complex. Any increase in GHG emissions is likely to have "significant effects on atmospheric chemistry and biogeochemistry" (Ganzeveld and Lelieveld 2004). The ecosystem provides a range of goods and services, which include climate regulation, clean air and soil formation (Costanza et al. 1997). Any proposal to deal with global warming will need to recognise these interactions and incorporate them in any model. It should also be recognised that there is a lower limit of GHG required within the atmosphere in order to prevent temperatures falling as opposed to rising (Bird et al. 2004).

Marland et al further propose that, if possible, "an integrated assessment that recognizes all of the global and regional climate implications involved in a change in biosphere carbon stocks and land surface" would be the optimal solution. I concur with this

[9] For the purposes of this model I will use carbon dioxide as a reference for GHGs.

conclusion and have developed a simple model, which incorporates both GHG emissions and the impacts of land-surface change.

GHG emissions come mainly from the combustion of fossil fuels. Under most of the proposals reviewed above, GHG emissions are calculated on a national basis. However, GHG are emitted by consumers of fossil fuels, namely households and firms, who purchase fossil fuels directly from the market. The logic of proposing solutions that do not include either of the parties involved seems flawed. I believe that this stems from the treatment of the atmosphere as a "common-pool resource" and attempting to allocate rights to emit (Dolsak and Ostrom 2003). Although that is the case, the optimal solution may be found in simply limiting the inputs that produce GHGs. The fossil fuel producers may be able to take action themselves and be part of the solution as opposed to part of the problem. As with the CFC problem, the producer base is relatively contained and in some cases already cooperates in volume control (Amuzegar 2001).

As Tony Vogelsberg, a former environmental manager for CFCs at DuPont, noted, "The original Montreal Protocol and London Amendments were simple in that they controlled CFC production, import and export (production and consumption). This sent clear, unambiguous signals to chemical equipment and product producers that alternatives to CFCs would be required in less than a decade" (quoted in Canan and Reichman 2002).

Now I will make some assumptions based on the above:

1) Global warming is a serious problem and some limit on GHGs needs to be established.
2) A full carbon inventory can be created to take account of land-surface changes.
3) The fossil fuel market is well defined and contains a manageable amount of producers with good data on production.

We should therefore be able to construct the following simple equation[10]:

$$L_1 \geq (P_1+S_0) + O_0$$

Where:

L_1 = Set limit for GHG in current year.

P_1 = Production of fossil fuels in current year.

S_0 = Closing stocks of fossil fuels in previous year.

O_0 = Change in carbon inventory due to land-surface changes in previous year.

Therefore we should be able to solve for P_1:

$$P_1 \leq L_1 - S_0 - O_0$$

Therefore, given the ability to set a limit on annual GHG emissions and to measure annual changes on land-surface changes, we should be able to calculate a figure for the total allowable production of fossil fuels in a given year. Deciding on the annual limit is

[10] All variables will be converted into carbon equivalents using Global Warming Potential (GWP) conversion factors (IPCC 2001).

where the debate will be quite strong but this can be achieved. The current level of total carbon dioxide in the atmosphere is 380 ppm, which is still some way below the generally quoted figure of 550ppm, which had previously been regarded as a level below which serious climatic impact can be avoided (King 2004). However in recent literature (Azar 2005) ranges from 400ppm upwards are being stated as "tipping points" with various predicted consequences[11]. At the 2006 British Association Festival of Science many presenters stressed that this tipping point may come within the next 10-20 years[12]. The no doubt controversial setting of this limit will need to be undertaken by an independent scientific body, which will be discussed in the next section.

It is important to state here that the annual limit is a dictated not only by the other variables in the equation but also by changes or advances in scientific knowledge. As our understanding of the interaction between atmospheric and terrestrial ecosystems advances, our projections for what is an acceptable limit may change. I call this "flexible precaution", which is a move away from the rigid "precautionary principle" (Lomborg 2001, 348-350). This element of flexibility mimics the constant change that occurs within the Earth system and calls for a framework that is "not a static solution, but rather an ongoing process" (Benedick 1998).

The land-surface change data will incorporate the offset and sequestration components of carbon mitigation. For the purposes of this proposal I will not delve too far into this subject as previous literature covers it well (see Pohjola, Kerkela and Makipaa 2003,

---

[11] http://www.stabilisation2005.com/14_Malte_Meinshausen.pdf
[12] http://environment.guardian.co.uk/climatechange/story/0,,1865081,00.html

Sedjo and Marland 2003, Ganzeveld and Lelielveld 2004). The main form of sequestration of carbon dioxide has been through forest sinks. This has raised another interesting ownership issue. As in the emission data, forest sink data is applied on a national basis, even though forests may be owned by private interests. In New Zealand for example, the government originally decided to "retain sink credits and associated liabilities" under the Kyoto Protocol in return for a mixture of "policies and programmes"[13] but recently changed this unpopular policy to allow private landowners to get into "carbon farming"[14]. For the purposes of this model, ownership of sinks is not a major issue though in practice it is likely to become one, as providers of sinks will want to sell their carbon credits to the market.

So we have three key parts of the model to examine:

1) A set maximum level of production of fossil fuels.
2) An annual set limit for GHG emissions.
3) Data on annual creation or loss of sinks and other changes in the land-surface.

[13] See http://www.climatechange.govt.nz/policy-initiatives/sink-credits.html
[14] http://www.beehive.govt.nz/ViewDocument.aspx?DocumentID=26972

IV: Reality Check – Empirical Evidence

In this section I will look at the issues raised by setting a limit on fossil fuel production, annual GHG emissions and how to incorporate land-surface change credits and debits into a real world framework.

Fossil fuel production mainly consists of oil, gas and coal production and this is where GHG emissions mainly emanate from. Each fossil fuel has a different Global Warming Potential and can therefore be converted into a carbon dioxide equivalent. The production quota for any given year will be a carbon based number which can then be split out against oil, coal and gas. Using 2004 data from the U.S. Energy Information Administration (EIA)[15] we can look at the make up of global production and the GHG emissions from fossil fuel usage:

Carbon Dioxide Emissions from Fossil Fuel Combustion (Million Metric Tonnes):

Petroleum Products	10,849.65
Natural Gas	5,601.96
Coal	10,591.96
Total	27,043.57

Using conversion factors we can calculate that 3.45ppmv were added to the carbon dioxide in the atmosphere from fossil fuel consumption. From this number we can look at global production and see how a quota system might be workable. Trying to impose a

[15] See http://www.eia.doe.gov/emeu/iea/

quota on three combined products seems far-fetched but when we look at the production statistics we note that the situation is quite hopeful for cooperation, as the market is controlled by relatively few producing nations as was the case with CFCs.

World Fossil Fuel Production (2004):

	G8+5	G20
Crude Oil	38%	59%
Natural Gas	57%	73%
Coal	76%	94%

If we analyse the Top 5 Producers we will also note some consistency:

Top 5 Producers of Fossil Fuels (2004):

Crude Oil	Natural Gas	Coal
Saudi Arabia	Russia	China
Russia	U.S.A.	U.S.A.
U.S.A.	Canada	India
Iran	U.K.	Australia
China	Netherlands	Russia

In July 2006 the G8 nations “plus five” met to discuss both energy security and climate change issues[16]. The larger grouping known as G20 also has climate change and energy security on its agenda and given that the nations represented account for 90% of global

[16] http://www.complusalliance.org/plugins/ComPlusDoc/details.asp?type=DocDet&ObjectId=MTk2MTE

GNP and 80% of world trade their influence is likely to be the critical force in climate change negotiations[17]. The U.S. and Russia are both in the Top 5 producers for all categories. This is extremely pertinent given the reluctance of both parties to ratify the Kyoto Protocol. What is does suggest though is that if these influential nations can agree on a way forward then cooperation and compliance should be easy to achieve. The most widespread market is the crude oil market but at the same time it is the one market where there is already advanced and historical cooperation amongst many producers, namely OPEC and also on the importer side, the IEA.

To summarize so far: we can define a limit for annual (perhaps 2-3ppm) emissions in order to stay within a prescribed overall atmospheric limit whether it be 400,450 or 550ppm. This paper makes no attempt to argue what this limit should be, only that as long as we can establish one, we can control how we get there. From that limit we can calculate the maximum production of fossil fuels taking into account sinks and land use changes. If this can be achieved then the problem of global warming can be at the very least brought under reasonable control if not dealt with completely. The question here is whether the world fossil fuel market can operate under a quota system. I will look at the crude oil market here, given that control of this market is likely to bring with it control of coal and gas, which are in the hands of fewer producers.

The Organisation of Petroleum Exporting Countries (OPEC) was founded back in 1962 with "production programming" as one of its core propositions (Hartshorn 1993, 174),

---

[17] http://www.g20.org/Public/index.jsp

"1.i.3: That members shall study and formulate a system to ensure the stabilisation of prices by, among other mean, the regulation of production".

OPEC has operated under a quota system of production ever since, though its ability to manage and achieve stability of prices has not been noted as a great success. Still, the framework is there for cooperation in the production of oil. Historically, the quota system has been about manipulating prices, conserving reserves and maximising revenue from a depleting non-renewable resource (Amuzegar 2001). As a counterweight to OPEC, the International Energy Agency (IEA) was established in 1974 to deal with "future oil emergencies" and reduce "dependence on oil"[18].

The IEA further notes,
"Among the important challenges we face today is how to reconcile energy production and use with protection of the environment, including the global climate. The IEA is strongly committed to helping countries meet both energy and environmental goals".

Although IEA and the OPEC have been the "standard-bearers of embattled importers on the one hand and exporters on the other" (Hartshorn 1993, 253), there is room for cooperation if the goal is clearly stated. In this case, the goal is to keep within certain production limits. "Voluntary pro-rationing" has always been a feature of the oil market (Griffin and Teece 1982) and there is no reason why this cannot be extended to the fossil fuel market as a whole.

[18] See http://www.iea.org/Textbase/about/Overview.pdf

Initial reactions may be that with rationing the oil price may rise but this has been the case for many years already. In fact it could be argued that the market as it stands is "distorted so long as comparative costs are not fully reflected in crude oil prices" and far from desiring lower oil prices many high cost producers outside OPEC are very happy to see prices high (Harthorn 1993, 280). That fact notwithstanding, the key to the overall energy picture is that if prices rise high enough they will hit a level at which "backstop technology" will be competitive (Nordhaus 1973 quoted in Griffin and Teece 1982, 96).

There are many potential scenarios that could emerge: the safe limit for GHG emissions could be adjusted up or down, depending on land-surface changes and increases in carbon intensity; alternative energy sources may come on line at a much earlier date than forecast (Lomborg 2001, 130-136). Of course forecasting demand for energy has always been a precarious profession. As the well known political economist Professor Edith Penrose noted, " Never….has an oil industry consensus turned out to be correct" (quoted in Hartshorn 1993, 252). Just as oil forecasts have never been very successful, current forecasts for energy demand and GHG emissions should be treated with caution.

Perversely by focusing on what is available for consumption, a more sustainable outcome may be achieved. As the US government has outlined in its proposals (Christiansen 2003), carbon intensity and efficiency advances may well produce the same results as the convoluted and complex Kyoto Protocol hopes for. Rising oil prices in the 1970s and 1980s produced: greater fuel conservation; increased efficiency in energy/output ratios; redesign of energy using machinery and stimulated the development of oil substitutes (conventional: coal, hydro and nuclear and "exotic": solar, wind and geothermal) (Amuzegar 2001).

There is no doubt that this trend will continue as technology improves and the price of alternative energy sources falls. As John Litchblau, Chairman of the Petroleum Industry Research Foundation, noted oil price increases "mobilized the entire technological and economic genius of the world for the task of reducing oil imports" (Griffin and Teece 1982, 208). This adaptive trend is likely to continue even with the increased demand for energy coming from countries like China.

There is a question over how production quotas will be allocated. If production allowance is left at the current level or even at a slightly higher level then it is unlikely any process will be required as the market can only just cope. However, looking forward some form of quota system will be necessary. The most usual form of allocation is historic use, which is likely to be the optimal solution here. If countries cannot produce at a given level then they can sell their quota. This issue is well covered in the literature (see Tietenberg 2003).

Given that the limit has been established and production set and quotas agreed upon, the next step is to decide on what type of institutional framework will be required to administer the system. I propose a Global Commons Authority (GCA) with a Global Energy Agency (GEA) to act as the administrator of this system. The GCA/GEA will have the following tasks to carry out:

1) Instructing a Scientific Panel to establish the acceptable annual limit.
2) To then establish the annual production quota.
3) To allocate the annual production quotas.
4) To monitor and enforce compliance.
5) To aid the establishment of an integrated World Energy Market.

Items 1 and 2 are fairly straightforward though there will be some conflict on the appointment of scientists as well as the allocation between oil, gas and coal at the margin. Still these are not insurmountable problems. Item 3 is crucial and quite simple. As the energy production market is quite simple to monitor there is not much chance of quota busting but to enforce compliance and establish certainty and trust, the GCA/GEA will process all payments between the market and the producers. No producer will be paid for production over the allowable quota. If that does happen the revenue will be held back against a reduction in next year's quota. This revenue will be held in bonds and interest will be paid. This provides a very simple yet effective process for compliance and creates a web of trust around the process.

Item 4 sees an integrated World Energy Market (WEM) being formed. Again there are institutions already in place within the oil, gas and coal markets but this proposal envisages a more integrated and efficient marketplace where transaction costs will be lowered and transparency increased. The dependence of the global economy on energy and on the ecosystem that provides it is becoming quite clear now and a proactive response is to move on from the rather inefficient processes that have underpinned the world energy market over the last 40 years (Amuzegar 2001).

The overall structure would see the GCA overseeing the GEA, which would process payments between the WEM and the producers. This would allow for certainty, maximise compliance and enable a more efficient market to operate. The goal of the Scientific Panel would be clear: to establish an integrated land-surface change model[19] and build this into forecasts for impacts from global warming. There is no doubt that as understanding increases forecasts will change. This model is built on that assumption and can accommodate changes on an annual basis or a longer time-scale. In reality, it is likely that emission paths will be set for a reasonable period in advance in order to facilitate production preparation and provide certainty for capital investment decisions.

To sum up this section I would argue as follows: it is possible to manage the world energy system in a simple and efficient manner. If we can establish production quotas and create a simple framework for implementing and monitoring those then the market may well become more transparent and efficient. If we can create a balanced and independent panel of earth scientists and a fully integrated land-surface change model (Marland et al 2003), then some kind of certainty in planning can be achieved.

[19] See http://www.atm.helsinki.fi/ILEAPS/ as an example.

V: Conclusion – Problems, Drawbacks and the Future

I have proposed a new framework for managing the global climate, which takes a very different approach to any proposal so far made. The logic is one of focusing on the problem and solving it in the most efficient way possible. The proposals surveyed in Section II seem complex, unwieldy and ultimately unworkable. The problem is simple: too much carbon dioxide in the atmosphere will have an extremely negative effect on humanity not just in environmental terms but in economic impacts. Simply put carbon dioxide emissions come mainly from fossil fuel combustion and land-surface changes. If we control both within an accepted limit then the outcome can be successful.

I have shown that it is indeed possible to manage the world energy market given the political will. The success of the Montreal Protocol showed that with the right leadership it is possible to craft a global environmental agreement (Depledge 2005). It is also important to note that the U.S. is in a strong position to make this happen as the world's largest producer of fossil fuels. The U.S. may also realise that the cost of dealing with global warming may not actually be as large as thought and by taking the lead they may well be able to put their influence to good use (Elliot and Hanson 2003). There is also the potential for the World Energy Market to be proactive in dealing with global warming, a point emphasised by the IEA. The problem is not going to disappear but at the same time it offers the opportunity for the re-development of the global energy scene potentially leading to a more efficient and transparent market.

There is also the advantage that not many countries are required to make this happen. If the G8/G20 producers can agree to proceed in this way, then it will happen. This is somewhat easier than getting 160 nations to agree on proposals that everyone knows are unlikely to be implemented. The employment of a "flexible precautionary approach" also enables room for new scientific understanding and room for new variables and solutions.

This is also an equitable solution. In fact, the market is being reorganised around a new framework but once that has been agreed and limits set, no one producer is likely to be negatively impacted. Energy supplies may be stabilised and secured as all producers realise it is in their interests to take charge of the situation and build for future.

This is clearly a new way of approaching the issue of global warming and one that may be simpler, more efficient and more likely to have a successful outcome. It is not however the first attempt to propose such an integrated energy system. The Brandt Commission in 1977 proposed an "international strategy on energy" and "a global energy research centre" (Evans 1986). Global warming may well provide the exogenous crisis required to enable this to happen (Young 1989).

This proposal can be regarded as a concrete starting point for the development of a more coherent energy system, which will be required if the interaction between energy inputs, outputs and the global climate are to be managed optimally. This proposal does not seek to debate what limit should be applied and how we might get there but accepts that there is a limit of GHG concentrations in the atmosphere above which more serious and potentially irreversible consequences may occur. At the same time this model is flexible enough to allow for increased understanding and new discoveries in climate science.

One obvious criticism is the unresolved issue of trading away short term gains for long term payoffs. What is to stop new cartels forming? My answer is to say that the Montreal Protocol worked even when the gains were seen to be a reduction in skin cancer in the long term. However, climate change is not just an environmental concern but an economic one. It is the economic impact of climate change that may well cause nations like the US to really take on this challenge. As more negative economic impacts are attributed to climate change, more politicians will take note and look for expedient solutions which are actually an investment in the future.

I believe all proposals to date have focused on mitigating, adapting to and dealing with an increase in GHG emissions. To have not focused on trying to control the cause of these emissions at the input level has been an oversight and a result of a firm reluctance to accept that there must be a fundamental restructuring of the global carbon based energy market. Whilst there is the necessity for further research into the model itself, whether it would be acceptable and how it might impact on the global economy, I hope this has paper has at least provided the foundation for such exploration.

Bibliography:

Aldy, J.E., Barrett, S and Stavins, R.N. 2003. Thirteen plus one: a comparison of global climate policy architectures. *Climate Policy*, 3, 4, 373-397.

Amuzegar, J. 2001. *Managing the Oil Wealth: OPEC's Windfalls and Pitfalls.*

Azar, C. 2005. Post-Kyoto climate policy targets: costs and competitiveness implications. *Climate Policy*, 5, 309-328.

Bartlett, S. and Hickman, J. 2001. Global Tragedy of the Commons at COP 6. *Synthesis/Regeneration*, 2001, Wntr, 47-50.

Baumert, K. ed. 2002. *Building on the Kyoto Protocol: Options for Protecting the Climate.*

Benedick, R. 1998. The Montreal Protocol as a New Approach to Diplomacy in LePestre, P.G., Reid, J.D. and Morehouse Jr, E.T. *Protecting the Ozone Layer: Lessons, Models and Prospects*, 81-89.

Biermann, F. 2005. Between the USA and the South: strategic choices for European Climate Policy. *Climate Policy*, 5, 273-290.

Bird, D.K., Hessler, A.M., Jones, R.L. and Lowe, D.R. 2004. A lower limit for atmospheric carbon dioxide levels 3.2 billion years ago. *Nature,* 428, 6984, 736.

Bohringer, C. 2003. The Kyoto Protocol: A Review and Perspectives. *Oxford Review of Economic Policy*, 19, 3, 451-466.

Canan, P. and Reichman, N. 2002. *Ozone Connections: Expert Networks in Global Environmental Governance.*

Christiansen, A.C. 2003. Convergence or divergence? Status and prospects for US climate strategy. *Climate Policy*, 3, 4, 343-358.

Costanza, R., D'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P. and van den Bett, M. 1997. The value of the world's ecosystem services and natural capital. *Nature*, 387, 253-259.

Depledge, J. 2005. *The Organization of Global Negotiations: Constructing the Climate Change Regime.*

Dolsak, N. and Ostrom, E. 2003. *The Commons in the New Millennium*.

Elliot, S.M. and Hanson, H.P. 2003. Syndication of the Earth System: the future of geoscience? *Environmental Science & Policy*, 6, 5, 457-463.

Evans, J. 1986. *OPEC, Its Member States and the World Energy Market*.

Faure, M., Gupta, J. and Nentjes, A. eds. 2003. *Climate Change and the Kyoto Protocol: The Role of Institutions and Instruments to Control Global Change.*

Ganzeveld, L. and Lelieveld, J. 2004. Impact of Amazonian deforestation on atmospheric chemistry. *Geophysical Research Letters*, 31, 6.

Griffin, J.M. and Teece, D.J. 1982. *OPEC behaviour and world oil prices*.

Hartshorn, J.E. 1993. *Oil trade: politics and prospects*.

Helm, D. 2003. The Assessment: Climate-Change Policy, *Oxford Review of Economic Policy*, 19, 3, 349-361.

Helm, C. and Sprinz, D. 2000. Measuring the Effectiveness of International Environmental Regimes, *The Journal of Conflict Resolution*, 44, 5, 630-652.

IPCC. 2001. *Climate Change 2001: The Scientific Basis*.

King, D.A. 2004. Climate Change Science: Adapt, Mitigate or Ignore? *Science*, 303, 176-177.

Lomborg, B. 2001. *The Skeptical Environmentalist*.

Marland, G., Pielke Sr., R.A., Apps, M., Avissar, R., Betts, R.A., Davis, K.J., Frumhoff, P.C., Jackson, S.T., Joyce, L.A., Kauppi, P., Katzenberger, J., MacDicken, K.G., Neilson, R.P., Niles, J.O., Niyogi, D.D.S., Norby, R.J., Pena, N., Sampson, N. and Xue, Y. The Climatic Impacts of Land Surface Change and Carbon Management, and the Implications for Climate-Change Mitigation Policy, *Climate Policy*, 3, 2, 149-157.

McKibbin, W.J. and Wilcoxen, P.J. 2002. *Climate Change Policy after Kyoto: Blueprint for a realistic approach.*

Meyer, A. 2000. *Contraction and Convergence: The Global Solution to Climate Change*.

Mitchell, R.B. 2003. International Environmental Agreements: A Survey of Their Features, Formation and Effects, *Annual Review of Environmental Resources*, 28, 429-461.

Pohjola, J, Kerkela, L. and Makipaa, R. 2003. Credited forest carbon sinks: how the cost reduction is allocated among countries and sectors, *Climate Policy*, 3, 4, 445-461.

Randall, D. and Schwartz, P. 2003. *An Abrupt Climate Change Scenario and Its Implications for United States National Security*.

Sedjo, R.A. and Marland, G. 2003. Inter-trading permanent emissions credits and rented temporary carbon emissions offsets: some issues and alternatives, *Climate Policy*, 3, 4, 435-444.

Tietenberg, T. 2003. The Tradeable-Permits Approach to Protecting the Commons: Lessons for Climate Change, *Oxford Review of Economic Policy*, 19, 3, 400-419.

Young, O.R. 1989. The Politics of International Regime Formation: Managing Natural Resources and the Environment, *International Organization*, 43, 3, 349-375.