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"Climate Change: Costs of Inaction"

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Testimony by

Ross McKitrick, Ph.D.
Associate Professor
Department of Economics
University of Guelph

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Section 1 Spoken testimony

My name is Ross McKitrick. I am an Associate Professor of Economics at the University of Guelph in Ontario. I hold a Ph.D. in economics from the University of British Columbia. My areas of specialization are environmental economics and climate change.

The term "costs of inaction" (on climate change) is an alternative label for what are more commonly referred to by economists as the *expected total damages* associated with greenhouse gas emissions. Estimation of total damages does not, on its own, provide a basis for policy analysis. Simply noting that a type of emissions may have social costs associated with them does not justify any and all policies proposed to reduce them. Some policies impose higher costs than the problems they are supposed to alleviate.

For this reason, economic analysis requires some further steps.

- A specific policy option must be outlined as the alternative to "inaction." In other words, if action is to be recommended over inaction, the specific form of the action needs to be defined and evaluated.

- The cost of inaction needs to be estimated in marginal, rather than total, terms. Decision-makers have control only over "one more unit" of emissions, i.e. *marginal* emissions, as opposed to total emissions and the damages that might be associated with them.

- Likewise, costs of the proposed course of action must be evaluated at the margin. Greenhouse gas controls can be defined over a range of strictness. Beyond the optimal point, further tightening of the policy causes higher economic costs than the value of the reduction in environmental damages.

A considerable amount of work has gone into estimating potential economic consequences of global warming induced by greenhouse gas emissions. The following points emerge from this analysis.

- The Stern Review was not, as many media sources claimed, a novel undertaking. It was number 211 in chronological sequence.

- The Stern Review's estimate of the marginal social costs of greenhouse gas emissions is far outside the mainstream view. It is even an outlier compared to non-peer reviewed studies that use low discount rates. It has been subject to extensive criticism by a large number of economists

- Average estimates of the marginal social cost of greenhouse gas emissions have declined over time. Estimates published prior to IPCC (1995) were larger than those published between IPCC (1995) and IPCC (2001). These, in turn, were larger than estimates published between IPCC (2001) and IPCC (2007). Hence the IPCC's claim that more recent estimates of the cost of climate change are increasing is unsupported by the data.

- The median estimate among peer-reviewed studies that use a 3% discount rate (pure rate of time preference) is $20 per tonne of carbon. The mean is $23 per tonne.

The academic literature has shown a number of consistent findings about the marginal costs of greenhouse gas abatement.

- Command-and-control measures are the most costly and the least effective. Economic instruments like emission taxes and tradable permits are cheaper.

- Cap-and-trade programs are more damaging to the economy than emission taxes. Cap-and-trade creates a cartel among the permit holders, allowing them to force up consumer prices and earn windfall profits. One study found that reducing US greenhouse gas emissions by 5% using cap-and-trade would cost 10 times as much as using a revenue-neutral carbon tax.

- The monetary value of permits trading systems is not new wealth, it is a measure of the wealth transfers created by the policy. When industry leaders lobby for a cap-and-trade system, they are asking the government to create a highly profitable industry cartel that would be illegal for them to create themselves.

In my written submission I discuss in detail the baseline-minus-control analysis done by the Energy Information Administration for the Lieberman-Warner bill.

Specifying the baseline requires assumptions about the factors that drive emissions growth. Note that total emissions of greenhouse gases (GHG) can be broken down into three factors:

- *Emissions Intensity of the Economy* (GHG/GDP)
    - Total GHG emissions per dollar of Gross Domestic Product (GDP) is called "emissions intensity".

- *Real Average Income* (GDP/Pop)
    - The total amount of GDP divided by population determines real average income.

- *Population* (Pop)
    - The number of people in the economy who have a share in income.

The annual percentage growth of GHG emissions is approximately equal to the sum of the annual percentage change in each of these three factors:

$$\%GHG = \%Pop + \%\frac{GHG}{GDP} + \%\frac{GDP}{Pop}.$$

Hence, to specify a baseline requires making assumptions about these growth rates. The historical rates of growth of these three factors for the USA are:

- Pop: From 1960 to 2005, US population grew at an average annual rate of **+1.1%** per year.

- GDP/Pop: from 1960 to 2005 US Real Average Income (real GDP per capita) rose at an average annual rate of **+2.2%** per year.

- GHG/GDP: From 1960 to 2005 US CO_2 emissions intensity fell at an average annual rate of **1.7%** per year.

Added up, these rates yield the observed average annual growth in total CO_2 emissions of +1.6% per year:

1.1 + 2.2 - 1.7 = **+1.6%** .

Any proposal to reduce US greenhouse gas emissions has to explain where the reductions will come from. If income and population continue to grow at their historical levels, emissions intensity would have to fall twice as fast as its historical rate just to cap total emissions.

I note that the EIA assumed slower growth in both population and real income than the historical pattern when computing baseline emissions. As a result they forecast a much smaller gap between business-as-usual emissions and the Lieberman-Warner target than if they had used historical trends. In my view this caused them to understate the costs of reaching the target. They also applied an assumption in one of their scenarios that the US could introduce 313 Gigawatts of wind energy by 2030—more than the current capacity for coal generation—with almost no effect on real per capita income. This strikes me as implausible.

Finally, I offer a few comments by way of summation.

1. **Costs of climate policy cannot be wished away.**
   It is important to dispense with any illusion that large reductions in greenhouse gas emissions in the near future will be cheap and/or easy. A policy that doesn't cost much will accomplish little. For this reason, it would be entirely reasonable to conclude that you are not prepared to impose the economic damage required to achieve major emission reductions.

2. **Cap and trade is not a good fit with carbon emissions.**
   Policymakers impressed with the success of the Acid Rain control program may instinctively jump on the cap-and-trade bandwagon. But achieving greenhouse gas reductions is not like

reducing sulfur dioxide, because there are so few options for CO_2 abatement. There is a widespread view among environmental economists that cap-and-trade would be a poor instrument choice for climate policy.

3. **Any tax on carbon emissions should start low.**
Another point of broad agreement among economists is that any carbon tax should begin at a low level, perhaps around $20 per tonne. But at this rate, very little emissions reductions would occur. Hence, another way of expressing this point is that the economics does not favor deep emission reduction targets at this time.

4. **A tax on carbon emissions should only go up if the atmosphere actually warms.**
Some analysts argue that the carbon tax should automatically rise over time. The case for increasing the tax rests on a lot of modeling assumptions about the climate response to greenhouse gases that I think are premature. I have proposed instead that the tax should be tied to an actual indicator of global warming The IPCC and the Climate Change Science Program have both shown that if greenhouse gases really affect the climate, then there will be a unique signature on the atmosphere in the form of a strong warming trend about ten miles over the equator, in the so-called tropical troposphere. Hence the tropical troposphere is our best ‘canary in the coal mine.’

The IPCC report examined 25 years of data from weather satellites and weather balloons, and found no evidence of a significant warming trend in the tropical troposphere. Satellite data from the University of Alabama-Huntsville shows a trend of only 0.06 ^{o}C/decade in the tropics, which is statistically insignificant.

The trouble with most greenhouse gas policy ideas being pitched to governments is that they only begin to make sense if the worst-case warming scenarios are right. If these scenarios are wrong, the policies are truly misguided. I believe you should look for a policy that makes sense no matter who is right.

Suppose you implement a low carbon tax and calibrate it to the mean temperature of the tropical troposphere. If the temperature starts going up, the tax would go up, forcing emissions down. If the tropical troposphere does not warm up, the tax won’t go up, nor should it. People on all sides of the issue would expect to get their preferred outcome.

Such a tax would cause investors to build long term expectations about future climate change into today’s decision-making. Someone building a pulp mill or a power plant would have to get the best information available about climate trends for the next ten or twenty years, in order to project the carbon price they will face. This will also create a market for accurate climate forecasts, injecting a dose of reality into academic studies. It will also mean that the policy outcome is rooted in reality. Whether the tax goes up enough to really force emissions down will ultimately depend on whether greenhouse gases are a problem. We will end up with the right outcome, without having to guess in advance what the right policy is. The alternative is a giant political struggle over whose speculations about the future climate are more likely to be right.

Section 2 Background Discussion

The "Costs of Inaction" versus the Net Marginal Benefits of a Proposed Policy

The term "costs of inaction" (on climate change) is an alternative label for what are more commonly referred to by economists as the *expected total damages* associated with greenhouse gas emissions. Estimation of total damages does not, on its own, provide a basis for policy analysis. Simply noting that a type of emissions may have social costs associated with them does not justify any and all policies proposed to reduce them. In much the same way, simply noting that a particular country poses a potential military threat does not justify any and all proposed responses. Some responses impose higher costs than the problems they are supposed to alleviate.

For this reason, economic analysis requires some further steps.

- A specific policy option must be outlined as the alternative to "inaction." In other words, if action is to be recommended over inaction, the specific form of the action needs to be defined and evaluated.
- The cost of inaction needs to be estimated in marginal, rather than total, terms. We only ever cause increments of damage. Nobody is in a position to take responsibility for, or alleviate, all damages—past, present and future—associated with greenhouse gas emissions. Decision-makers have control only over "one more unit" of emissions, i.e. *marginal* emissions, as opposed to total emissions and the damages that might be associated with them.
- Likewise, costs of the proposed course of action must be evaluated at the margin. Greenhouse gas controls can be defined over a range of strictness, ranging from less than a 1% reduction to a complete ban. The optimal degree of strictness is defined as the point where the marginal costs of tightening the policy just equal the marginal damages of the emissions. Beyond that point, further tightening of the policy causes higher economic costs than the value of the reduction in environmental damages.

In order to identify the optimal policy, economists look at the *net marginal benefits* of a proposed policy instrument. The term 'net' means that we are interested in the environmental benefits of the policy over and above the economic cost of implementing it. The term 'marginal' is a reminder that we are always starting from the status quo: we are never in a position to rewrite history or prescribe a path whose starting point is unconnected to the current economy or state of technology.

Marginal Damages of GHG's

A considerable amount of work has gone into estimating potential economic consequences of global warming induced by greenhouse gas emissions. Tol (2007) presents a survey of 211 estimates of the marginal cost of greenhouse gas emissions, expressed as dollars per tonne of carbon-equivalent. The following points emerge from his analysis.

- The Stern Review was not, as many media sources claimed, a novel undertaking. It was number 211 in chronological sequence.

- Studies in the 'gray' literature – i.e. non-peer reviewed – report higher cost estimates than peer-reviewed studies. Peer review is a guard against fearmongering.

- Studies that use inappropriately low discount rates estimate higher costs than those that use conventional discount rates.

- The Stern Review's estimate of the marginal social costs of greenhouse gas emissions is far outside the mainstream view. It is even an outlier compared to non-peer reviewed studies that use low discount rates. It has been subject to extensive criticism by a large number of economists (e.g. Weitzman 2007, Tol and Yohe 2006, Tol 2006, Mendelsohn 2008, Dasgupta 2006, Byatt et al. 2006, Nordhaus 2007, Beckerman and Hepburn 2007, etc.)

- Average estimates of the marginal social cost of greenhouse gas emissions have declined over time. Estimates published prior to IPCC (1995) were larger than those published between IPCC (1995) and IPCC (2001). These, in turn, were larger than estimates published between IPCC (2001) and IPCC (2007). Hence the IPCC's claim that more recent estimates of the cost of climate change are increasing is unsupported by the data.

- Because there is an upper tail of very high cost estimates, cost-benefit analysis will be highly influenced by the weight attached to the risks associated with the upper tail.

- The median estimate among peer-reviewed studies that use a 3% discount rate (pure rate of time preference) is $20 per tonne of carbon. The mean is $23 per tonne.

Nordhaus (2007b) uses integrated assessment modeling to derive the discounted present value of the marginal social damages of greenhouse gas emissions. He puts the cost at about $17 (US) per tonne of carbon.

My own opinion is that figures like $17-23 per tonne are too high. Tol (2007) notes that many studies assume a static economic environment in which people do not adapt or change in response to climatic changes. This is one way in which the costs can be overstated. Also, the modeling assumptions take for granted the distribution of warming scenarios in IPCC reports. My work on the surface temperature record (McKitrick and Michaels 2004, 2007) shows that the land-based warming record is substantially exaggerated. The UAH satellite temperature record from the tropical troposphere[1] exhibits a statistically insignificant trend of about 0.06 ^{o}C/decade

[1] Data from http://vortex.nsstc.uah.edu/public/msu/t2lt/tltglhmam_5.2.

since 1979, yet in all climate models this atmospheric region is supposed to exhibit the maximum warming response to greenhouse gases. This suggests to me that many climate models are programmed with overly high greenhouse gas sensitivity parameters.

However, nothing in the discussion presented below turns one way or the other on this issue. Readers can form their own opinions on the value of the marginal social damages of greenhouse gas emissions. The key point is to realize that the number is not infinite, and that a great deal of research over the past few decades has largely indicated that the dollar values on a per tonne basis are not especially large at this time.

Costs of Abatement

There are two commonly-used ways of evaluating the costs of abatement policies. The first is to compute the marginal abatement costs associated with specific policies, starting from the present time. The is the approach most commonly applied in the academic economics literature since it allows for comparative calculations of the costs of different approaches. The second is to compute a macroeconomic 'baseline-minus-control' simulation for many decades ahead, in order to estimate the total implementation costs of a specific policy mix out to some specified time. This approach uses some of the information generated by the first method, but is also dependent on ad hoc modeling assumptions. It is used by agencies such as the Energy Information Administration to provide policymakers with estimates of the macroeconomic impacts of policies like the Lieberman-Warner Climate Security Act (S.2191).

Marginal Abatement Cost Estimates

Economists use the general equilibrium framework to examine the costs and benefits of policy changes (see, e.g., Shoven and Whalley 1992, McKitrick 1997). The appropriate measure of net benefits is a monetary equivalent of consumer utility, after the economy has fully adjusted to the policy change. Policymakers often want to know the results in terms of changes to GDP. While this statistic matters, focusing on it can also mask important changes. Some policies can raise GDP but make everyone worse off, if people have to work harder to maintain the same standard of living. When presented with estimates of GDP change, always ask to see the estimated changes in real per capita consumption, since this is a better measure of the economic consequences of the policy.

General equilibrium analysis is important because it allows us to examine how a change in one sector (e.g. energy) affects other sectors, and also allows us to study the interactions among different policies. Sometimes introduction of a new policy exacerbates costs associated with older policies—this is an important finding with respect to greenhouse gas abatement.

Much of the underlying theory for analysis of environmental policy was spelled out in Sandmo (1977) and Baumol and Oates (1988) Studies that have used numerical general equilibrium models to look at the costs of reducing air emissions in the US include Bovenberg and Goulder (1996), Parry et al. (1999) and Goulder et al. (1999). From these and many other studies (e.g. McKitrick 1998), a few key insights have repeatedly emerged.

- Different policies for achieving the same emissions reduction can have very different costs. Command-and-control measures are the most costly and the least effective. Economic instruments like emission taxes and tradable permits are cheaper. Revenue-neutral emission taxes are the cheapest, as long as all the revenue is refunded via reductions in taxes on income or investment. If the revenue is used to subsidize abatement expenses (i.e. through grants for alternative energy) much of the economic efficiency is lost.

- Cap-and-trade programs are more damaging to the economy than emission taxes (Elkins and Baker 2001). Cap-and-trade creates a cartel among the permit holders, allowing them to force up consumer prices and earn windfall profits. This not only imposes direct costs, but it creates a large class of hidden costs because of the way the increased energy costs and reduced real wages amplify the economic costs of the pre-existing tax system. Such costs can only be detected using general equilibrium modeling, and they are significant. Parry et al. (1999) estimate that reducing US greenhouse gas emissions by 5% using cap-and-trade would cost 10 times as much as using a revenue-neutral carbon tax.

- Cap-and-trade is also regressive, since higher energy prices fall disproportionately on the poor. Carbon taxes can alleviate this more easily since the offsetting tax reductions can be directed towards low-income houses.

- It is a fallacy to refer to the monetary value of permits trading systems as a new market to be exploited. Instead, the value of permits being traded is a measure of the wealth transfers created by the policy. For example, if the US uses cap-and-trade to reduce its CO_2 emissions to 1.2 Gigatonnes (the Kyoto target), and the permits end up costing $100 each, the windfall gain to permit holders would be $120 billion. *This is not new wealth*, instead it is the transfer of wealth from the general public to the members of the newly-created cartel who hold the permits. When industry leaders lobby for a cap-and-trade system, they are asking the government to create a highly profitable industry cartel that would be illegal for them to create themselves.

- Cap-and-trade systems for greenhouse gases would likely impose marginal economic costs on the US of between $18 and $55 per tonne for the first tonne of abatement (Parry et al. 1999, Bovenberg and Goulder 1996). The costs would rise from there, roughly doubling for every 10% additional emissions reduction. Consequently, unless the marginal damages of greenhouse gas emissions are believed to be higher than the $18-55 range, cap-and-trade should be ruled out, since it is guaranteed to make the US worse off, even taking into account generous estimates of the benefits of reducing greenhouse gases.

- When uncertainty is taken into account, the case for using a price instrument, e.g. a carbon tax, rather than a quantity instrument like cap-and-trade, becomes even stronger (Nordhaus 2007b, 2006; Newell and Pizer 2003, Parry 2003; etc.) Policymakers can set an emissions cap, and let the market choose the price, or choose a price and let the market choose the emissions level. Either way, uncertainty means that policymakers are, by necessity, taking a guess at the optimal price or quantity target, and will undoubtedly make a mistake. In the case of carbon dioxide emissions, mistakes on the quantity axis have much higher expected economic costs than mistakes on the price axis. It is better for policymakers to decide what they believe the marginal damages of carbon emissions are, and then set that amount as a price, rather than imposing an emissions cap and hoping the permits market doesn't lead to prices far in excess of that amount.

Baseline-minus-control scenarios

In a baseline-minus-control approach, the modeler estimates what the emissions will be out to some distant target date, such as 2030. Then the cap prescribed by a policy instrument is imposed, and the model is re-run under various assumptions about how the cap will be achieved.

Specifying the baseline requires assumptions about the factors that drive emissions growth. Note that total emissions of greenhouse gases (GHG) can be broken down into three factors:

- *Emissions Intensity of the Economy* (GHG/GDP)
  - Total GHG emissions per dollar of Gross Domestic Product (GDP) is called "emissions intensity".

- *Real Average Income* (GDP/Pop)
  - The total amount of GDP divided by population determines real average income.

- *Population* (Pop)
  - The number of people in the economy who have a share in income.

These factors, multiplied together, yield total annual emissions:

$$GHG = \frac{GHG}{GDP} \times \frac{GDP}{Pop} \times Pop$$

Note: this is not a theory or an economic model, it is a mathematical identity that must hold true.

Mathematically, this means that the annual percentage growth of GHG emissions is approximately equal to the sum of the annual percentage change in each of these three factors:

$$\%GHG = \%Pop + \%\frac{GHG}{GDP} + \%\frac{GDP}{Pop}.$$

Hence, to specify a baseline requires making assumptions about these growth rates. The historical rates of growth of these three factors for the USA are:

- Pop: From 1960 to 2005, US population grew at an average annual rate of **+1.1%** per year.[2]

- GDP/Pop: from 1960 to 2005 US Real Average Income (real GDP per capita) rose at an average annual rate of **+2.2%** per year.[3]

- GHG/GDP: From 1960 to 2005 US CO_2 emissions intensity fell at an average annual rate of **1.7%** per year.[4]

Added up, these rates yield the observed average annual growth in total CO_2 emissions of +1.6% per year:

1.1 + 2.2 - 1.7 = **+1.6% .**

Note: CO_2 comprises 95% of US emissions covered by the Lieberman-Warner bill.

From this analysis we can see that future growth in CO_2 emissions will be driven by future population growth + future income growth + future change in emissions intensity. To assess the credibility of any cost estimates it is essential to examine the assumptions made about each of these factors.

To get some sense of the scale of challenge involved in the Lieberman-Warner bill, note that it required an annual average reduction in total GHG emissions (subject to partial attainment through offsets) of

- - 1.1% per year on average between 2006 and 2012
- - 1.9% per year on average between 2006 and 2030
- - 2.9% per year on average between 2006 and 2050

If the US Congress intends that population growth should continue to average +1.1% per year, and real income growth should continue to average +2.2% per year, S.2191 would have required emissions intensity to decline by the following approximate amounts:

- - 4.4% per year on average between 2006 and 2012
- - 5.2% per year on average between 2006 and 2030
- - 6.2% per year on average between 2006 and 2050

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[2] http://www.gpoaccess.gov/eop/tables07.html
[3] http://www.gpoaccess.gov/eop/tables07.html
[4] http://cdiac.esd.ornl.gov/ftp/trends/emissions/usa.dat and http://epa.gov/climatechange/emissions/downloads06/07ES.pdf for CO2 emissions; GDP at http://www.gpoaccess.gov/eop/tables07.html

There is no historical precedent for such rapid reductions in CO_2 emissions intensity. Nor is there any explanation in the legislation of how this reduction in emissions intensity is to be achieved, especially if, as is likely, international offsets are not a reliable option.

Comparison to Sulfur Dioxide Market

Some commentators point to the dramatic reduction in sulfur dioxide emissions under the Clean Air Act Amendments as a good analogue to what can be done with CO_2. However the situations are very different. According to EPA data,[5] total US sulfur dioxide emissions fell by approximately 50% between 1970 and 2002. However, about half these reductions occurred through use of scrubbers and about half from switching to low-sulfur coal, following railway de-regulation in the 1990s (Schmalensee et al. 1998). Neither of these strategies are applicable to greenhouse gas abatement.

- There are no scrubbers for CO_2 . Even if the gas can be stripped from smoke, it cannot be disposed of or used as an industrial feedstock, since that will just delay its eventual release. It must be pumped underground (carbon capture and storage, or CCS), which is costly and rarely feasible.

- While it is possible to find low-sulfur coal or oil, there is no such thing as low-carbon coal or oil.

The only way to reduce CO_2 emissions on a large scale is to reduce fossil energy consumption or switch fuel types, such as from coal to natural gas. These are much more expensive methods than scrubbers or source switching. This is why they did not play much role in reducing sulfur dioxide emissions under Acid Rain regulations, and that is why cost estimates for reducing CO_2 emissions are higher than those for sulfur emissions.

Baseline assumptions in the EIA Analysis

The analysis of the Energy Information Administration[6] is generally seen as yielding high cost estimates for the Lieberman-Warner bill. However, a close look shows that their key assumptions probably understate what the implementation costs would have been.

- In the EIA analysis, Population was assumed to grow at an average rate of +0.9% per year from 2006 through 2030 in all scenarios, four-fifths the average growth rate experienced since 1960. This assumption reduces the base case emission levels in the absence of legislation, thereby artificially reducing the cost of reaching the target. Unless the US Congress has adopted, or plans to adopt, a policy of sharply restricted immigration, this assumption is inappropriate. Cost estimates should have been presented assuming +1.1% population growth in the future. This would likely have increased the estimated macroeconomic costs of S.2191 by at least 20%.

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[5] http://www.epa.gov/ttn/chief/trends/index.html and http://www.epa.gov/ttn/chief/trends/trends98/index.html

[6] Available at http://www.eia.doe.gov/oiaf/servicerpt/s2191/index.html. References to spreadsheets are to those on this page.

- In the EIA analysis, real per capita income in the base case was assumed to grow at an average rate of +1.6% per year after 2006, less than three-quarters the average growth rate experienced since 1960. This assumption reduces the base case emission levels in the absence of legislation, thereby artificially reducing the cost of reaching a target. Unless the US Congress has adopted a goal of permanently reducing real income growth, this assumption is inappropriate. Cost estimates should have been presented assuming base case +2.2% real income growth in the future. This would likely have increased the estimated macroeconomic costs of S.2191 by at least 30%.

- In the EIA analysis, by scaling down assumed population and income growth, the estimated base case GHG emissions in the US after 2006 grow at an annual rate of only +0.7% through 2020 and +0.4% through 2030.[7] Since the observed historical annual growth rate in US emissions since 1960 is +1.6% per year, the EIA analysis assumed away half to three-quarters of potential future growth in GHG emissions. In my view this had the effect of sharply reducing the estimated policy compliance costs. It was misleading to present such estimates without also presenting information about how the costs would increase if future business-as-usual emission trends follow historical trends. Such estimates would likely have at least doubled the cost estimates reported by the EIA.

- Even more remarkably, in the EIA analysis, none of the implementation scenarios for S.2191 had much effect on the resulting annual average rate of growth of real per capita income. The following table lists the results for the base case and three scenarios, encompassing the cheapest ("Core") and the costliest ("Limited Alternatives and No International Offsets").[8]

Growth in real GDP per capita	**Compared to 2006 Total % Change**		**Compared to 2006 Annual Avg % Chg**	
EIA Scenario:	**2020**	**2030**	**2020**	**2030**
Base Case	24.8%	44.7%	1.6%	1.6%
"Core" - Cheap and Easy Alternatives	24.4%	44.7%	1.6%	1.6%
Limited Alternatives	24.2%	44.1%	1.6%	1.5%
Limited Alternatives and No Int'l Offsets	23.6%	43.9%	1.5%	1.5%

In all cases, real average income continues to grow at the base case rate (+1.6%) or just under. Despite the enormous price shocks experienced under the policy scenarios, and despite the massive diversion of resources required to restructure much of the US energy system towards nuclear or renewables, the EIA model predicts no income effects. This is simply not credible, and flies in the face of ample historical evidence concerning past energy price shocks. With this assumed structure the EIA model would not be able to account for the recessions experienced in response to past energy price shocks, and it therefore likely underestimated the economic consequences of future policy-induced price shocks. At the

[7] Reference spreadsheet line 1865.
[8] Lines 1758 and 1795 from relevant case spreadsheets.

very least the EIA should have provided sensitivity analyses to demonstrate how their cost estimates would have changed if major energy price increases were allowed to affect the economic growth assumptions in their economic model. This would obviously have led to much larger economic cost estimates for S.2191.

- In the *least cost* scenario ("Core"), EIA modelers assumed that the USA can increase its nuclear power capacity by 26% between now and 2020, and by an astonishing 267% between 2020 and 2030. This requires that in the decade after 2020 the US could flawlessly bring online two new nuclear reactors for every one operating as of 2020. By historical standards this is very implausible, especially in light of the decades-long failure to open the proposed nuclear waste storage facility at Yucca Mountain. The EIA ought to have conducted sensitivity analyses of additional costs likely to be incurred under the "Core" scenario if the massive additions to nuclear capacity cannot occur on the stated schedule.

- In the *highest cost* EIA scenario ("LA – NoInt"), new nuclear power does not become available. However, this does not address the implausibility of the Core scenario since the EIA substitutes in the equally implausible assumption that 313 Gigawatts of continuous wind energy will become available,[9] more than the entire current coal-fired generating capacity (305 Gigawatts). But wind energy is neither scalable during peak hours nor continuously available, so it is unrealistic to assume it can displace that much fossil generation in just over two decades. Even under this unrealistic assumption, domestic energy costs go up by 180%[10] and 1 million jobs in manufacturing are eliminated.[11]

In sum, key assumptions about the baseline, and about the ease of implementing specific policy scenarios, likely understated the economic costs in the EIA analysis of S.2191 by about half. The EIA should be asked to do any future analyses of major climate change legislation applying the assumption of future population growth of +1.1% per year and base-case real income growth of +2.2% per year; and they should be asked to put realistic limits on the extent to which wind and nuclear energy can replace coal.

Some Policy Conclusions

I would like to present a few summary conclusions to guide you in your search for the best climate change policy.

1. **Costs of climate policy cannot be wished away.**
   It is important to dispense with any illusion that large reductions in greenhouse gas emissions in the near future will be cheap and/or easy. Under current US energy technology, any emissions reduction large enough to "count" will be large enough to hurt, possibly badly. A policy that doesn't cost much will accomplish little in terms of emission

[9] Limited/No International spreadsheet lines 1532-33.
[10] Limited/No International spreadsheet line 1775.
[11] Limited/No International spreadsheet line 1797.

reductions and virtually nothing in terms of actual climate effects. For this reason, it would be entirely reasonable to conclude that you are not prepared to impose the economic damage required to achieve major emission reductions. A straightforward comparison of costs and benefits supports this position, with the caveat that action may be justified to speed up technological innovations in low-emission energy sources, as long as the new technologies have a realistic prospect of being economically competitive in a reasonable period of time. Beyond that, it is quite defensible to conclude that the costs of any actions open to you exceed the costs of inaction. In any case, do not try to wish away the dilemma by pretending emission reductions won't be costly.

For instance, The Natural Resources Defence Council (NRDC) has claimed Lieberman-Warner could be attained at very low costs, and in many cases households and firms would be better off.[12] Their reports demonstrate the error described above by describing the revenues raised from emission permit sales as new wealth. They list the tens of billions of dollars in new Congressional subsidies for money-losing alternative energy projects and political rent-seeking, and repeatedly refer to this as "new" money or "new" investments.[13] It is nothing of the sort. These funds are transfers away from existing consumers and firms to the government for redistribution, in effect a set of hidden taxes. And since taxes always generate deadweight losses—i.e. more wealth is destroyed by implementing the tax than is generated for the government to spend or redistribute—the permits revenue from S.2191 represents an overall destruction of wealth, not a source of new wealth.

Moreover, the NRDC apparently does not believe its own claims. They have argued that reductions in GHG emissions sufficient to yield compliance with S.2129 could be implemented by the private sector at low or no cost.[14] If so, then a nominal carbon emissions tax at, say, five dollars per tonne of carbon equivalent, would be more than enough to induce full compliance. If firms really are better off implementing the emission reductions they don't need the threat of fines and jail terms to make them do it. But when it has been suggested that a low safety valve price should be added to cap-and-trade legislation, the NRDC objects,[15] claiming that a strict cap with a high permit price is necessary to force emission reductions. Hence they contradict the conclusions of their own economic analysis. They don't believe their own analysis, and neither should anybody else. Greenhouse gas emission reductions will be costly, especially if the implementation relies on command-and-control or cap-and-trade approaches.

2. **Cap and trade is not a good fit with carbon emissions.**
Policymakers impressed with the success of the Acid Rain control program may instinctively jump on the cap-and-trade bandwagon. But achieving greenhouse gas reductions is a different situation than achieving sulfur dioxide emission reductions, primarily because there are so few options for reducing CO_2 emissions. Those differences matter, and have led to a

[12] See http://nrdc.org/globalWarming/liebwarner.asp.
[13] http://nrdc.org/legislation/factsheets/leg_08052701A.pdf.
[14] http://nrdc.org/legislation/factsheets/leg_08051401A.pdf.
[15] http://www.nrdc.org/legislation/factsheets/leg_07032601A.pdf.

widespread view among environmental economists that cap-and-trade would be a poor instrument choice for climate policy.

3. **Any tax on carbon emissions should start low.**
Another point of broad agreement among economists is that any carbon tax should begin at a low level. Nordhaus (2007) suggests $17 per tonne. Using the data from Tol's survey we would get marginal damages of about $20, then applying the adjustment derived by Sandmo (1977), which requires us to divide the marginal damages by the marginal cost of public funds, we would get a figure of about 20/1.4 = $14.30. Personally I think even this is too high, but for the sake of argument suppose that carbon tax were implemented. At this rate, very little emissions reductions would occur. Hence, another way of expressing this point is that the economics does not favor adopting deep emission reduction targets at this time.

4. **A tax on carbon emissions should only go up if the atmosphere actually warms.**
Nordhaus and others argue that the carbon tax should automatically rise over time. The case for increasing the tax rests on a lot of modeling assumptions about the climate response to greenhouse gases that I think are premature. I have proposed instead that the tax should be tied to an actual indicator of global warming (McKitrick 2007a,b). The IPCC and the Climate Change Science Program have both shown in their modeling work (IPCC 2007 Fig 10.7, CCSP 2006 Fig. 5.7) that if greenhouse gases really affect the climate, then there will be a unique signature on the atmosphere in the form of a strong warming trend about ten miles over the equator, in the so-called tropical troposphere. Of all the factors that might cause warming in the future, only greenhouse gases will yield a big relative warming there, and according to the IPCC it will be rapid, and will be stronger than warming at the surface (IPCC 2007 pp. 714-715). Also, if carbon emissions really drive climate change, models show the trend should already be well underway (IPCC Fig. 9.1, CCSP Fig. 1.3). Hence the tropical troposphere is our best 'canary in the coal mine.'

So it is noteworthy that the IPCC report examined 25 years of data from weather satellites and weather balloons, and found no evidence of a significant warming trend in the tropical troposphere. Satellite data from the University of Alabama-Huntsville shows a trend of only 0.06 ^{o}C/decade in the tropics, which is statistically insignificant. The average temperature has drifted upwards since 1980, but not beyond the bounds of natural variability. The CCSP noted this too, and pointed out that the models showing the greatest agreement with observations are those that have the lowest amounts of warming (CCSP p.11).

The trouble with the most greenhouse gas policy ideas being pitched to governments is that they only begin to make sense if the worst-case warming scenarios are right. I believe you should look for a policy that makes sense no matter who is right.

We have good quality data on the mean temperature in the tropical troposphere. Suppose you implement a low carbon tax with full revenue recycling to make it revenue-neutral. And suppose you calibrate the carbon tax rate to the mean temperature of the tropical troposphere. If greenhouse gases really drive climate change, the temperature will go up, and the tax would go up, forcing emissions down. If the tropical troposphere does not warm up, the tax won't go up, nor should it. People on all sides of the issue would expect to get their preferred outcome.

Such a tax would force investors to build long term expectations about future climate change into today's decision-making. Someone building a pulp mill or a power plant would have to get the best information available about climate trends for the next ten or twenty years, in order to project the carbon price they will face. This will create a market for accurate climate forecasts, injecting a dose of reality into academic studies. It will also mean that the policy outcome is rooted in reality. Whether the tax goes up enough to really force emissions down or not will ultimately depend on whether greenhouse gases are a problem. You will end up with the right outcome, without having to guess in advance what the right policy is. The alternative is a giant political struggle over whose speculations about the future climate are more likely to be right.

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