The Fix: A Global Warming Policy Practitioner's Handbook

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I. Introduction

There has been in the last few years a very substantial restating of the global warming "problem." This restatement has been vetted and has stood examination by an erudite group of economists and economic modelers who have been thinking about the problem for the last 20 years (at least). These new conclusions, in my view, have quite different policy implications than those currently driving the global policy debate. In this paper, I extract some straightforward policy conclusions from the new analyses. The outline of a plan I present here could be turned into very concrete, practical, and inexpensive steps, which are intended to put us on a path to resolving the global warming problem.

This paper begins with a review of evidence and the argument that the global warming problem, if it is that, cannot be very usefully addressed with substantial greenhouse gas emissions reduction now. However, the same evidence strongly suggests that other, more strategic, action to prepare for possible future reductions should be taken now. The paper presents a case that such strategy should be focused on the long run viability of warming policy and thus facilitate implementation of possible future policy action probably directed at emissions. Instead of pursuing a partial measure (i.e. Kyoto) now, strategy should be focused on preparing the world to do all of what might need to be done later. The initial action suggested here is to develop a formal international program of energy research and development that is "permanently" funded. That funding is to be based on a small tax (on carbon) to support energy R&D on a multilateral basis.

Better energy-related technology gives future decision makers greater optionality for necessary choices, that is, the right choices will be less economically burdensome. Further, several key and recent economic developments (rapid financing of new energy infrastructure and the large scale rise of energy service outsourcing within our more competitive world

economy) strongly affect energy use, (and therefore emissions levels). The energy sector of the world economy has grown more responsive to market-based policy and will continue to do so. There is reason for greater optimism that future policy can be made to work. And finally, by creating a policy mechanism now (i.e. a carbon tax), we can make available to future policymakers tools to help future governments make the "right" decision.

II. A Meta Paradigm

To my knowledge, what I view as the new global warming paradigm made its first published appearance in a 1996 *Nature* article by Tom Wigley, Rick Richels, and Jae Edmunds. (Let's call it the WRE Paradigm.) As it has been further developed, this approach has become so powerful (in our opinion) that it deflates the emissions target-setting focus of the Kyoto treaty *and* the view of skeptics that a human induced global warming has not been proven. What follows is my summary of that hypothesis and subsequent implications. (I am, of course, responsible for oversimplification or error, not these or other authors.)

The first cornerstone of the WRE Paradigm is a strong focus on the global warming problem as one of "managing" the future level of concentration of warming gases in the atmosphere and not, for example, on current emission levels. This is exactly in conformance with the science, of course. The current policy debate, however, has moved to a focus on emission levels. This is perhaps understandable because almost all scientists in the field believe that human caused emissions are causing a rise in concentration levels. However, it is undeniable that long term management of concentration levels is the fundamental issue. Further, the authors specify that management problem as one of stabilizing concentrations at some acceptable long term level. This focus gives modelers the opportunity to make a very important point: stabilization of greenhouse gas concentrations at almost any conceivably acceptable level is virtually impossible except in the very long term. They have suggested by the end of the 21st century as a guidepost.

Basically, this long term focusing of the problem hinges on two facts: Emission levels consistent with stabilization are extremely costly to achieve in the short run, and even Kyoto's

very ambitious, short run goal of returning emissions to 1990 levels will not stabilize concentration levels (at least in the short term).

The second insight of the Paradigm is to frame concentration stabilization as a risk-management problem. Part of the public debate on global warming is a fierce "op-ed" discussion between skeptics and proponents as to whether global warming effects are real, and if real, whether they'll prove to be overall more helpful than harmful. The WRE Paradigm greatly diminishes the significance of this debate. Briefly, the logic is as follows: Even if one gives full credit to the skeptics' points, one still cannot dismiss the *possibility* that global warming exists and will be substantially harmful. Since there is a risk of great harm, prudent individuals and governments should desire to buy insurance against these risks. Thus, even if skeptical, we should still - to some degree - alter our behavior (at some cost) in response to global warming risk. Of course, we should do less (incur less cost) than if we were absolutely certain of global warming harm. But no action is indefensible intellectually, and we must address the question of what is to be done.[1]

Economists and modelers have worked to answer that question by extrapolating into the future reasonable alternative economic activity and emissions levels consistent with achieving various stable concentration levels and maximizing economic benefits to the world (i.e. minimizing the cost of achieving stabilization). These time paths tend to have a very notable

[1] There are other logical routes (or additional arguments) which support the imperative of cautious initial action. See some of the following for these discussions. (Hahn, Robert W., *The Economics & Politics of Climate Change*, American Enterprise Institute, The AEI Press, 1998, p. 37-43, a particularly good summary: Mendelsohn, Robert, *The Greening of Global Warming*, American Enterprise Institute, The AEI Press, 1999.) Recent contributions highlight evidence of possible benefits from global warming. Certainly, one must agree with these authors that the existence of global warming benefits that offset some (or all) harm for a period of time militates in favor of incurring more limited costs now. However, I remain most impressed with the open-ended nature of global warming harm. I will suggest (see below) that the "benefits" arguments tend to support the optimality strategy developed here.

feature in common: they call for rather modest (if any) reductions in GHG emissions in the near future, and very large reductions toward the end of the century.[2]

Thus, the modelers tell us that extrapolated emission levels for the near future consistent with stabilization paths are not very different from emissions that would be normally expected. On the other hand, substantial reductions in the near future, in and of themselves (i.e. if not sustained on an annual basis), have almost no impact on the extrapolated timing of stabilization. These may be very counterintuitive conclusions to many. But if they are correct, what follows is irresistible: it is the end game that is critical and the end game occurs in the distant future.[3]

Hence, the appropriate issue for today is how to prepare to win the end game. This is by no means a trivial matter, since the reductions that seem to be required for the end game are daunting indeed. But the answer is also not necessarily expensive at all in the near term since it does not involve achieving stabilization level emissions reductions immediately (which would be very expensive).

One answer given to us by WRE and others is "new energy technology (both in terms of creating supply and in use)," that is, technology which is much less carbon intensive and less

[2] The term *reductions* needs to be used carefully. Throughout recent history, the economies of the world have shown a steady improvement in the cost and efficiency of production and use of energy. There is every reason to expect this to continue. Yet, total GHG emissions will continue to increase because expected economic growth swamps improvements in energy efficiency. Analysts and modelers in this field tend to think of emissions reduction as those achieved *relative* to the level of emissions that would result from "normal" economic growth and improvement in energy efficiency, that is business as usual. The optimal time paths to concentration level stabilization calls for large relative reductions to occur by the end of the century. Since these reductions are, by definition, greater than would normally be expected, they must result from some policy action on the part of governments or follow from some unexpected set of events. It is also important to note that these business as usual scenarios assume most of the GHG emission-inducing growth occurs in the developing world. This is because many developing economies with very large populations are assumed to grow rapidly, largely catching up to the developed world in terms of per capita income. Ultimately, stabilization requires that emissions fall significantly below the 1990 target levels established at Kyoto.

costly than would otherwise be expected. The fact that the global warming problem can only be solved over the very long term creates any number of difficulties. (Foremost among them: for better or worse, we're going to have to live with some increased concentration effects.) But it does yield the following advantage: over the very long term it is reasonable to believe we can dramatically change our energy-related technologies, and, just as importantly, the energy infrastructure in place. Nor is there any reason to believe creating and using such carbon free (or very low carbon) technologies need be nearly as crushing an economic burden as achieving similar reductions in tomorrow's economy with today's technology.

Even though inducing greater than expected technology change might not be fabulously expensive, it is very unlikely to be free. Further, this course of action is not without its own difficulties. Relying on a strategy of long term energy infrastructure reformation to "solve" the global warming problem means that, should the problem prove real, policies designed to induce technology change must be sustained for a century and possibly more. Democracies typically have great problems keeping policy focus beyond election cycles measured in years not centuries.

This is exactly the problem I seek to address here: what are some immediate policies and actions that can realistically be taken to set us on the "right" policy path and then sustain that path.

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[3] One of the insidious features of global warming is that effect (warming) follows cause (presumably emissions) only with a very long time lag. Further, there are also time lags associated with remedying the cause itself (emissions). When nations face clear and immediate danger from warming, emission reduction remedial action will not prevent the problem from getting much worse before it gets better. The existence of offsetting benefits from global warming may exacerbate this effect. Mendelsohn cogently argues that warming benefits from temperate regions will offset some, and perhaps all, of the harm to tropical regions for some time to come (Mendelsohn, Robert, *The Greening of Global Warming*, American Enterprise Institute, The AEI Press, 1999.) Obviously any call to action on global warming must be joined by the temperate climate nations. However, their perception of clear and immediate danger (to them) may be delayed substantially past the point in time when net harm begins to accumulate because they themselves may be experiencing benefits rather than harm.

III. Sequential Decisionmaking Requires an Options Framework

Creating Optionality

If one posed the WRE CO_2 concentration level curves to a financial market trader and added the information that such high levels might be accompanied by very high, but not certain damages, he or she would immediately start thinking in terms of "creating cheap optionality". This phrase is poor English, but will be readily understood. Basically, it means creatively finding and acquiring options that can be exercised to offset high costs should the adverse uncertainties be realized. This regimen is very different than simply placing a bet on one outcome or another, and at least several steps beyond the fairly straightforward action of buying "insurance" as mentioned above. Insurance or a simple option is really a retail product offered to a customer when normal business activity exposes him to undesirable financial risk. The trader who sells the option simultaneously seeks to find ways to tease out countervailing market positions that may be hidden in even unrelated markets and then acquires the rights to those positions at very low cost.

Consider the following simple example: Suppose there are manufacturers in the Northeast United States who find natural gas and related technologies to be their most economically efficient fuel choice over the long term. However, using gas could render them highly vulnerable financially to the very volatile gas market. They might, therefore, decide to use "inferior," but less risky technology or, having gotten locked into gas use during a period of price stability, simply bear a highly undesirable risk. A trader, of course, might offer to sell a long-term option to buy the commodity at an acceptable price, which solves the manufacturers' problem, but leaves the trader "wearing" the risk. The trader, however, will search for "cheap optionality" and might find it, for example, among electric power generators in Florida who have secure (price guaranteed) supplies of natural gas as fuel. The trader could buy from them the right to switch them to an alternate fuel and finance the installation of the fuel switching capability. Thus, optionality that might otherwise have been missed is realized to the benefit of all. (Of course, the manufacturer could undertake the same transaction with the same benefit.

The trader, in principle, is simply better at finding and transacting such opportunities, a specialist in the great division of labor.)

By analogy, investment in energy research and development (R&D) creates cheap optionality, making less costly (than would otherwise be expected) low carbon energy technologies available if and when needed.[4] This analogy is appropriate to global warming matters for a number of reasons. Two have already been touched upon. First, the reality and the extent of the global warming problem are uncertain. Second, both the greatest cause of the problem (caused by future growth in emissions) and its solution will flow from decisions made in the distant future (per WRE).[5] Energy technology R and D can give future decision-makers who must deal with these issues more attractive options from which to choose.

Of course, optionality is only of value if it can be exercised in a timely fashion. Global warming thinkers generally assume that reforming the world's energy infrastructure with better technologies will be a lengthy process requiring very long lead times with a slow turnover of embedded capital. In fact, this dynamic has changed and continues to change in several significant ways. I believe that unfolding economic events militate in favor of placing greater reliance on the R&D optionality strategy, rather than less, as seems to be occurring almost by default as nations and private firms reduce energy R&D expenditures.[6]

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[4] Traders are not readily led to sell global warming options and finance energy R&D because future market realized penalties for greenhouse gas emissions are a matter of policy rather than market economics. And, of course, the trader is unlikely to capture the full benefit of R&D expenditures: it's what economists call "a public good."

[5] Alternatively what is the value of the reduction of one ton of CO_2 today? It depends critically on the outcome of uncertain events, and future responses to those events. For example, if scientists find over the next 10 or 20 years that the global warming case is fully borne out, both as to effect and harm, and immediate steps are taken to forestall the problem, then the value of today's reduction is virtually zero. Alternatively, if the problem is nonetheless ignored and dire consequences result, then today's reduction might be valuable indeed. But this sort of sequential branching of possible outcomes with substantially different consequences is exactly the type of circumstance that calls for creating optionality.

[6] *Powerful Partnerships, The Federal Role in International Cooperation on Energy Innovation,* A Report from the Panel on International Cooperation in Energy Research, Development, Demonstration, and Deployment, The President's Committee of Advisors on Science and Technology (PCAST), June 1999, Chapter 2, p. 6.

Exercising Optionality

In financial and commodity markets, contractual options are exercised, literally, with the flick of a finger. Substantial effort is devoted to structuring options contracts and options markets to assure that such exercise can, in fact, occur virtually instantaneously. Were policymakers to rely on technology optionality as a global warming strategy, we must have some assurance the optionality will be used. There are at least two concerns that come to mind with regard to such exercise. First, as a matter of history, energy related infrastructure is long lived and turns over very slowly. Second, it is likely, though not certain, that exercising available low carbon technology options will require significant global policy action. How can we be assured that governments will, in fact, take action to exercise a technology option in a timely fashion? I'll first try to tackle the economic question, before delving into politics.

The essence of optionality is finding and creating a greater range of possible choices in the face of contingent circumstances. The perceived global warming problem and existence of the causative technology infrastructure are at this juncture largely outcomes of contingent circumstances. WRE tells us that what we do with emissions over the next 10-20 years (at least) is of limited consequence with regard to future CO_2 concentration levels and long term (net) harm. A very large portion, almost all, of the physical equipment that is expected to cause unacceptably high CO_2 concentration levels at the end of the this century is not in place today. Nor have any irrevocable decisions been made to install it. Alternatively, if carbon free energy-conversion technologies costing less than those carbon-based were to appear tomorrow (or we could be certain it would appear 10 - 20 years from now) global warming would lose its significance as a policy issue. (There still might be significant global warming, primarily dictated by already existing concentration levels.) Such technology developments should be deemed unlikely perhaps, but far from impossible. Safe, cheap, low radiation nuclear plus cheap electric storage, for example, does it.

The possibility of such a serendipitous contingency militates against incurring substantial incremental emissions reduction costs in the near future, but does not dictate incurring no costs. It does, however, strongly support the efficacy of an optionality approach: "Don't solve the

problem before we need to." The problem might even solve itself, if business as usual technology development provides us with timely, carbon-free technologies.[7]

IV. The World Energy Economy is Different Now

An optionality strategy is made additionally attractive by continuing and highly significant developments in the structure and functioning of the world economy. The importance of certain developments in energy markets has not been appreciated fully, if at all, in the context of global warming policy. One such development is a substantial trend worldwide toward privatization and deregulation of most countries' economies in general and their energy sectors in particular. This, of course, has the greatest significance in developing countries, which are actually expected to contribute most heavily to anticipated global warming problems (i.e. the second half of the 21st Century). Surprisingly, even within developed, free market economies, the structure and modus operandi of business entities is rapidly evolving in ways that will affect global warming.

These developments give us every reason to believe that, given the right economic incentives, the private sector will implement new energy-related infrastructure technologies much more rapidly than in the past. Therefore, infrastructure turnover and changes in market structure, both in electric power generation and end-use activity, could occur more quickly than is suggested in current economic models. In addition, there is good reason to suppose that such reformation will shift the world economy to a lower emissions path than is currently expected with business as usual. Business as usual has changed and continues to change.

Infrastructure Development Reform

The recent British performance on CO_2 emission targets is both illustrative and a highly significant indicator of evolving business practices associated with power generation infrastructure (and other large industrial infrastructure). It is not so well known, but almost alone among developed countries Great Britain actually met the CO_2 emission guidelines set out in the

[7] Creating a non-carbon lowest cost energy technology is, in fact, the one sure path to solving the global

1992 Rio Accords. Such an amazing achievement did not result, as one might assume, from a very aggressive global warming policy. Rather, it occurred in large part because Britain's gas and power markets were deregulated. As a consequence, natural gas from the North Sea became available as a viable fuel source to the electric power industry. Such gas had previously been effectively shut-in by a national monopoly.

Given gas deregulation, power plant developers could make effective use of gas-fired turbine technology that is recognized world wide as simply the most efficient and cost effective means of producing power (assuming gas is available). Competition was also unleashed in the power markets and quickly led buyers to purchase the lowest cost power which, of course, came from new gas plants. Finally, private banks in conjunction with project developers continued to use and further refine modern project finance techniques so as to readily raise the many billions of pounds of capital needed to build facilities to meet demand for low cost electricity. The result was, in very short order, a substantial turnover of the power-generating infrastructure in Great Britain, gas for coal, to the extent that CO_2 emissions were reduced despite vigorous economic growth.[8]

To a lesser degree, the British experience has been repeated in a number of developing countries—i.e. modern project financing techniques used to expand infrastructure in general, and energy infrastructure in particular, much more rapidly than history would lead us to believe is possible. The British experience, per se, could not likely be repeated on a global scale concurrently in every country—there would be delays in build-up of capital equipment manufacture and shut-in supplies of natural gas are not so readily available everywhere, among other differences. Further, the British experience does not remotely suggest that the global warming problem could solved by energy deregulation. The rapid displacement of coal by gas infrastructure led to GHG emissions reductions only through serendipity: the fact the gas has lower emissions was not inherent to the displacement decision. But it is fair to conclude that deregulation, privatization, and newly honed financing capabilities have reduced expected

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warming issue: if it is cheaper, we can be sure it will be used.

[8]Substitution of these gas plants for existing coal plants reduced CO_2 emissions in a twofold manner: first, gas is much less carbon intensive per unit of energy than coal; second, the gas plants are substantially more efficient, so more energy is converted into electricity.

response time for infrastructure turnover and should continue to reduce it. Therefore, it may be concluded that incentive based GHG reduction policies (i.e. carbon taxes or emission credit schemes) in the future will have a more rapid and powerful effect than we currently conceive. Further, that response will be proportional to the incentive created, that is turnover acceleration is more accessible to policymakers if they use the right tools.

Business Organization Reform: Hierarchies and Infrastructure

I would also posit that market economies will in the future become much more responsive in taking advantage of improved efficiencies in energy utilization technologies (again, given the right incentives). Basically, a more competitive world economy causes business to be much more aggressive in its efforts to reduce costs, including more efficient use of energy. Such an improvement in performance is not yet as readily visible as is market driven infrastructure creation. There are, however, developments afoot.

In order to achieve competitive advantage, many businesses are now organizing themselves around what is referred to as a core function or mission. This is accomplished in part by delegating substantive non-core functions to outside providers. Of course, we know that retail firms sell goods, hotels sell rooms, real estate companies sell office space, hospitals sell heath care; and the list goes on. Currently, the evolving core function management theory suggests such companies will be more competitive if their top executives are extremely skilled, focused and even visionary with regard to that core function. By focusing on and making sound judgements relating to the core business, management is, in the parlance of the day, maximizing shareholder value. But such executives are almost certainly not equally well versed in any number of ancillary activities that support the core function.[9]

Consequently, given a typical hierarchical corporate structure that controls core and all related activities, it is not to be expected that corporations will make very good business decisions regarding ancillary functions. Nor should they—executives' time is better spent

[9] Operation of physical facilities and acquisition of energy supplies, which will be the focus of our attention here, is typically such an ancillary activity for most commercial and industrial companies. Top management is not expected to be well versed, for example, in "building operations."

focusing on maximizing results from core activities even through this might cause inefficiency in other non-core activities.

Today, however, it is becoming commonplace (though far from universal) for companies to contract for customized service packages which provide a range of non-core functions. Known by the inelegant term—*outsourcing*—this practice was pioneered by Ross Perot and EDS in information technologies (IT). In addition to EDS, IBM, CSC, Arthur Andersen and others now have large practices in this field. In this model, high level management's scrutiny of IT technical intricacies is displaced by competitive bidding on price (assuring cost effectiveness) and monitoring of service levels. CEOs may not understand bits and bytes, but they can readily survey their own organization to see if the company is receiving the service for which it is paying.

Management theorists argue that reorganizing corporate functions in this way can lead to greater economic efficiency along several dimensions. One has already been alluded to: improved management focus on selected activities of fundamental competitive advantage, that is, core functions. It is also hypothesized that non-core service providers can reduce costs by aggregating the non-core activities of a number of corporate entities into a large scale services operation, thereby achieving economies of scale and scope. What is a non-core activity for most businesses is thus transformed into a core activity for an arm's-length provider.[10]

Outsourcing as a management technique has proceeded by steps with the offering applied to different elements of company functionality in succession; first information technologies, then transportation logistics, human relations services, and others, which have become well entrenched in business practices.[11] Now these techniques are being applied to corporations' (non-core) energy using functions – heating, lighting, air conditioning.

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[10] As one might expect, the contractual transaction cost of this type of arrangement is substantial. Cost savings and efficiency gains must be great enough to overcome these costs. However, this model has been adopted by enough corporate entities with regard to a range of functions so that it clearly constitutes a viable modus operandi for a very significant sector of the economy. These contracts are typically long term in nature (7-10 years minimum) so that transaction cost and efficiency related investment are amortized over a long schedule. See for example *Turning Lead into Gold*, Peter Bendor-Samuel (2000) which is a how to on outsourcing for executives. It amply discusses the theory and scope of outsourcing and exemplifies its ubiquity.

[11] Ibid., pp 51-63

This outsourcing management theory seems to apply well to facility management that encompasses both energy and operational efficiency of those facilities. But, driven by energy deregulation, a number of major energy companies recently and actively offer such an "energy service."[12]

The outsource logic for these functions is compelling: the customer divests what should be unwanted responsibility. Energy procurement and energy facility management are transferred to a specialist company whose scale of operation and level of expertise in this activity is larger and stronger than can be deployed by any such customer. The customer's facility employees go to work for an organization that understands them and is better able to motivate and supervise them. Cost saving is "shared" with the customer in the form of a guaranteed price for a contracted set of facility and energy-related services. The service company has every incentive to invest in energy and labor saving equipment and develop management tools that reduce cost. They will be eager to do so and confident of their ability to achieve results because they have the skills to understand and manage the risks inherent in such activity.

It is already clear that such an outsourcing-based reformation of business practices in general—and facility energy services in particular—is a successful model in at least some instances and is here to stay. A number of major energy companies, driven in part by deregulation, recently and actively offer such a service. The degree of success and penetration is, of course, still uncertain.

But the implications for global warming policy implicit in this reformation of organization strategy have not been widely disseminated: they are potentially of great significance. First, these business practices might well supercede, and will clearly augment, any policymaker's efforts to induce energy efficiency. Such innovation in business practice could shift the level of global concentration of greenhouse gas to a lower point than would have been reasonably predicted as business as usual just a few years ago. That shift will be greater or lesser depending on the breath of applicability of this business reformation and the underlying potential for realizing additional energy saving.

[12] Among those offering: Duke Energy, PG&E, Dalkia and Enron. Astute readers will note that by a strange and eerie coincidence, the author happens to be employed by Enron.

Currently, this activity is improving energy efficiency in developed rather than developing economies. Outsourcing services in general and outsourcing of energy services in particular have made only minimal penetration in developing country markets – exactly those markets whose future incremental contribution to the global warming problem is expected to contribute greatly to projected adverse effects. There are a number of reasons for this; foremost among them are: 1) lack of adequate contractual legal support and infrastructure, and 2) lesser opportunity to achieve economies of scale in services (i.e., smaller economies with regions of sparser economic development).

But that is today's situation. Global warming forecasts implicitly assume that many of these economies will grow enormously over the course of this century. A further, and probably necessary, corollary is that these economies will become more open and deregulated. There is every reason to believe that in these circumstances as in currently developed nations such development will also result in the adoption of more efficient business practices such as energy efficiency and facility management outsourcing.

Almost everyone would view this as a bit of good news. But there's more! Such a business structure will be more responsive to incentive-based global warming policy. If policymakers raise the cost of emitting carbon, (and thereby raise the price of using carbon-based energy), the energy management provider will move more quickly to restructure his customer's use of energy than would currently be expected. [13] Energy price increases *widen* the service providers' scope of action. It becomes more beneficial to turn over inefficient equipment sooner.

V. Policy for the Competitive World

Increasingly, the economy of the whole world becomes more market-oriented and competitive. This fact drives reformation of business practices and organizational structure to

lower costs and increase efficiency in general. These developments are also likely to lead business organizations to find more energy efficiency than we reasonably would have thought existed. Such an economic structure is, of course, also ever more responsive to customers' needs expressed through prices in the marketplace. Such an economy can also be expected to be more responsive to properly formulated incentive-based policy initiatives as well.

If such economic developments are accepted as representative of a reality we can expect to occur, then the benefits of a technological optionality policy are all the greater because it becomes more feasible to exercise lower cost technology options with greater alacrity. New technology becomes a better, quicker policy option because the world economy is more responsive to economic incentives.

Thus, these real and potential developments in the world economy support the idea that today's policy can reasonably place greater reliance on creating optionality and less on achieving current emission reductions.

Next I will discuss how to assure that the actions that are a necessary predicate to creating and exercising optionality do, in fact, occur.

Characteristics of an Evolutionary Policy

Developing a global warming policy presents a series of extremely difficult problems. First and foremost among these are free rider issues. All nations are responsible for some greenhouse gas emissions. Almost any single nation can choose to ignore the problem and suffer no harm if all others take action. If too many nations respond to this incentive, the global problem obviously will not be solved. Historically, such issues have proven very difficult to resolve.

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[13]It might be argued, given a locked-in position with existing capital investments, such service providers will resist global warming policy initiatives. Those who could make such an argument must also contend that EDS resists reduction in computing power costs. EDS instead learns to profit from it. Such service providers will, in our opinion, strongly resist arbitrary and capricious command and control global warming policy. They will strongly favor transparent, market-based policy. They will do so because transparency will allow them to anticipate policy and thereby gain cost advantages that can be financially realized if that policy is market-based.

One notable success has been an international agreement regarding high level ozone, the Montreal Protocol. The problem it addresses is the impact of CHCs on the upper level ozone layer. But, at first glance, this effort seems to be dwarfed by the global warming issue. The Montreal Protocol was a great accomplishment, but CHC restrictions involved a relatively small industrial sector in a relatively small number of developed countries. Much of the future global warming problem is, on the other hand, expected to be caused by substantial economic growth in China and India. These and other less developed countries must somehow be persuaded to substantially burden their economies with more expensive carbon free energy technologies in order to help solve a world problem heretofore principally caused by already developed nations who made no such sacrifice during their development.[14] Nonetheless, I think there are significant lessons to be learned from the Montreal Protocol process and will make use of those.

Further, there is some urgency to implementation of policy. Even though delaying stringent emissions reduction efforts is sensible, the technology development which will later permit such reductions at more reasonable cost needs to be accelerated soon.[15] Broad-based development of fundamental technology (which is what is needed) is to a substantial degree an evolutionary process whose pace can be accelerated, but only to a limited extent.

Lower levels of expenditure on technology development today cannot be readily compensated for with greater expenditures later when the problem is upon us. It is very difficult to rapidly accelerate technology progress, particularly since we cannot even be sure that the "right" technologies have even been conceived yet. Secondly, it is highly likely that offsetting greenhouse gas emissions will eventually require long term policies to provide incentives to avoid emissions. It is my view that the process of putting in place such incentive based policies and

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[14] Stram, Bruce N., *Shaping National Responses to Climate Change, A Post-Rio Guide*, edited by Henry Lee, Harvard Global Environmental Policy Project, Island Press, 1995, p.219. Also, Gaskins, Darius G. and Stram, Bruce N. in *A Meta Plan: A Policy Response to Global Warming*, Chapter V. Meeting the Technology Transfer Challenge, in *Opportunities for Collaborative Greenhouse Gas Research by the Electric Utility Industry*. Palo Alto, CA: Electric Power Research Institute, April, 1991.

[15] For example, the crash program that established nuclear power in the 1940s is very unlikely to be a repeatable experience. That effort was a capstone on 50 years of revolutionary developments in fundamental physics. These last 50 years have not seen any such similar revolution. Further, we have had direct experience to the contrary: a broad-based crash program of R&D in the 70s and 80s to find new energy technologies to replace oil did not generate outcomes remotely proportionate to the increases in expenditures.)

programs is also long term and evolutionary in nature.[16] (In fact, I have argued, as a counter example, that the recent history of accelerated energy policy development has been substantially dysfunctional.)[17]

Current trends are not particularly encouraging given this viewpoint. Worldwide energy technology research and development expenditure is declining, not increasing.[18] The Kyoto accords, while laudable in some respects, have taken a less than ideal turn by creating a heavy emphasis on emissions reductions in the near future. (I would further argue, separate from the WRE Paradigm, that Kyoto also took a wrong direction in setting national emissions targets.)

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[16] Other authors agree with this point: Hahn, Robert W., *The Economics & Politics of Climate Change, American Enterprise Institute*, The AEI Press, 1998; Schelling, Thomas C., *Costs & Benefits of Greenhouse Gas Reduction*, American Enterprise Institute, The AEI Press, 1998, p. 9. It was also explored at greater length than in this paper in *A Meta Plan: A Policy Response to Global Warming*, Gaskins and Stram; and *Shaping National Responses to Climate Change, A Post-Rio Guide*, Stram.

[17] Gaskins, Darius G. and Stram, Bruce N. in A Meta Plan: A Policy Response to Global Warming, Chapter V. Meeting the Technology Transfer Challenge, in Opportunities for Collaborative Greenhouse Gas Research by the Electric Utility Industry. Palo Alto, CA: Electric Power Research Institute, April, 1991. At least in the United States, the policy responses to the 70s oil crisis ranged from ineffectual to perverse in effect because effective policy required a long term focus out of synch with the near term perceived policy emergency. The energy policy record is more dismal. It is difficult to conclude there has been any result of 1970s energy policy but waste and misdirection. Oil imports did finally fall and oil prices with them. However, energy prices have fallen more in spite of U.S. policies rather than because of them. Meanwhile, the country is left with an overhang of expensive and now uneconomic projects." (See also the Section: "Energy Policy.")

[18] The President's Committee of Advisors on Science and Technology (PCAST). *Powerful Partnerships, The Federal Role in International Cooperation on Energy Innovation*, A Report from the Panel on International Cooperation in Energy Research, Development, Demonstration, and Deployment, June 1999. Given the high degree of concern regarding global warming, some readers may be astounded that there is a reduction in world energy R&D. Look to PCAST for a recent documentation of this fact.

Nonetheless, these facts, however surprising, do not in and of themselves establish with certainty that current worldwide energy R&D expenditure levels are too low relative to their private and public benefits. Indeed, the right question is "How much is enough"? The answer, of course, should be supported with benefit and cost analysis and scrutinized by a tough-minded budgetmaker (green eyeshaded OMB-type).

I find this to be a quite important question. As best I can determine, it is a question that has not been addressed. My literature search and queries directed to knowledgeable colleagues have not really yielded any direct attempts to establish such a target. There is, of course, a strong sentiment among scientists I've queried that current funding is inadequate, but such views would be quickly dismissed as special pleading by Mr. Green Eyeshade, unless substantially supported. One gauge is that we do know that much larger expenditures did not accomplish much vis-à-vis a similar task, the quest for an oil substitute in the 70s and 80s. However, that effort was fraught with waste and unreasonable urgency.

Given these circumstances, the logical course is to make an assessment of the level of R&D appropriate to the global warming task part of the process of establishing the fund. Obviously, it is a difficult endeavor, weighing the value of highly uncertain results and the degree of difficulty against the cost. There is probably a good case to be made to err on the high side, but only to a limited extent.

I would also note that even were funding not substantially increased, creating a permanent level of funding (congruent with the permanent character of the problem) would be a potential benefit even in itself. Long-term programs of R&D are best served by long-term funding.

Solutions and Directions

I propose two courses of action, mutually supportive, to meet what we believe are the imperatives implicit in the WRE Paradigm, at least as I have cast it.

The first is centered on a "technology tax" which would, in fact, be a multilateral carbon tax, but with crucial differences from past proposals.[19] The primary purpose of this proposed tax is to provide support (i.e. creating an international trust fund) for energy technology research and development. The level of spending should be targeted to achieve development of non-carbon (or very low carbon) energy generation technologies. Energy efficient end use technology research would also be supported at appropriate levels. This technology would be targeted for introduction no later than the middle of the century. Given such a limited goal, a little tax can go a long way (i.e. $1/ton or less, as compared to $100/ton or more, as has been suggested in the past. A one dollar per ton carbon tax would generate $2.8 bil, doubling the OECD R&D budget for energy. A $1/ton tax is the equivalent of .1¢/gal of gasoline.). Further, the international scope of such a tax can be limited as well. Only a relatively small number of developed nations need to agree initially to bear this small burden. Like the Montreal Protocol, such an agreement perhaps could be quickly reached to because of its limited scope and economic impact. It could even proceed through example on a unilateral or bilateral basis.

Obviously, the proposal outlined here is just a sketch of a plan. There are a myriad of details which would need to be worked out: which nations voluntarily join the "tax coalition," timing for putting the tax in place, interim funding (if any) until the tax is in place, and certainly not least, how the fund will be administered and by whom. But these are tiny issues compared to the enormity of political obstacles associated with implementing the Kyoto Plan. Further, pursuing a coordinated R&D tax in no way precludes attempts to follow through on Kyoto. Rather, it augments potential Kyoto success by rendering it less costly, and acts as a backstop to Kyoto failure.

[19] We will distinguish two types of carbon taxes: the technology tax intended to support an R&D trust fund, and an incentive tax intended to cause dramatic changes in carbon emissions. Presumably, these could be highly similar from an administrative point of view, and the former could evolve or be transformed into the latter.

More speculatively, I also believe that the existence of such a tax coalition would provide a focal point that could draw in additional nations one by one, or in groups, as they became persuaded of global warming reality. In the longer term, if and as the global warming evidence becomes fully persuasive, the administrative mechanisms developed to implement technology taxes could be used to provide greater emissions reductions incentives (in addition to technology support) simply by agreement to raise the tax level.

"Raise the tax level" is easily said, but, of course, potentially very hard to do. By definition, it raises the stakes for tax coalition members and makes membership much more painful. Further, based on what we know now, we would have to think it likely that a very substantial tax might be in order ($100 or more per ton) to achieve reasonable incentives. However, we must also realize that the world in which such decisions will have to be made will be very different than the one we see today.

Of course, such decisions might never need to be made. The prerequisite for an incentive tax (or other drastic policy measures) is a series of contingent outcomes. First, research on global warming effects will have presumably resolved significant scientific uncertainty in favor of a continued expectation of significant, harmful effects. Secondly, a vigorous effort at energy research and development (financed by the technology tax) must have failed in finding lowest cost, non- (or very low) carbon energy alternatives. Third, the large developing economies will have continued to evolve with strong economic growth and free market economies rather than (heaven forbid) fall back because of collapse in financial, social or political institutions.

One may view those outcomes singly and in the aggregate as highly likely, but they are not certain. Further, in such a world, a decision to impose strong incentive taxes will be, if not easy, at least much easier than today. The scientific global warming case will be more compelling. The world, especially developing countries, will be much wealthier and better able to bear the burden of higher energy costs. The increased technology R&D, while it may not have found the lowest cost carbon free technology, will almost certainly have reduced the cost of that technology substantially lower than we currently expect.

Let's recapitulate: several useful principles are invoked here. Because the WRE Paradigm and my "optionality corollary" strongly suggests that only limited emissions reduction actions are initially appropriate; the resulting flexibility can be used to craft a response which is (relatively) simple to initiate. Starting a tax-funded, low cost technology collaborative among like-minded nations is, I suggest, much more feasible than creating and fulfilling a worldwide agreement of any sort, let alone one which calls for ambitious short-term emissions reductions. Further, I suggest that a smaller multilateral initiative, which does achieve its goals (and whose goals not incidentally also achieve what needs to be done even from a global perspective) is a better starting point than a grandiose "all inclusive" effort which does not achieve its (somewhat misdirected) goals. Success, we suspect, will breed further success. And finally, this approach does not require that global consensus be achieved at one fell swoop, but allows consensus to be achieved through accretion, nation by nation.

Future Policy

No action we can take today guarantees that the citizens of the world will in the future make the right choices regarding global warming (unless the R&D effort gives us carbon free technologies at lower cost than those carbon-based). However, creating cheap optionality and providing the means to exercise that optionality greatly encourages them to do so. Policymakers exercise optionality simply by raising the tax. The fact that a tax mechanism exists will both enable and encourage them to do the right thing. These much greater tax revenues could also be used to fund incentive to induce economic actors in remaining developing countries to introduce and use (presumably) more costly carbon-free energy technologies.[20]

In addition, while the increased R&D effort may not have found cheap, carbon free energy sources, it is very likely to have substantially lowered emissions reduction costs relative to what we now expect.

These principles suggest an even simpler and supportive process: bilateral initiatives between appropriately matched developing and developed nations with commonly agreed upon

[20]Stram, Bruce N., Shaping National Responses to Climate Change, A Carbon Tax Strategy , Island Press, 1995, p227-228.

global warming goals. We cannot ignore the imperative that the best way to do something is to start. More precisely, in this context, substantial action-oriented international cooperation should happen sooner rather than later. That means undertaking cooperative efforts whose goals, if achieved, represent significant progress. I have here presented a case, I hope cogently, that energy technology R&D and technology transfer are the very highest priority items on a reasonable global warming mitigation agenda. Bilateral cooperation, properly focused, could be a precursor even to developing technology's R&D trust fund to help achieve these ends.

Most broadly, two nations could establish cooperative goals focused toward: a contribution to technology research and development; a mutual commitment to achieve long term emissions goals (consistent with stabilizing greenhouse gas emissions); and finally, a mutual commitment to energy technology transfer and transfer support. Again, this arrangement reduces the scope of agreement and cooperation that must occur between nations to an even lesser level than that required for the technology trust fund.

It can begin by an agreement between just two nations. Thus, it is more likely to successfully get started and achieve its goals, thereby encouraging other combinations of nations to create similar bilateral deals. Most importantly, such agreements are responsive to the WRE Paradigm imperative of immediate action.

There are many scholars and observers who might better opine on which combinations of bilateral arrangements might make the most sense. But consider the combination of the United States and China as a pairing for one such bilateral arrangement. Very broadly, we would contemplate that such an agreement would commit them jointly to long-term emissions paths consistent with stabilization of greenhouse gases at an ambitiously low level over the course of this century. They would further commit to a proportionate joint program (relative to the size of their economies) for near term increases in energy technology R&D expenditures, funded by a joint tax mechanism. Finally, the two nations would commit to a long-term program of joint implementation of emissions taxes and subsidies for technology transfer (or joint implementation of bilateral emission trading) should such need be borne out by future research.

The reference to bilateral combinations above is intended to be more than casual. It reflects a strong expectation that any global warming policy must contemplate some strong

inducements to less-developed countries (LDCs) to offset the harm to their economies caused by using clean but higher-cost energy technologies. One of the strongest themes voiced in this paper has been to view policy as a set of sequentially contingent decisions so as to reduce the political difficulty and economic burden that are associated with setting and implementing policy before its time. Perhaps less costly clean technologies will be found which permit unburdened LDC development. Perhaps today's LDCs will develop so rapidly that they should be expected to bear the full economic burden of emissions reduction sooner rather than later. But I think we can be very certain that if either of these contingencies fail to occur, some offset of the emission reduction burden for the LDCs will be an irreducible element of a global emissions policy. Bilateral cooperation between LDCs and developed nations should help to lay the groundwork for this partnership.[21]

Further, any such combinations would be highly significant in relation to the entirety of the potential problem (in terms of emissions). For example, just a US-China bilateral would address nearly 50% of the expected global warming problem. One might further anticipate that if three or four such bilaterals came into existence, they might address 80% or 90% of the problem.[22]

VI. Conclusion

New thinking on global warming problems creates a much more powerful rationale for a specific immediate policy response than has previously been the case. On the other hand, the immediate policy goals implicit in this new paradigm suggest that the potentially key burden of emissions reduction be substantially deferred for the time being. But these ideas do require an

[21] Again, this concern regarding potential buy in to costly emissions reduction policies by developing countries has been voiced by a number of authors, Hahn, Mendelsohn and Schelling, as well as Gaskins and Stram, and Stram.

[22] Each such bilateral accord is likely also to arrive at different conclusions as to appropriate concentration levels, tax levels or emissions targets. Since we don't now have a very good inkling as to the right answers to any of these questions, and because the answers will be dramatically affected by initiatives undertaken by these bilateral partners, it is rather hard to get disturbed about a potential lack of harmonization. Further, at a time when there is a greater certainty about global warming effects and technology costs, unification of goals among a few bilaterals should be a relatively small issue.

immediate specifically focused effort: specifically, aggressively developing new energy technologies. This paper identifies immediate goals and initiatives which address that needed effort and which offer the prospect of evolving into policy frameworks which can bear the weight of a long term global greenhouse policy if the need is fully proven. These are:

1. A technology tax institutionalized among a small subset of cooperating nations (presumably developed nations), the purpose of which is supplementing and expanding energy technology research and development support to an appropriate level rather than immediately providing significant emissions reduction incentive; and

2. Bilateral (LDC – developed country) collaborations formed to achieve technology research and development, long term emissions targets consistent with greenhouse gas stabilization, and energy technology transfer.

I should also emphasize that the policy ideas in this paper are not necessarily conceived of to supplant the Kyoto process. This paper is principally about creating more "easy" options for global warming policy. In presenting these options, I have suggested they could, indeed, form the basis of a fully functional global warming policy. Such logic, (if I have been successful), establishes that these could be viable policy path options. But the same logic does not imply nor have I contended that these should be exclusive policy options.

In fact, the inherent rationale of the "options" argument presented here implicitly supports pursuing alternative strategies simultaneously (depending upon cost and non-correlative outcomes). Further, as a practical matter, many people convinced of the certainty of global warming have invested much effort in the Kyoto process.

Recently, of course, that process has fallen on hard times.[23] Whether it is or is not revived in some form, the difficulties its supporters have encountered speak volumes as to the hurdles such a policy effort faces. Given, therefore, the manifest difficulty facing policymakers, perhaps it is time to put some other eggs in another basket.

[23] Hopefully, any reader would have noted my view that the inherent structure of Kyoto was likely to lead to "hard times." This is reflected in early writings as well, and as noted above, I am far from unique.