Climate Change Policy: A View from the US

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ABSTRACT

The Bush Administration followed its withdrawal from the Kyoto Protocol in March, 2001, by a February, 2002 proposal for unilateral action to reduce US greenhouse gas emissions. The February proposal has been widely criticized for having little content and no teeth. The lack of teeth is clearly a valid criticism. The proposal is unlikely to result in much in the way of changed behavior within the U.S. economy. However, a side benefit is that other actors, particularly states, are attempting to fill the void left by the Federal Government. Those actions are reviewed in this paper. Furthermore, there is an interesting idea within the Bush Proposal, an idea that may warrant further examination at the international level. Although the idea is probably not original, its emphasis by the Bush Administration gives it more prominence that it has had in the past. The idea is to focus on the rate of decline of the emissions *intensity* of the economy, rather than the total amount of emissions (though the two are obviously related). This has a number of advantages, including dynamic consistency, reduced uncertainty, and potential attractiveness to non-Annex I countries. These characteristics are reviewed in this paper.

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I. INTRODUCTION

With the very emphatic withdrawal of the Bush Administration from the Kyoto Protocol, it might appear that there is no US policy on climate change policy. This view is reinforced by the 2002 Valentine's Day announcement from the Bush Administration that the cornerstone of its climate policy was to *set a goal* to reduce the greenhouse gas intensity of the US economy by 18% over the coming decade; never mind that this was roughly the rate at which the economy had been "de-carbonizing" over the previous decade.

But politicians come and go. This is particularly true in the case of climate change. It was President Bush's father who participated in the setting up of the treaty underlying the Kyoto Protocol, the Framework Convention on Climate Change, and no doubt climate policy will outlive the current President Bush. Furthermore, there is other positive activity on climate change in the U.S., though relatively modest. There are federal government programs, mostly in research and development as well as activities by state governments, private parties and non-governmental organizations.

In this paper we provide a review of the assorted actions that are being taken in the U.S. to deal with the climate change problem. The review is by no means comprehensive – just indicative of the types of activities that are underway. In addition, we consider some of the remaining problems that are not addressed by Kyoto, problems which must be addressed regardless of whether Kyoto becomes effective. We conclude by a re-examination of the much-maligned Bush approach of focusing on declining greenhouse gas intensity in the economy. Although its

voluntary nature makes it not much of a policy, the approach has innovative dimensions, addressing at a general level some of the problems associated with the quantity targets approach of Kyoto.

II. THE POLICY ARENA

In March 2001, U.S. President George W. Bush announced that the U.S. would not be a signatory to the Kyoto Protocol. There is no point in providing another review of the context of the President's withdrawal of the U.S. from the Kyoto Protocol; in any event, it is unclear whether the U.S. Senate would ever have ratified the Protocol.[2] On February 14, 2002, the President announced his "new approach" to a climate strategy.[3] This new approach has charitably been called weak. However, an ancillary benefit of the Federal government relinquishing its leadership role in addressing the climate change problem in the U.S. is that a number of non-federal organizations, including state governments, have stepped forward and taken steps towards controlling precursors of climate change.

A. The Bush "Initiative"

On February 14, 2002, the Bush Administration unveiled its new initiative on climate change, a set of unilateral actions to be undertaken by the U.S. Although many observers feel the initiative is weak and largely ineffective, it is important to separate the strength of the initiative from the substantive approaches to the climate problem suggested by the initiative. In other

[2] It is far from clear how damaging Bush's decision was to global climate policy. It could be argued that dragging out the Kyoto process only to have it rejected by the US Senate some time in the future would be worse. Refer to the op-ed piece by David Victor in the New York *Times*, "Piety at Kyoto Didn't Cool the Planet;" (March 23, 2001); and his book, *Collapse of the Kyoto Protocol and the Struggle to Control Global Warming* (Princeton University Press, 2001).

[3] For details: http://www.whitehouse.gov/news/releases/2002/02/climatechange.html.

words, there are innovative ideas in the proposal; it is in large part because they are applied weakly or voluntarily or both that the net effect is so modest.

The cornerstone of the Bush proposal is a focusing on reducing the greenhouse gas intensity of the U.S. economy,[4] rather than setting a quantitative cap on emissions, as proposed in Kyoto. The four key dimensions of the proposal are, in brief:

- Reduce the Greenhouse gas intensity of the US Economy by 18% over 2002-2012
- Strengthen the Emission Reduction Registry
- Fund Climate R&D
- Tax incentives for renewable energy, cogeneration, fuel cells and hybrid vehicles

There are a number of other miscellaneous actions[5] that are either not new, very modest or of negligible consequence to climate, including:

- Increased funding for idling farm acreage (ostensibly for carbon sequestration)
- Fund R&D in energy, including automobile fuel efficiency
- Fund climate change technology transfer programs with the developing world
- Issue "challenges" to the business community to reduce greenhouse gas emissions
- Fund debt-for-nature swaps

[4] Although the emphasis on reducing intensity has achieved new prominence through the emphasis it has received in the Bush proposal, it is not a new concept. In fact, the German industry has couched its voluntary agreement on reducing greenhouse gases as a commitment to reduce the intensity of greenhouse gas emissions in individual German industries.

[5] The plan includes dozens of actions which are very modest or a repackaging of existing programs: for instance, plans for a meeting with the Japanese to discuss opportunities for joint climate change research.

The goal of a reduction in greenhouse gas intensity seeks to decouple growth in output and consumption from greenhouse gas emissions reduction. Although GDP decreases are a way of reducing emissions (witness the case of Russia in the 1990's), it is not a popular strategy, nor likely to be very effective in the long run. A country whose economy is in the doldrums is unlikely to want to invest much in environmental protection. A reduction in the greenhouse gas intensity of production inevitably means a change in the structure of production (moving away from greenhouse gas intensive industries) as well as pursuing proactive measures to control emissions, such as switching from coal to natural gas in electricity production and reducing vehicle kilometers traveled by auto. Of the two major flaws in the Bush proposal on greenhouse gas intensity, one is that the reductions are modest. Table I shows the reduction in greenhouse gas intensity in the US and selected other countries over the decade of the 1990's. As can be seen, the greenhouse gas intensity of the US economy "naturally" declined by 17% over the 1990's with most of that occurring in the last five years of the decade.[6] It is unlikely that this was due to any action by the US Government; rather, it results from structural change in the economy with a gradual movement away from greenhouse gas intensive industry. Consequently, setting a goal of a reduction of 18% over the decade ending in 2012 is not very ambitious and should be an easy target to hit.

In terms of improvements in greenhouse gas intensity of the economy, the record of other Annex I countries during the period is quite similar to that of the US.[7] Germany and the UK did very well (much better than the US) in reducing the greenhouse gas intensity of its economy,

[6] Table I excludes land use change and forestry (so-called LULUCF) from greenhouse gas emissions. Had those been included, the figures would be somewhat different, though the general picture would remain the same.

[7] An examination of other Annex I countries for the 1990-99 period indicates a similar pattern. The FCCC and the OECD report data on 18 Annex I countries for 1990 and 1999. The median decline in greenhouse gas (excluding LULUCF) intensity is 14.1%; the US decline is 16.1%; Germany and the U.K. have the greatest decline, of approximately 29%; intensity in Ireland, Switzerland and Italy actually goes up by 10-15%.

though the absorption of East Germany made this somewhat easier for Germany and the introduction of North Sea gas (and phase out of coal) made this easier for the UK. The EU minus Germany performed almost identically to the US in terms of reducing greenhouse gas intensity (though the overall intensity is considerably lower than that of the US). The EU minus Germany and the UK did not do as well as the US in terms of the decline of intensity. On the other hand, all European countries have economies which are much less greenhouse gas intensive than the US. Focusing on the reduction of greenhouse gas intensity, the US looks good; focusing on the absolute level of greenhouse gas intensity, the US looks much less noble.

The primary flaw in the Bush proposal on reducing greenhouse gas intensity is that there are precious few ways of implementing the goal of reducing intensity. The goal is just that – a goal – and there are no regulations and few other steps proposed to accomplish the goal. That makes it largely meaningless. The Bush proposal does indicate that there will be a reassessment in 2012 and if progress is slow or the "science" is more alarming, further steps will be taken. However, the public record is littered with goals in energy conservation, environmental cleanup and in other arenas, goals which are subsequently not met; generally the only consequence of an unmet goal is to regret the optimism of goals set in an earlier more naive time.[8]

There are a few steps proposed by the Bush Administration to push the US towards achieving the goal. Most of the proposals are a continuation of activities of the Clinton Administration or even earlier Administrations. Although they are meritorious, it is unlikely they will have much impact.

[8] One classic unmet goal is the goal of attaining air and water ambient quality standards, a goal set out in the Clean Air and Clean Water Acts of the early 1970's. After thirty years, the best measure of the extent to which the goal has been met is the number of days a year the standards are violated – down to less than 100 in some of the most polluted cities, such as Houston and Los Angeles.

Strengthening the greenhouse gas registry can have a positive effect on voluntary actions to reduce greenhouse gases. With policy uncertainty, there is a tendency for firms to delay greenhouse gas reductions until the uncertainty is resolved. This is particularly true if any greenhouse gas reduction serves to redefine a lower baseline from which future reductions must occur. The strengthening of the greenhouse gas registry serves to eliminate or at least greatly reduce the incentive for individual firms to postpone action.

The Bush Administration has indicated it will push tax incentives for investment in renewables and new transportation technology. Tax incentives for solar and renewables were part of the Carter Administration energy program. Though meritorious, they will probably not have significant impact. In any event, they require congressional action for passage and it is unclear whether that will happen.

Another major thrust of the Bush proposal is continued high levels of R&D funding in energy, including automobile fuel efficiency. There have been decades of research on fuel efficiency in automobiles and much progress has been made. A cynic would conclude that this has made possible even larger SUV's. Highly fuel efficient cars have been available for many years. However, without incentives for consumers and automakers, fuel efficiency *of the average vehicle purchased* will not improve. Ultimately, consumers see a menu of vehicles on display at their automobile dealer and make a free choice among alternatives.

The Bush Administration has also indicated it will continue to invest in R&D in the climate arena. Certainly the U.S. Government has been a leader in funding research in many dimensions of climate science. This is to be lauded. However, this is not new. Nor is it likely to result in significant reductions in US greenhouse gas emissions.

In sum, the Bush Administration proposal is a very modest proposal that is unlikely to do much to US greenhouse gas emissions, over what will occur from the natural evolution of the economy. Leaving aside the modesty of the Bush proposal, there are some dimensions of it which merit closer attention, particularly the shift to greenhouse gas intensity. We return to this issue later.

B. Missing Incentives

Two conspicuously absent dimensions of the Bush Initiative are incentives for reduced energy consumption in transportation and incentives for switching away from GHG-intensive coal in electricity generation. These are tremendously important determinants of the greenhouse gas intensity of the economy.

Within the transportation sector, a major source of greenhouse gas emissions is private automobile transportation. To address emissions from this sector, one must concentrate on two things: efficiency of the fleet of automobiles and the annual distance each vehicle is driven. A high tax on gasoline provides incentives for both – driving becomes expensive which provides incentives for consumers to seek high-efficiency vehicles and to drive those vehicles less. One of the quirks of American politics is that high gasoline taxes appear to be politically impossible. This is a mystery to some but it certainly seems to be an accepted truth by most politicians. Consequently, one must rely on other mechanisms to achieve the same effect.

To increase the fuel efficiency of vehicles (which would occur automatically with a high gasoline tax), Congress adopted fuel efficiency standards in 1975 – the CAFE (Corporate Average Fuel Economy) standards. These standards required auto companies to gradually ramp up the average fuel efficiency of all the cars they sell (averaged over a company's total sales). This

worked fairly well except for an exemption that started tiny and eventually became big enough to drive a large SUV through: trucks were subject to much weaker standards. The auto companies responded to CAFE legislation by constructing a whole new set of vehicles which were technically trucks – minivans and sports utility vehicles.

In the early 1990's (during the elder Bush Administration) there was a movement in Congress to further ratchet up the CAFE standards and close the truck loophole.[9] This effort failed, in part because of a lack of a clear a present need for more fuel efficiency. Last year the National Academy of Sciences again studied the question and recommended tightening the CAFE standards. The Bush Administration opposed this, ostensibly on the grounds of safety. Safety is primarily affected by a heterogeneous mix of vehicles on the roads – big ones with little ones. A ramping up of fuel efficiency would have the effect of bringing more homogeneity to the fleet. The President's Climate Initiative calls for continuing study of this issue but most view such study as merely a delaying tactic.

Another major source of greenhouse gas emissions is coal combustion, primarily in electricity generation. Coal involves much higher levels of carbon dioxide emissions per unit heat content than either natural gas or petroleum. Coal is used for electricity generation because it is cheap. Without incentives to switch to lower carbon-intensive fuels, electricity generators will continue to use the least cost source of energy. The President's initiative is totally silent on this issue, except to encourage the use of renewables for electricity production.

C. Non-Federal Initiatives

[9] Refer to the National Academy of Science Study, "Automobile Fuel Economy: How Far Can We Go?," National Research Council, Washington, DC (1992); and the more recently released study on the same topic: "Effectiveness and Impacts of Corporate Average Fuel Economy (CAFÉ) Standards," National Research Council, Washington, DC (2002).

One of the positive ancillary benefits of inaction at the Federal level in the US is that other actors have stepped up to fill the void. As political theory would suggest, the abrogation of responsibility by one branch of government results in the filling of that void by other branches of government.

In much the same way that action by member states of the EU can substitute for action by the EU, over a dozen states are considering or have instituted programs that might be found in a more proactive federal program.[10] To gain a true picture of what the US is or isn't doing on the climate front, it is important to look at individual states as well as the federal government. Refer to Table II for a selection of state activities in the area of greenhouse gas management.

Energy conservation programs have been a mainstay of state energy and environmental policy from the 1970's, and remain so today. This is true in part because of the historic role of the states in regulating public utilities. A number of states have aggressive building and appliance efficiency standards as well as conservation programs, often implemented through the regulated energy utilities. Furthermore, there are a number of state programs aimed at encouraging the use of renewable sources of energy. Some of these also date to the 1970's.[11] These include renewable portfolio standards, requiring a minimum level of use of renewable energy sources. In many areas where the electricity system has been deregulated ("restructured"), consumers are given the choice of purchasing "green power," electricity produced from renewable sources. Energy conservation and renewable energy programs obviously play a major role in reducing greenhouse gas emissions. Such programs are so varied and common that they will not be reviewed here.

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[10] The organization NESCAUM (Northeast States for Coordinated Air Use Management) maintain a comprehensive set of data on non-federal actions to control greenhouse gas emissions (refer to their website: www.nescaum.org/Greenhouse/). See also, Brian Jones, Nathan Monash, David Bubenick, and Kristen Vaurio, *Survey and Evaluation of State-Level Activities and Programs Related to Climate Change*, prepared from Natural Resources Defense Council (MJ Bradley & Associates, Boston, July, 2002).

[11] For example, New Mexico was one of the first states to implement sizeable tax credits for the installation of solar energy facilities – a quarter century ago.

Four states (California, New Hampshire, Wisconsin and New Jersey) have implemented greenhouse gas registry programs, all voluntary. Other states are considering such action. It is not clear to what extent these overlap, duplicate or augment the voluntary federal registry program. Several bills have been introduced into Congress to institute mandatory greenhouse gas registries.

At a more proactive level, California recently passed a law which is, in effect, a state fuel efficiency standard for new cars. The law (which is being challenged in court) calls upon the state Air Resources Board (CARB) to set emission standards for carbon dioxide emissions from new cars. CARB has been setting standards for automobile emissions of other pollutants since the 1960's. In many cases, California standards have led the country. With respect to greenhouse gas emissions, these standards are effectively fuel efficiency standards, since unlike other automobile pollutants, there are no ways to make engines cleaner burning without simply using less fuel. These fuel efficiency standards are to take into account technology and cost, and are to be applied to the 2009 automobile model year (new cars only). As Californians like to point out, its economy is only exceeded in size by the economies of Germany, France, the UK and the US.

Oregon has one of the first state laws requiring emission reductions from major energy sources in the state. House Bill 3283, passed in 1997, requires new fossil-fueled power plants to either meet strict emission standards for carbon dioxide or to acquire offsets of their emissions in excess of these strict standards.

In May of 2002, New Hampshire passed House Bill 284, which sets aggregate greenhouse gas emission limits on power plants in the state, to be achieved by 2010. The bill also includes provisions to further tighten the cap for the post-2010 period. Massachusetts has a similar cap on state emissions from power plants.

There is a variety of private initiatives to reduce greenhouse gas emissions. Two interesting market approaches are the Chicago Climate Exchange,[12] set up to trade greenhouse gas emission among sources in several midwestern US states. The Exchange is not yet operating and without legal manadates for greenhouse gas reductions, it is unclear exactly what will be traded. Another interesting enterprise is the market in offsets for carbon dioxide generated from international air travel[13] This allows travels on international flights (a loophole in the Kyoto Protocol) to offset the emission from their seat on a particular flight.

III. THE ISSUES: QUANTITIES VERSUS INTENSITY RATES

One of the major components of the Bush Climate Plan is the concept of moving away from committing to a national emission cap by a specified date (such as is embodied in Kyoto) to a targeted *rate of decline* in the emissions intensity of the economy. Leaving aside the issue of the strength of the Bush proposal, it is worth examining the relative merits of a cap on overall emissions vs. an agreement on a rate of reduction in emissions intensity.

It is appropriate to emphasis that a targeted rate of decline in the emissions intensity is not the same as a growth indexed cap.[14] A targeted rate of decline (say 3% per year) applies indefinitely and specifies a continuing rate of decline in intensity. A cap applies to a particular point in time and is not a continuing target. Thus there is not a real symmetry here.

There are two fundamental dimensions of climate policy upon which we will focus this comparison: dynamics and uncertainty.

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[12] Refer to http://www.climateexchange.com.

[13] See http://travel.500ppm.com/. In the context of this meeting here in Dresden, I purchased an offset for my flight from Boston to Dresden and back through this service. My share of Lufthansa's CO2 emissions was estimated to be 1.53 tonnes, for which I bought an offset at a cost of £13.34. The offset involved a share of an aforestation project in the Brazilian Amazon.

[14] Refer to Denny Ellerman, "Growth Indexed Caps: A Better Idea?," presentation at Global Trading Workshop, Kiel Institute for World Economics, Kiel, Germany (Sept 30—Oct 1, 2002).

A. Dynamic Issues

It is important to realize that the Kyoto Protocol has been a long time in the making. The Protocol was negotiated (at least in its initial form) in 1997 and keyed off of emissions a few years earlier, in 1990. The Protocol calls for each developed (Annex I) country to reduce annual emissions in the period 2008-2012 to about 5% below what they had been twenty years earlier (1990). It is now 2002, five years after Kyoto, and we are still debating the ratification of the protocol (though in October 2002, it seems close to happening). These are very long time frames. Furthermore, no sooner will we have settled on Kyoto targets and the signatories than it will be time to embark on another round of negotiations, for the so-called second commitment period, possibly with associated additional emission reductions.

This is a key issue. The use of national caps on emissions implicitly involves repeated negotiations. The same parties must come together every decade or two to renegotiate new emission targets. This leads to dynamic incentive problems, first identified in the context of central planning in the Soviet Union. The incentive problem has been termed the *ratchet effect*. If an agent knows that his performance in period n will influence his negotiating position in period n+1, there is an incentive to bias performance in order to enhance the negotiating position.

There are many environmental examples of the ratchet effect. Consider the problem of setting automobile emission standards. In the US in the 1970's, the government promulgated challenging automobile emission standards. The auto companies were faced with a conundrum. If they tried hard and met the tough standards, they knew their reward was to be subject to even tighter standards in the next negotiating period – their good performance would be rewarded by ratcheting up the expectations in subsequent regulatory interactions.

In the context of the Kyoto Protocol, a country that does well in meeting its commitments will be rewarded by further required reductions in the subsequent commitment period. Germany is of course a good example of this. Not only is this not fair but it creates incentives for poor performance.

This problem can be solved by precommitting to a path of emissions, eliminating the need for repeated renegotiation. Of course there are many ways of defining a path of emissions, though there is some appeal to simplicity and a formulaic path. The idea of committing to a rate of reduction in greenhouse gas intensity of the economy (x% per year) has the advantage of simplicity while at the same time providing a continually changing target for emission reductions, with the changes predetermined. Of course if the agreed rates of reduction are subsequently viewed as inadequate, then renegotiation will be necessary.

B. Uncertainty

One of the major concerns with the Kyoto Protocol for many countries has been the cost of meeting the targets. Will it be easy (cheap) or tough (expensive)? Information on control costs is sketchy since the world has had very little experience with reducing emissions of greenhouse gases; in any event, the reductions will not be at their strictest until 2012 or so – far into the future. The fear has been that a country would commit to a cap on emissions and then find that the cost of abatement was exceptionally high. For instance, if a marketable permit system were implemented for a country's cap, the fear was that the price of a permit might be very high. The fear was not helped by the great deal of variation in the estimates of the marginal cost of emission control associated with Kyoto limits.

One of the proposals for dealing with this uncertainty was to put a cap on the marginal cost of emission reductions. These proposals took many forms[15] but one of the most popular was associated with domestic trading schemes for carbon. The assumption was that the Kyoto targets would be implemented with some sort of cap and trade system for greenhouse gases: a country would issue permits for its allowed emissions and trading in those permits would proceed. The "safety valve" idea was that the government would sell additional permits at a predetermined price – for example, $25 per tonne of carbon. This is a variant on the permit system proposed by Marc Roberts and Michael Spence some years ago.[16]

On the one hand, the safety valve approach assured that the marginal cost of carbon control would never exceed the price of extra permits. On the other hand, should extra permits be issued, then the quantitative limits of the Protocol would be abrogated. This has made many, particularly environmentalists, wary of allowing a safety valve of this sort.

For an individual country, uncertainty in the costs of meeting the Kyoto targets comes from two primary sources. One is that there is uncertainty about the overall level of economic activity in the country, come 2012. High levels of growth over the 1990-2012 period mean that the target is much harder to "hit." Low or negative levels of growth (eg, Russia) make for easy targets. The second source of uncertainty regards the cost associated with reducing greenhouse gases, holding the level of economic activity constant.

IV. THE SIMPLE ANALYTICS OF QUANTITIES VS INTENSITY CHANGES

[15] See Warwick J. McKibbon and Peter J. Wilcoxen, "A Better Way to Slow Global Climate Change," Brookings Institution Policy Brief #17, Brookings Institution, Washington, D.C. (June 1997); Raymond Kopp, Richard Morgenstern and William Pizer, "Something for Everyone: A Climate Policy that Both Environmentalists and Industry Can Live With," Resources for the Future Weathervane Feature, Washington, DC (Sept. 27, 1997).
[16] Marc J. Roberts and Michael Spence, "Effluent Charges and Licenses Under Uncertainty," *J. Public Econ.*, 5:193-208 (1976).

In the last section we reviewed some of the broad issues related to an emissions cap – the approach taken in the Kyoto Protocol – and a target rate of reduction in greenhouse gas intensity – the approach proposed by the current U.S. Administration. We first take a look at the dynamics of stabilizing greenhouse gas concentrations, the goal of the Framework Convention on Climate Change (FCCC), to which the US and many other countries are signatories. We then look at the question of uncertainty and the nature of a safety valve under either an emissions cap or a targeted rate of reduction in emissions intensity.

A. Decomposing Intensity

The stabilization of greenhouse gas concentrations is the stated goal of the Framework Convention on Climate Change. Fundamentally, this translates into eventually achieving zero growth in net emissions; presumably that will ultimately be reflected in Kyoto, son-of-Kyoto or other subsequent protocols to implement the FCCC. Let G(t) be the global emissions of greenhouse gases in year t and Y(t) the net economic output in year t. Define the greenhouse gas intensity, g(t), by the quotient:

$$g(t) = G(t)/Y(t) \qquad (1)$$

Solving Eqn. (1) for G, differentiating with respect to t, and manipulating yields

$$\frac{\dot{G}}{G} = \frac{\dot{Y}}{Y} + \frac{\dot{g}}{g} \qquad (2)$$

The interpretation of Eqn. (2) is that the growth rate for greenhouse gas emissions is the sum of the growth rate for economic output and the growth rate for intensity. Since the growth rate for intensity is typically negative (see Table I), the growth rate in output exceeds the growth rate in

greenhouse gas emissions. In order to stabilize concentrations, it is necessary to ultimately achieve zero net growth in emissions, which means that the growth rate in output must eventually equal to rate of decline of greenhouse gas intensity.[17]

Clearly, the rate of growth of greenhouse gas emissions can be affected by reducing the rate of economic growth. Most countries, however, would probably prefer to focus efforts on reducing the intensity without retarding growth. In fact, this has been a big issue with developing countries, who have strongly argued that their economic development should not be slowed by greenhouse policies.

We can decompose the greenhouse gas intensity into two parts, an autonomous technological part, dependent only on the passage of time, t, and an abatement effort part, E. The autonomous technological part has to do with the overall level of technology in the economy as well as the structure and composition of the economy; it is largely outside the control of national governments. The abatement effort part, E, involves costly resources being invested to reduce the intensity of production:

$$G(t) = F(t, E(t), Y(t)) \qquad (3)$$

The function F in Eqn (3) should be homogeneous of degree 1 in E and Y: doubling of the size of the economy and the amount of effort should lead to a doubling of the greenhouse gas emissions.[18] We can divide Eqn. (3), and F, through by Y(t), letting effort normalized by the overall level of output be denoted by $e(t) = E(t)/Y(t)$:

$$g(t) = F(t,e(t),1) = f(t,e(t)) \qquad (4)$$

Differentiating Eqn. (4) and rearranging yields

[17] The US economy grew by 38% in the 1990's yet the intensity only declined by 17% (Table I), leaving a substantial gap. The economy of the EU minus Germany grew by 24% while its intensity declined by 17%, leaving a more modest gap.

[18] Homogeneity is easy to see through a thought experiment. Take a country like the US or the UK and divide it in half. Each half has half the GDP, half the effort to reduce emissions, and half the emissions.

$$\frac{\dot{g}}{g} = \frac{f_t}{f} + \frac{f_e \dot{e}}{f}$$

or

$$\frac{\dot{g}}{g} = \frac{f_t}{f} + \frac{\dot{e}}{e} \div s_E(t) \quad = r_A + r_E \tag{5}$$

where $s_e(t) = \frac{f}{ef_e} = \frac{G}{EF_E} \approx \frac{\frac{\Delta E}{E}}{\frac{\Delta G}{G}}$ (6)

and r_A and r_E are, respectively, the rates of growth in autonomous greenhouse gas intensity and endogenous greenhouse gas intensity. Eqn. (5) can be interpreted as saying that the rate of decline in greenhouse gas intensity is composed of an autonomous part, related to the passage of time plus a part that requires effort on the part of a country.

What is the interpretation of the $s_e(t)$? As the right-hand-most expression suggests, it is roughly the percentage change in effort associated with a percentage change in emissions. If effort is denominated in dollars, than this is closely related to the marginal cost of emission control, expressed as an elasticity. In fact, it is the change expenditures on control effort necessary to achieve a unit change in aggregate emissions, expressed in percent change rather than absolute change – it is the elasticity of control costs with respect to emissions. The elasticity is a function of time because we would expect it to decrease over time, as the marginal cost of emission control drops.

Rewriting Eqn. (2), using Eqn. (5), we obtain

$$r_G = r_Y + r_A + r_E \tag{6}$$

which states that the rate of growth in emissions of greenhouse gas is the sum of the rate of growth of output (GDP) plus the autonomous rate of growth of greenhouse gas intensity (generally negative) plus the rate of growth of intensity due to proactive efforts (hopefully also negative). The autonomous rate of change in intensity is difficult to estimate, although from Table I we see that during the 1990's a rate slightly less than 2% per year was common.[19]

The bottom line here is that committing to ultimately reducing intensity at the same rate that GDP is rising is a simple and robust way to commit to a dynamic greenhouse abatement path. It is a more natural target than a quantity target that must subsequently be revised. Of course, agreeing on a rate of reduction and adjusting it as additional information becomes available is not easy.

B. Uncertainty.

One of the concerns that many have had regarding the Kyoto Protocol is the cost of meeting the agreed targets. Ironically, for some countries, the cost is zero (or even a net gain); for other countries, the cost is substantial. Although the playing field appears somewhat level in that most Annex I countries need to reduce emissions by about 5% from the baseline year. But the targets are in terms of greenhouse gas emissions, some twenty years after the baseline of 1990. Much can happen in those intervening years resulting in a great deal of uncertainty in costs.

Several things can influence the uncertainty over a country's cost for meeting a target. One is the size of the required reduction relative to "business-as-usual." A 20% reduction in emissions is obviously more difficult to accomplish than a 2% reduction in emissions. The second source of uncertainty in cost is simply how much it costs to reduce emissions, holding constant the

[19] An examination of nineteen Annex I countries for the period 1990-1999 indicates a median reduction in greenhouse gas intensity of 16% per decade, which translates into slightly less than 1.4% per year. There is, however, considerable variation around this figure, as was mentioned in an earlier footnote.

required emission reduction. Although there are estimates of how much it might cost to achieve a 10% reduction in emissions in a country such as the U.S., there is considerable uncertainty over that figure.

These uncertainties can be decomposed into uncertainty regarding the overall level of economic activity and uncertainty regarding the cost of emission control at the margin, given the level of economic activity. Let e be a random variable reflecting the uncertainty regarding GDP in the commitment period. Certainly with a 10-15 year lead between negotiating something like Kyoto and the commitment period, e will have a great deal of variability. The fact that US GDP grew so much in the 1990's resulted in much higher levels of economic output than had been expected. Recall that the US has for sometime had lackluster GDP growth.

The other source of uncertainty regards the "ease" with which the economy can achieve the target greenhouse gas intensity during the commitment period. How that intensity declines over time is not well understood nor easily predicted. Let ? be a random variable that reflects the uncertainty in the marginal cost of greenhouse gas control conditional on the level of economic output; thus we can define marginal cost as c(?,Y). We make the assumption that ? and e are independent, though that may be somewhat of a stretch.

It is clear that under a quantity target for emissions, the cost is more uncertain: c(?,Y(e)), depending on two random variables. On the other hand, with a commitme4nt to a reduction in emissions intensity, the uncertainty is less, since the costs are conditional on the level of output, Y, and hence the realization of the random variable, e. What is the significance of this? Simply that safety valves or other mechanisms to ameliorate the risk of cost uncertainty will result in far less variability in greenhouse gas emissions and, in fact, are less likely to be exercised when operating under an rate of reduction in intensity target.

How might a country implement an agreement to reduce greenhouse gas intensity? If a commitment to a rate of decline translates into an intensity in year t of g_t, and the realization of the random variable influencing output is e_t, then $g_t Y(e_t)$ emission permits would be issued for that year. Thus every year, the number of permits issued would fluctuate, depending on the realized economic output as well as the agreed level of greenhouse gas intensity.

V. CONCLUSION

We have taken a close look at what appears to be a non-proposal: President Bush's Climate Initiative, proposed on February 14, 2002. The proposal is very weak and conspicuous for the absence of any strong measures to address greenhouse gas emissions in the U.S. However, there are ideas in the proposal, ideas that have some merit, when combined with a higher level of stringency. In particular, the idea of focusing on the rate of reduction of the greenhouse gas intensity of an economy (greenhouse gas emissions per unit of real economic output) would seem to have real merit.

One advantage is that it addresses the problem with the emissions cap approach of Kyoto that requires continual renegotiation of the caps as we proceed through time. Focusing instead on achieving a rate of reduction in emissions intensity that equals the long-run rate of growth of GDP effectively stops the growth of global greenhouse gases. (Of course, that may not be enough – it may be important to stabilize at an even lower level.)

Another advantage of the intensity measure is that it does not penalize countries for economic growth. This has been a major problem with the developing world, who view Kyoto-like caps as hindering growth. Decoupling growth from intensity largely neutralizes this criticism.

Anther advantage of the intensity measure has to do with reducing the uncertainty over

emission control costs. A major impediment for ratification by some countries has been the wide-ranging potential costs associated with the Protocol. The cost uncertainty arises from a combination of uncertainty over how much an economy may grow by the time the commitment period arrives (2012 is 15 years after Kyoto). Cost uncertainty also arises from simple uncertainty over how difficult it is to control emissions, given a particular level of economic activity. The rate of reduction in intensity target has the advantage of resolving the uncertainty over economic growth – emissions are conditional on the level of economic activity. Thus overall uncertainty is reduced.

In sum, there would appear to be more advantages to the rate of reduction of emissions intensity target than might at first appear. It may be worth examining more carefully in the context of the second commitment period.

Table I: Greenhouse Gas Emissions (excluding LULUCF) and Emission Intensity, 1990-2000

Country/Region	GHG Emissions			GHG Change (%)		GHG Intensity			Intensity Change (%)		
	1990	1995	2000	90-95	95-00	1990	1995	2000	90-95	95-00	90-00
US	6131	6482	7001	5.7	8.0	0.94	0.88	0.78	-6.0	-11.8	-17.1
EU-15	4216	4088	4068	-3.0	-0.5	0.53	0.47	0.41	-9.8	-12.6	-21.2
EU-14 (EU-15 less Germany)	2993	3017	3077	0.8	2.0	0.52	0.49	0.43	-6.0	-11.8	-17.1
EU-13 (EU-15 less Germany & UK)	2251	2332	2428	3.6	4.1	0.48	0.46	0.42	-3.0	-10.0	-12.8
Japan	1247	1373	1386	10.1	0.9	0.26	0.26	0.24	-0.5	-6.0	-6.4
Australia	424	443	501	4.5	13.1	1.33	1.19	1.11	-10.9	-6.7	-16.9
Germany	1223	1071	991	-12.4	-7.5	0.54	0.44	0.37	-19.1	-15.4	-31.5
Italy	521	527	547	1.2	3.8	0.51	0.48	0.45	-5.0	-5.4	-10.2
UK	742	685	649	-7.7	-5.3	0.71	0.60	0.50	-15.3	-17.7	-30.3

Notes:

(1) Source: GDP data from OECD National Accounts; GHG data from FCCC database.
(2) Units for GHG: Millions of metric tones of CO2 equivalent
(3) Units for GDP: 1995 US$, converted at 1995 exchange rates
(4) GHG Intensity: kg of CO2-equivalent per $GDP
(5) GHG Emissions omit LULUCF – Land Use, Land Use Change, and Forestry

Table II: Selected U.S. State Actions in Climate Change

State	Nature of Actions
California	- Voluntary Greenhouse Gas Registry - AB 1493 (2002): Mandated greenhouse gas emission reductions from autos for 2009 model year
Oregon	- HB 3283 (1997): new energy facilities required to reduce or offset greenhouse gas emissions
New Hampshire	- HB 284 (2002): CO2 emissions to be reduced to 1990 levels by 2010 - Voluntary Greenhouse Gas Registry
Wisconsin	- Voluntary Greenhouse Gas Registry
New Jersey	- Voluntary Greenhouse Gas Registry - Committed to reducing GHG emissions to 3.5% below 1990 levels by 2010
Massachusetts	- CO2 emissions from six largest power plants capped and to be reduced

NB: Most states have energy conservation and renewables programs; these have not been detailed here.

Sources: Pew Center for Global Climate Change; personal communication, Jill Gravender, California Climate Action Registry; NESCAUM; Jones et al (2002), *op. cit.*