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GREENHOUSE GAS ABATEMENT COSTS

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PREFACE

The series of AECS White Papers are based on the assumption that human societies will not implement effective policies for coping with climate change until a critical mass of opinion leaders reaches consensus about the problem, about possible solutions, and about how solutions should be weighed against other valid concerns. Hence, strengthening the intellectual rigor of the policy dialogue is an essential first step toward finding and implementing solutions.

These papers are designed to offer the authors' judgments about the relative validity of various proposals and pieces of climate policy analysis. The intention is that the resulting controversy will clarify the issues. Although the reader will doubtless find many of the thoughts and theories implicit in the policy stance of AECS reflected in the analysis presented by the White Papers, the goal is more to elucidate a wide range of climate policy issues than to advance the cause of the particular policy preferences of AECS.

Progress in this endeavor is possible only because much excellent climate policy analysis is being done in academia and at a few of the many think tanks active on climate policy. The great difficulty is to make this sensible discourse audible above the noisy ideologically motivated cacophony. Richard N. Cooper has well summarized the task:

The political process, while essential for making decisions on collective risk, contains some serious weaknesses, most notably that the discussion is not conducive to honesty and straight-forwardness. Some risk averse parties will naturally exaggerate the risks in order to persuade those who are less risk averse than themselves. Some risk averse parties will attempt to minimize the estimated costs of early action, or suggest that they can be borne by non-voters (e.g. corporations) in order to gain the support of voters less risk averse than themselves. And some parties will use legitimate concerns with the issue at hand, e.g. greenhouse warming, to encourage society as a whole to adopt a "lifestyle" more congenial to them, e.g. by less reliance on the automobile, what for many has been a greatly liberating device. In these last cases, alarms over greenhouse warming become instrumental rather than the true objective. On the other side, those who expect to bear the costs of political decisions in response to concerns over climate change will tend to minimize the risks and exaggerate the costs of mitigation. In short, we should be on guard against strong but wrong or misleading or exaggerated arguments put by all sides to the case. ¹

The AECS White Paper series will seek to highlight those areas where the academic literature can provide useful correctives to the "strong but wrong" arguments.

ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

INTRODUCTION

This paper will lay out a case for believing that *rapid or deep* reductions of greenhouse gas emissions in developed countries is likely to prove to be expensive both in absolute terms and in relation to benefits. This conclusion has profound implications for the future of government policies to mitigate the harmful consequences of climate change. These implications include the following:

- Although voluntary business commitments to reduce emissions may effect some marginal emissions reductions, they cannot accomplish large or rapid reductions where markets are competitive.
- Although mandatory programs could be far more effective than voluntarism, even they are likely to produce only gradual and modest results.

Clearly the force of these conclusions depends on the strength of the evidence for the proposition that developed country mitigation efforts will be expensive and on the evidence presented in another forthcoming AECS white paper that abatement is much less expensive in developing countries.

THE HIGH COSTS OF REDUCING GREENHOUSE GAS EMISSIONS

Strong *prima facie* evidence indicates that rapid or steep reductions in greenhouse gas (GHG) emissions would be expensive, were it to be undertaken in OECD countries. This statement is not intended to dispute that some inexpensive carbon emission reductions may be available. Nor does it mean that some cautious emission reduction strategies might be perfectly affordable for the economies of developed countries. It does assert that emission reductions large enough to meet either the Kyoto Protocol targets or the somewhat less aggressive UN Framework Convention on Climate Change goals would be very expensive *relative to the benefits*.

The goal of stabilizing greenhouse gas concentration levels conflicts with the world's continued and growing massive reliance of fossil fuels. Combustion of fossil fuels is the leading source of anthropogenic greenhouse gasses. Fossil fuels, however, are the basis of much of the economic infrastructure (broadly defined) on which mankind's current wealth and numbers depend. This common sense conclusion is confirmed by economic modeling. One way to put the costs in perspective is to relate them to GDP. The multi-model comparison organized by the Stanford Energy Modeling Forum found that by the year 2010, assuming Annex I emission rights trading, the Kyoto Protocol would have reduced the GDP of the United States by .24 to 1.03 percent. The average result of the eight models was a GDP reduction of .59 percent.² Thus in comparison with total economic output the cost of Kyoto would have been neither trivial nor catastrophic.

Studies of the costs of the electric power plant emissions control legislation now under consideration in the U.S. Senate send the same signal, *i.e.* abatement will be expensive. In terms of the cost of avoiding an additional ton of carbon emissions, this legislation, *as currently drafted*, would impose a cost of \$122 per ton (using DOE's estimate), or \$138 per ton, (using EPA's).³ These costs are quite high when judged against the most important standard of the benefit of reducing a ton of emissions. These estimated costs approximate the low-end estimates of the cost for controlling an additional ton of emissions under the Kyoto Protocol, which had been much criticized as prohibitively expensive.

COUNTER ARGUMENTS

Some, however, continue to avidly support *rapid and steep* greenhouse gas emission reductions in the United States and in the rest of the developed world. At least part of the reason appears to be that these advocates do not believe the evidence suggesting that GHG emission abatement would be extremely costly.

Notwithstanding the persistence of claims that emission controls would be cheap, the best available economic analysis suggests that on the contrary:

- The historical record does not support the conclusion that *ex ante* abatement cost estimates for carbon are necessarily overstated. In general *ex ante* estimates of unit cost of abatement done by EPA do not show a systematic bias. And the often cited claims that the *ex ante* studies over estimated abatement costs of the Title IV Acid Rain program (of the Clean Air Act Amendments) would prove absolutely nothing about the accuracy of current estimates of carbon abatement costs, even if these claims were true. In reality, however, the claims that all *ex ante* studies overestimated the costs of Title IV are exaggerated and based on confused economic reasoning.
- There is little prospect of finding an economic “free lunch” that would make carbon emission abatement economically cheap by compelling consumers to conserve energy. Although engineering studies have claimed to find evidence of massive inefficiency in society’s use of energy, economic assessments of these studies have discovered both empirical and theoretical problems. When these problems are accounted for, the size of the allegedly inefficient consumption shrinks and other explanations emerge for reconciling actual investment behavior standards of economic rationality. While a debate continues, the present credibility of engineering studies purporting to demonstrate an energy conservation “free lunch” is far too flimsy to justify their use as guides to high stakes public policy making.
- Although some recent studies such as the Clean Energy Futures (CEF) study, attempt to answer some earlier criticisms, they have done little to boost the credibility of the theory of the energy conservation free lunch. The CEF effort is to be praised for helping to make the terms of the debate more concrete and transparent. Nevertheless, specifying what policies might be employed has merely shifted the question to new doubts about the realism and efficacy of the proposed policies. And nothing in the new study assuages doubts about the validity and quantitative importance of the basic assumption of widespread economically irrational investment behavior.

In light of this evidence, the most reasonable going-forward assumption is that carbon emission abatement will be an expensive proposition certainly in the United States, and probably in much of the rest of OECD.

CONCLUDING THOUGHTS

The high costs of climate change mitigation policies certainly do not imply that action is unnecessary. But high costs, especially when juxtaposed to the public’s limited willingness to pay, do imply that the proponents of mitigation policies face a far greater need to craft only cost effective policy prescriptions than has been the case with previous environmental problems. How they respond will profoundly affect the prospects of avoiding harmful climate change.

Unfortunately, some advocates fear that admitting the high cost of carbon emission abatement might delay implementation of emission controls. This fear has so far beclouded discussion of the abatement cost issue. But the evidence of the high cost of carbon abatement cannot *plausibly* be denied or refuted. And the costs of truly effective action are too big to be hidden by public policy sleight-of-hand. In that event, therefore, acknowledging high abatement costs and forthrightly minimizing them is likely to be the best strategy for making progress.

Denying the reality of high costs, moreover, increases the risks that the political process will institute inefficient policy mechanisms. This risk is already evident in the many proposals to “solve” the climate problem with CAFE standards, energy efficiency standards, renewables portfolio standards, demand side management schemes, and an elaborate panoply of tax and direct subsidies for “approved” technologies. Long run, reliance on such inefficient policies would hobble the pursuit of the already fast receding goal of avoiding climate change. And in the short run, moving swiftly to implement policies that are doomed to long run failure is a dubious kind of progress.

POLICY IMPLICATIONS

VOLUNTARISM IS OF VERY LIMITED EFFICACY

If steep carbon emission reductions are expensive, voluntary programs in which businesses pledge to achieve them will not work. Businesses in competitive markets cannot afford to put themselves at cost disadvantages relative to their competitors. Thus if businesses pledge to reduce greenhouse gas emissions on a voluntary basis, either the specific reductions that they are pledging to make are not costly, or the markets into which they sell are not competitive, or they are simply claiming public relations credit for actions that they would have taken anyway on grounds other than climate.

The United States government manages several programs designed to induce voluntary emission reductions. Because some greenhouse gas emission reductions are either free or very cheap, it may be worthwhile for some businesses to participate in order to reap a public relations benefit at small cost. But despite these programs U.S. emissions are projected to continue growing at a rate of about 1.5 percent per year.⁴ Clearly then, voluntarism is falling far short of halting the growth of emissions.

The public discussion of costs and voluntarism has become somewhat incongruous. On the one hand the Bush Administration has emphasized the great expense of steep emissions reductions as called for by the Kyoto Protocol. Yet the Administration touts the efficacy of voluntarism, which cannot accomplish much if emission reductions are expensive. On the other hand, some environmentalist advocates of stringent mandatory emission reductions insist that the cost of such reductions would be negligible, although if they were right about the trivial costs, voluntarism might actually work.

FIRST WORLD EMISSION REDUCTIONS WILL BE LIMITED

If the costs of steep emission reductions are high, such emission reductions are unlikely to occur. The opposition to emission reductions is powerful and well financed. Those opponents of emission limitations will have little trouble in proving that emission reductions will be expensive.

The political record to date does not demonstrate a public willingness to tolerate high costs in the cause of climate change mitigation. In the United States, not even elite opinion has concluded that

the risk of global warming justifies paying the high costs needed to mitigate it. Popular opinion is likely to lag several years behind elite opinion. The evidence supporting this lack of consensus to incur costs in the cause of protecting the climate is overwhelming. The massive political unpopularity of the Kyoto Protocol in the United States is one illustration. And the inability of the proponents of carbon controls for power plants to advance their agenda confirms that the problem extends well beyond the numerous flaws and defects of the Kyoto Protocol.

Even in Europe, the self-proclaimed leader on climate policy, a recent political analysis assessed the current situation thusly: “The European Union’s climate policy is characterized by uncoordinated measures taken at [the] national level and a preference for inefficient instruments. The vanguard role taken by the EU in international climate negotiations stands in contrast to the lack of action in meeting far-reaching emissions-reduction targets on a European level.”⁵ This assessment may change with time. And some individual EU nations may impose significant costs on their economies in the service of climate mitigation.

Much of the “action” in the EU, however, even in Germany, the location of some of the most intense climate rhetoric, consists of proclamation of ambitious goals to be achieved some time after the next election. In the same vein, German industries have made voluntary pledges to reduce emissions, but with deregulation governments have little leverage to enforce such commitments.⁶ This pattern may of course change at some future point, but – at the very least – the timing and degree of the change remain uncertain.

In both the United States and the EU, transformation of such a weak position into a social consensus will not happen swiftly. Consensus on controversial issues is usually slow to emerge even among opinion leaders, who are likely to decide well before the less attentive and less well informed. Although events sometimes accelerate the emergence of consensus, various odd weather patterns have so far failed to evince rapid change in attitude toward climate. Nor has the evolution of scientific thought on the subject.

THE COSTS OF REDUCING GHG EMISSIONS

THE PRODUCTIVITY OF FOSSIL FUELS

The goal of stabilizing greenhouse gas concentration levels conflicts with the continued and growing massive reliance of fossil fuels. Combustion of fossil fuels is the leading source of anthropogenic greenhouse gasses. Fossil fuels, however, are the basis of much of the economic infrastructure (broadly defined) on which mankind’s current wealth and numbers depend. Moreover fossil fuels hold their dominant economic role because they are cheaper, often much cheaper, than alternative energy sources. The prospect of replacing so much of the existing economic infrastructure (infrastructure that is often both long lived and of relatively recent vintage), and replacing it with more expensive energy sources clearly carries the risk of large costs.

THE EXAMPLE OF KYOTO

This common sense conclusion is confirmed by economic modeling. For example, Nordhaus and Boyer, using the RICE 99 model, estimate that the Kyoto Protocol, even if implemented with rules that allowed emission trading within Annex I countries, would have cost \$217 billion (in present discounted value).⁷

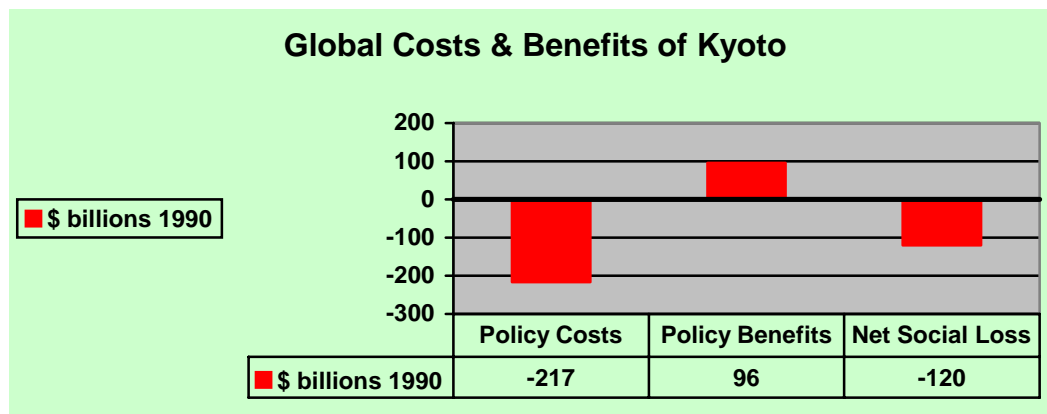
One way to put the costs in perspective is to relate them to GDP. The multi-model comparison organized by the Energy Modeling Forum (which included the RICE model among many others) found that by the year 2010, assuming Annex I emission rights trading, the Kyoto Protocol would

have reduced the GDP of the United States by .24 to 1.03 percent. The mean result of the eight models was a GDP reduction of .59 percent.⁸ Thus, in comparison with total economic output, the cost of Kyoto would have been neither trivial nor catastrophic.

The United States would have borne by far the biggest share of the costs had the Kyoto Protocol been implemented with emission allowance trading largely confined among Annex I countries. In fact, in that case, the present value costs of Kyoto for the United States would have exceeded the costs for entire world by \$108 billion. This seeming paradox was possible because Kyoto would have compelled the United States to purchase large quantities of emission allowances from the rest of the world. The revenue from selling these allowances to the United States would have made the rest of the world (taken as a whole) a net beneficiary of the Kyoto system quite independently of any gains from reduced greenhouse gas emissions.⁹

What is, however, more shocking is how small the benefits would have been. Partly because Kyoto concentrated so much of the emission reductions effort in the Developed World, where the costs are relatively high, the Protocol would have produced few benefits in the form of emission reductions despite its substantial costs. According to Nordhaus and Boyer, “{the} Kyoto Protocol is expected to have very modest impact on CO₂ concentrations and on global warming,”¹⁰ (This analysis predated the Hague and Marrakech modifications of Kyoto that would have reduced both the costs *and the benefits* presented in the Nordhaus Boyer analysis.)

Figure 1



THE EXAMPLE OF THE CARBON PROVISIONS OF S.556

Studies of the costs of current proposals for domestic U.S. emission reductions send the same signal that carbon abatement will be expensive. For example, a recent analysis by the United States Department of Energy concluded that S. 556, legislation being considered in the Senate, would increase consumer electricity prices by a third.¹¹ This legislation would reduce the Gross Domestic Product of the United States economy by .8 percent each year. By 2007, total annual losses would approach \$100 billion.¹²

Although the legislation entails more than just carbon emission controls, carbon emission controls would represent approximately half of the total costs of the controls according to EPA.¹³ By inference, the carbon emission controls would represent an economic loss equal to about .4 percent of GDP. Note that the estimated cost of reducing an additional ton of emissions under S. 556 is only slightly below the mean estimate (cited above) of the cost of Kyoto with Annex I trading, although Kyoto was much criticized as much too expensive.

In terms of marginal cost of abatement, achieving 1990 levels of carbon emissions in the electric utility sector would also imply costs quite comparable to those of the Kyoto Protocol with the assumption of Annex I trading. For example, DOE estimates the marginal cost of carbon emissions reductions under S.556 as \$122 per ton in the year 2020 (expressed in 1999 dollars); EPA reached a similar (but not entirely comparable) \$138 estimate.¹⁴ EIA's model estimated the marginal cost of carbon abatement in 2010 for Kyoto (with Annex I trading) at \$133.¹⁵ Thus, the EIA model predicts that the marginal costs of carbon abatement for Kyoto and for S.556 are quite similar to each other and to the EPA result.

Some environmental advocates protest that EIA cost estimates are too high. And it is true that the average cost estimate of all the EMF models is about 29 percent lower than that of EIA's model.¹⁶ But even if one assumed that the EIA was overstating the costs of S.556 by 29 percent, the cost would still be \$87 per ton. And it would by no means be valid to conclude that the EIA estimate was too high just because it exceeded the average of the estimates generated by the EMF exercise.

S. 556 BENEFITS VERSUS COSTS

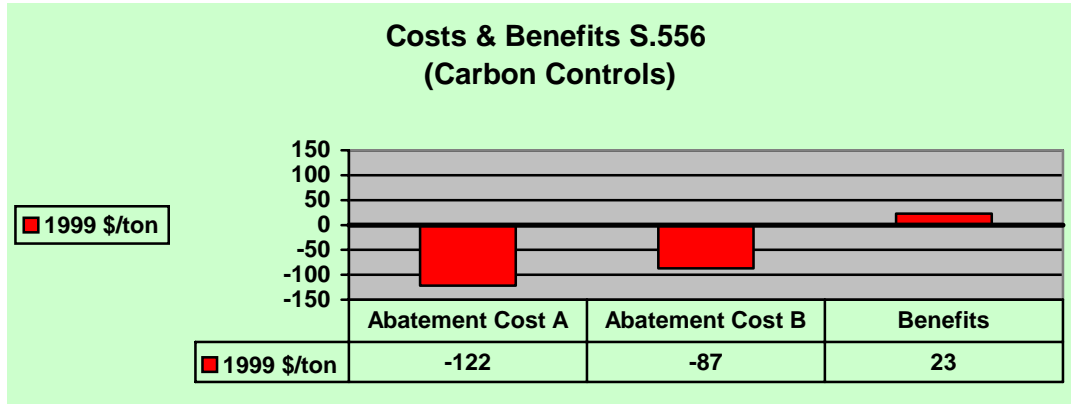
Perhaps the best metric for determining whether S. 556's carbon provisions are properly characterized as "expensive" is to compare their costs with the benefits that they offer. Unfortunately estimating the marginal benefits of carbon abatement is an exercise subject to even more uncertainty than is estimating the marginal costs. After a survey one recent study concluded: "A wide range of estimates appears in the literature, from negative values to values well over \$100 per ton ... of C."¹⁷

Of course, with such an enormous range of uncertainty about the benefits, society is most unlikely to be willing to pay very high costs. Assume for sake of illustration that the Nordhaus and Boyer estimate of the marginal benefits of carbon emission reductions is approximately accurate. If so, in the year 2020, the value to society of reducing a ton of carbon emissions would be \$17.79 in (1999 dollars).¹⁸ There are ancillary benefits to carbon emission reduction because such reductions also typically lead to the reduction of other types of pollution. One recent study estimated that these ancillary benefits (in the electric power sector) were roughly 30 percent of the value of the marginal abatement cost of carbon.¹⁹

Adjusting the Nordhaus and Boyer marginal benefit estimate to reflect ancillary benefits would yield a value of \$23.13 in 1999 dollars. ***Thus, society could be paying \$87 per ton, \$122 per ton, or even more in order to achieve benefits that may well be no more than \$23 per ton.*** Thus, the deviation between marginal costs of abatement and marginal benefits of abatement, numbers that should ideally be *equal*, would in this example be greater with S. 556 than it would be with no carbon emission controls whatever. Theoretically enactment of the legislation in this form would actually make society even worse off than it currently is with the complete failure to adjust prices to reflect the future costs of global climate change.

Figure 2 illustrates the comparison. Abatement cost estimate "A" is based on the EIA analysis. And cost estimate "B" reduces that estimate by 29 percent to crudely approximate what the mean result of the EMF models might be if applied to S. 556. (Estimate B is cited not because it is preferable to the EIA estimate but merely in hopes of keeping a larger point from becoming lost in a somewhat myopic controversy over the validity of a single model.) The benefits estimate is the marginal benefit of abatement estimated by Nordhaus and Boyer.

Figure 2



In terms of politically realistic outcomes, S. 556 seems most unlikely to be enacted with an implicit marginal cost of carbon abatement that exceeds the social optimum. But the legislation's proponents may wish to consider that just the realistic *possibility* that benefits of abatement are only in the range of \$23 per ton, means that legislation implying costs that might be \$87 per ton, let alone \$122 per ton, has no realistic prospect of enactment.

COUNTER ARGUMENTS

CONTINUED BELIEF IN CHEAP ABATEMENT

Some, however, continue to demand steep reductions in U.S. greenhouse gas emissions. Usually the proponents of this viewpoint do not assert that abatement although expensive is worth the cost. Instead they continue to insist, despite modeling results to the contrary, that it is actually inexpensive.

On the one hand one is reminded of part of the Cooper quotation from the Preface of this paper: "Some risk averse parties will attempt to minimize the estimated costs of early action, or suggest that they can be borne by non-voters (e.g. corporations) in order to gain the support of voters less risk averse than themselves."

On the other hand the economic models showing that steep emission reductions will be expensive are inevitably imperfect and fallible. To be sure it seems significant that most of the models tell roughly (although it must be conceded only roughly) similar stories. Even so, it could be that most of the modelers are making the same or similar mistakes.

Clearly ascertaining the most likely state of reality on this question of abatement costs presents an intellectual problem. One possible way of resolving that problem would be to look more closely at the merits of the specific grounds on which the proponents of cheap abatement theories base their claims.

THE COUNTER CLAIMS

The grounds for these claims boil down to three basic contentions. These are:

1. Government mandated emission reductions always cost less than indicated by *ex ante* estimates. At least one study comparing *ex ante* and *ex post* cost studies seem to suggest that a bias might exist.
2. Because American consumer preferences are allegedly irrationally wasteful of energy, according to a theory sometime called the energy paradox, consumers could actually be made economically better off by government regulations that compelled them to reduce their energy consumption.
3. A few technology-oriented studies appear to contradict the mainstream conclusion that carbon emission controls will be expensive.

The next three sections of the analysis will address each of these arguments in turn.

IS ABATEMENT ALWAYS CHEAPER THAN EXPECTED?

COMPARING EX ANTE AND EX POST COST STUDIES

Actual studies of *ex ante* and *ex post* studies of regulatory costs produce a mixed and somewhat confusing picture. The results of one such study seem at first to confirm that exaggeration of costs does take place, or at least this study found that cost over estimates were more frequent than underestimates.²⁰

A closer look, however, revealed a more complex pattern. For example, the comparison found *no* systematic cost overstatement in the analyses of per unit costs done by the United States Environmental Protection Agency or by OSHA. In effect these agencies did tend to overestimate total costs but they also overestimated the total quantities of pollution abated or injuries avoided. As a result, the, costs per unit controlled were not systematically biased either up or down.²¹

Many of the assertions of systematic cost overestimation are not based on this careful analysis of numerous cases. Instead they depend on a single “well known,” or at least much cited example, Title IV of the Clean Air Act Amendments, the Acid Rain Program.

TITLE IV: THE HISTORICAL RECORD

The arguments about Title IV start from an undisputed kernel of truth. The Title IV program has worked exceptionally well, in part because it relied on market mechanisms rather than command-and-control regulations. Indeed, Title IV has much to recommend it as a model for a policy to reduce carbon emissions. Nonetheless problems arise when proponents of large carbon emission reductions assert that the experience of Title IV “proves” that the application of UNFCCC or Kyoto Protocol level emission reductions would be low cost.

The acid rain program did produce more pollution abatement sooner than the law required. But, generally, companies over-complied in phase one in order to have available the emission allowances that they will need to under-comply in Phase II. So, the 40 percent over-compliance just cited is a temporary phenomenon, not a permanent feature of the program’s performance.²²

Moreover, it is untrue that the actual costs of emission controls are only a tenth of projected costs. In fact, they are within the range of *ex ante* predictions of total abatement costs of the program. The *ex ante* average cost projections were in the range of \$150 to \$300 dollars per ton; actual costs, as measured in the late 1990s, were between \$187 and \$210 per ton.²³ Although actual costs were in the lower range of the earlier estimates, the program had also benefited from the

happy chance that railroad deregulation and mergers had drastically lowered the transportation costs of low sulfur western coal. These cost decreases accelerated the market penetration of this coal and offering a lower cost alternative approach to sulfur emissions reductions that had not been fully accounted for in the cost projections predating the 1990 enactment of Title IV.²⁴

The widespread confusion about the degree to which actual costs have undershot predictions is mostly caused by failure to distinguish between emission allowance prices and abatement costs. Although abatement costs are within the predicted range, allowance prices are well below predicted levels. Allowance prices do reflect what polluters are willing, under current circumstances, to pay to eliminate an additional ton of pollution. Today's expectations and conditions differ radically from those of the past; so current allowance prices tell nothing about what has been spent in the past to abate pollution.²⁵

DOES THE TITLE IV RECORD SAY THAT CARBON ABATEMENT WILL BE CHEAP?

The experience of Title IV says virtually nothing about the costs of carbon abatement. Title IV does suggest that an efficiently structured cap and trade system is likely to be less costly than an old fashioned inefficient command and control regulatory system like that of most of the rest of the Clean Air Act Amendments. But the past costs of controlling sulfur emissions to some particular level are simply irrelevant to the question of how expensive it will prove to be to control a completely different emission, carbon, where the technological options and costs are entirely different.

The success of Title IV depended on the emergence into the market of inexpensive western coal, and a long secular decline in natural gas prices. These developments were certainly fortunate ones. Reasons for expecting comparable good fortune in the case of carbon are not immediately evident. If natural gas prices resume their secular decline carbon emission controls would, *ceteris parabus* become cheaper to achieve, although carbon emission controls will drive up natural gas prices. And future declines in the delivered price of coal would merely increase the marginal cost of carbon emission abatement. It is a *nonsequitur* to claim that carbon abatement will be cheap because Title IV was.

TITLE IV AND THE LESSON OF MODERATE TARGETS

Title IV may, nonetheless, carry important lessons for the construction of a carbon emission reduction regime. It is just that those lessons push in the opposite direction than the extreme conclusion some advocates would like to reach. One of the real lessons of Title IV was that the flexibility of the program worked so effectively to reduce costs in part because the standards were moderate:

The SO₂ cap was set at a level that left a wide range of options for many individual sources, and more importantly, for all affected sources in the aggregate. An approximate 50% overall emissions reduction was required in a situation where there was a technologically proven option that could achieve reductions of 95%. Combined with that was the presence of a wide continuum of lower percentage reductions possible via fuels with many different sulfur content levels. Thus, there was room for applying the best available control measures on only a small fraction of the regulated units, where they would be truly cost-effective and, more generally, for meaningful competition among a diverse set of options. A more stringent cap would have reduced this flexibility, and price competition among suppliers of control options. For example, the ability to take advantage of cheaper low-sulfur coal from the West would have been greatly

diminished if aggregate required SO₂ reductions had been substantially greater than 50%.²⁶

TITLE IV AND INDUCED INNOVATION

Proponents of pushing for extreme emission reduction targets cite as their rationale the desire to use “tough” standards to force technological progress. And they cite Title IV as an example of how well this approach can work. But is the example apt?

According to the above analysis, the success of the Title IV program is **not** primarily the result of policy induced technological innovation. In expanding on this point, Anne Smith has noted that the main reason that flue gas desulfurization became cheaper was because the flexibility of trading allowed companies to dispense with expensive back-up units, should the primary flue gas desulfurization unit fail. This effect was not obviously a matter of better technology. Dr. Smith relates that she has been told that this option — which was created solely by the relative moderation of the targets embodied in Title IV — knocked about 30% off the price of a command-and-control version of FGD - and of course, the costs from a history of command-and-control FGD installations were used to estimate the costs of meeting SO₂ caps.²⁷

Had the success of Title IV been dependent on induced innovation, given the lag times inherent in developing and applying new technologies, the pattern of emission reductions would more likely have been lagged. Instead, the pattern was one of such rapid emission reductions that Phase I significantly overshot its legally mandated abatement targets. This pattern is more consistent with the above quoted hypothesis that moderation and flexibility were the keys to success than it seems to be with the claim that policy induced technological innovation played a key role. Hence the success of Title IV cannot validly be used to support the claim that induced technological innovation is likely to radically reduce the costs of carbon emission controls.

From this analysis, one could draw the overriding implication for carbon emission control that, far from proving that legislation should set aggressive targets, the success of Title IV depended crucially on setting legislative goals that were well within the envelope set by existing technology.

DO CONSUMERS AND PRODUCERS SYSTEMATICALLY UNDERVALUE ENERGY SAVINGS?

The second contention of cheap abatement is somewhat more complicated to resolve than is their assertions about Title IV. To proponents of the energy paradox theory the average consumer and producer are behaving foolishly. For the energy paradox theory to be true, (and important) the average consumer must be systematically over discounting (undervaluing) future energy savings.

THE THEORY OF SIMPLE HEURISTICS AS AN ALTERNATIVE TO THE “ENERGY PARADOX”

Perhaps part of the apparent plausibility of the energy paradox theory derives from its implied rejection of the fiction of the perfectly informed and computationally omnipotent consumer. There exist, however, alternative theories of economic psychology more plausible than either the construct of the ideal consumer of some economic theory or the systematically myopic and profligate consumer of the energy paradox theory.

One such model is outlined in Gerd Gigerenzer's and Reinhard Selten's book, *Bounded Rationality: The Adaptive Toolbox*. Following this model consumers in general make good decisions. These decisions approximate, albeit imperfectly those that would be made had the consumers employed far greater information and computational resources. Consumers achieve these results by using various "fast and frugal" decision strategies, which have been shown to broadly mimic the results of more formal economic analysis with much less investment of intellectual time and effort.)²⁸

This theory is broadly consistent with the summary delivered by one team of economists. Having surveyed the economic literature on this controversy, they concluded, "there are good reasons to doubt the existence of a vast pool of cheap energy reducing opportunities that offer a 'free lunch' in reducing GHGs [Green House Gases]."²⁹ The next four sub-sections describe why this conclusion seems correct.

ENGINEERING STUDIES MAY EXAGGERATE ENERGY SAVINGS

Engineering studies assume laboratory conditions and often exaggerate the actual energy savings that various technologies yield. For example, a study by Metcalf and Hassett using the Department of Energy's Residential Energy Conservation Survey concluded that although the data could not conclusively rule out all possibility of the existence of the energy paradox "...the distribution of returns in our sample suggest that for the bulk of investors, the realized return is far below that required for the existence of the energy paradox."³⁰ Studies by Seebold and Fox, of San Diego Gas and Electric Company's audit program "found that on average total returns came in somewhat below those predicted by engineering studies. A similar finding is reported in Hirst (1986) who finds that actual savings from retrofit programs fall short of savings predicted by energy auditors by 22 to 53%."³¹

Moreover Metcalf and Hassett found still other evidence that consumers treated energy costs in an economically rational manner. If consumers made rational trade-offs between energy conservation investments and energy costs, households with older and less well-insulated houses should invest more in insulation than those with newer houses. So should households with higher total energy bills. Both these patterns were clearly evident in the data.³²

ENGINEERING STUDIES MAY UNDERSTATE COSTS OF ADOPTING NEW TECHNOLOGIES

The IPCC cited this concern as a major reason that economists were so frequently skeptical of claims that new technologies could produce emission reductions at little or no costs.³³ The transaction cost of adopting new technology is often neglected or understated. Put in the simplest terms, people and businesses have to learn how to buy and manage new technologies.

In a hypothetical ideal world in which economic actors are omniscient, these costs are assumed away. In the real world, the costs are real. People use fast and frugal heuristics, as described above, to make reasonable trade-offs between the costs of acquiring knowledge and using it against its benefits. But the costs of acquiring knowledge and processing it are real. And these costs may constitute an important and economically rational reason for moving slowly to adopt new energy saving technologies.³⁴

Also, engineering studies may miss other relatively "hidden costs" of technological innovation, such as those associated with installation, maintenance, and personnel training.³⁵ Most economic actors have learned to expect new technologies to be afflicted with varying degrees of reliability and maintenance cost problems. And the promise of new technologies sometimes conceals unpleasant service quality surprises. Thus, a degree of consumer wariness is rational.

ENGINEERING STUDIES MAY IGNORE DIFFERENCES AMONG CONSUMERS

Another source of exaggeration in engineering estimates of potential energy savings is that these analyses often assume a homogeneous consumer population. In the real world, however, the preferences of consumers are diverse. Hence, the “average” consumer may operate an air conditioner or auto enough during a year to justify paying a higher initial price to achieve higher operating efficiencies. It does not follow that *all* consumers would rationally make the same choice:

...[I]t may not make sense for someone who will only rarely use an air conditioner to spend significantly more purchasing an energy efficient model — they simply may not have adequate opportunity to recoup their investment through energy savings. Analysis based on single estimates . . . — unless they are very conservative — will inevitably lead to an “optimal” level of energy efficiency that is too high for some portion of purchasers.³⁶

The concern is that engineering studies leap from the assumption that the average consumer in a heterogeneous population might benefit from owning a more energy efficient appliance to concluding that *all* consumers in that population would benefit. But consumers with below average use rates may be acting perfectly rationally in purchasing and retaining lower price but less energy efficient appliances, cars, or houses. Studies that ignore the different circumstances among consumers will inevitably find “irrational” consumer behavior where none exists. And they will predict that energy efficiency standards that compel consumers to buy higher priced but more energy efficient appliances are providing unambiguous consumer benefits, when, in fact, at least some consumers are being economically harmed.

ENGINEERING STUDIES MAY IGNORE QUALITY CONSIDERATIONS

The IPCC notes that many economists believe that engineering studies often ignore the fact that consumers do not like certain features of the energy saving technologies.³⁷ For example, Professor Jacoby of MIT cites this problem when he observes that: “A classic example is the finding that a highly cost-effective energy-saving technology would be to cover the roofs of all U.S. residences with white paint. (National Academy of Sciences 1991) The analysis does not ask the question whether people want to do this, and how they might be encouraged to carry it out, or what they might pay to avoid it.”³⁸

In fact, it is quite likely that many households would insist on a payment far in excess of the cost of painting the roof to accept this “highly cost-effective” measure. And if these additional quite real social costs of having a white roof when the home owner preferred not to were included in the analysis, painting roofs white might not be cost effective at all. Similarly many people would insist on payments far in excess of the energy cost savings achieved by “efficient” light bulbs or energy-efficient replacements to their powerful and safe SUVs. The list goes on and on.

The prevalence of these real but hard-to-measure product quality differences suggests that studies purporting to show that consumers are not acting in their own interests should carry a very heavy burden of proof. And the burden of proof is compounded when the proposed remedy is an energy efficiency regulation the explicit purpose of which is to restrict the range of consumer choice. The Cooper’s observation seems especially apposite here: “Some parties will use legitimate concerns with the issue at hand, e.g. greenhouse warming, to encourage society as a whole to adopt a “lifestyle” more congenial to them.” To put the matter plainly, climate policy should not become a pretext for sumptuary laws.

ENGINEERING STUDIES MAY IGNORE REAL HURDLE RATES AND OPTION VALUES

Consumers have good reason for insisting that investments in energy efficiency surpass relatively high hurdle rates. Proponents of the theory of the energy paradox cite studies of consumer behavior purporting to show that consumers use very high “implicit discount rates” in comparing the often somewhat higher initial prices of energy efficient consumer durables with the future energy savings offered by these products. These studies are in general accurate.³⁹ In fact, it is well known that businesses routinely use “pay-back” rules implying hurdle rates on the order of 30% or more. The conclusion that consumers and businesses are therefore behaving economically irrationally is, however, not evident.

Most investments in energy efficiency are “irreversible”, *i.e.* once the insulation is installed or the more expensive fuel-efficient appliance is purchased, the investor is “locked in”. Moreover, in most cases potential investors have the option of postponing a decision to invest until a later time.

Irreversibility means that the investor, once the asset is acquired, cannot recoup his costs by tearing out the insulation, or heat pump and reselling it. And the ability to delay means that the potential investor may be better off waiting to see if the price of energy *or* the prices of fuel-efficient equipment fall next year. In the event of either of these contingencies, this year’s investment can easily become a money-losing proposition. In fact, energy prices have been quite volatile. Indeed, if there is a secular energy price trend, it is downward. And the energy efficiency levels of many consumer durables have been broadly advancing. By inference, it is quite possible that consumers are merely being economically rational to insist on relative fast payoffs in energy savings before incurring the costs.

Given irreversibility and the ability to delay, the investment decision is analogous to holding a financial call option. The potential investor has the right but not the obligation to buy. When an investor

...Makes an irreversible investment expenditure, it exercises or ‘kills’ its option to invest. It gives up the possibility of waiting for new information to arrive that might affect the desirability or timing of the investment. This lost option value is an opportunity cost that must be included as part of the cost of the investment. As a result the NPV rule “invest when the value of a unit of capital is at least as large as its purchase and installation cost” must be modified. The value of the unit must exceed the purchase and installation cost by an amount equal to the value of keeping the investment option alive.⁴⁰

The insight that the investment decision must take account of the value of the option that is “killed” by investment explains why so many observers of actual business practices find “hurdle rates that are typically three or four times the cost of capital.”⁴¹ Once it is recognized though, that hurdle rates several times the cost of capital can be entirely rational for investors a good deal of the “market failure” alleged to occur when investors apply high hurdle rates to the purchase of energy saving technologies is exposed as illusory.

ENGINEERING STUDIES MAY IGNORE “REBOUND EFFECTS”

When appliances automobiles, capital goods or other equipment or structures are made more energy efficient, there is a “rebound effect.” Higher energy efficiency reduces the operating costs of these goods. But as operating costs decline, there is likely to be an increase in use. Hence at least part of the energy savings projected to occur as a result of greater efficiency of the appliance, automobile, or whatever will be offset by the more extensive use occasioned by the lower operating cost.

CLEAN ENERGY FUTURES STUDY

CLEAN ENERGY FUTURES RESPONSE TO CRITICISM OF FIVE-LABS

Clean Energy Futures (CEF), was commissioned by DOE's Office of Energy Efficiency and Renewable Energy and prepared by a working group of DOE laboratories. CEF represents a follow-up to an earlier report, *Scenarios of U.S. Carbon Reductions*—that is, the so-called Five-lab study. The Five-labs study had been widely cited but also roundly criticized for methodological weaknesses.

CEF differs from the prior study by not only identifying *technologies* that could potentially reduce energy consumption and CO₂ emissions, but also examining the specific *policies and programs* that might encourage the adoption of these technologies. CEF is, in part, a response to the criticism that, to be useful for policymaking, it is insufficient to simply show that there are technologies on the shelf technically capable of achieving a certain goal. One must also demonstrate that there are feasible policies that are likely to lead to such technology adoption, with defensible links between the policy and the predicted energy savings, emission reductions, and abatement costs.

CEF examined both a “moderate” and an “advanced” scenario of policies and associated emission reductions. The more than 50 policies modeled in these scenarios included fiscal incentives, voluntary programs, efficiency standards, regulations, and increased research and development funding. The advanced scenario further extended the programs included in the moderate case, added new programs, and also included a CO₂ trading system that was assumed to impose a permit price of \$50 per metric ton of carbon, as well as a 7.5% renewable portfolio standard for electricity.

ANOMALOUS RESULTS

In aggregate, CEF asserted that the moderate scenario could reduce CO₂ emissions from “business-as-usual” levels by 5% by 2010, while the advanced scenario could bring emissions down by 18% by 2010. The overall annual cost of these programs was asserted to be of the same order of magnitude as the energy savings they delivered.⁴² In other words, CEF asserts that bringing emissions back to 9% above 1990 levels by 2010 could be a free lunch overall, and only about \$50 per ton for incremental reductions.

This finding is clearly at odds with other major studies of the costs of carbon mitigation. Take, for example, the results from the National Energy Modeling System (NEMS), which was developed by the independent Energy Information Administration (EIA) for the purpose of projecting energy trends that are widely used by government agencies, the private sector, and academia for planning and policy purposes. EIA has used NEMs on several occasions to estimate the costs of carbon mitigation. In their report *Impacts of the Kyoto Protocol on U.S. Energy Markets and Economic Activity* EIA found that the incremental costs of reducing domestic carbon emissions 18% below expected levels by 2010 is \$170 dollars per metric ton, and the total estimated cost is about \$39 billion annually or 0.4% of GDP — \$214 billion if one includes short run business cycle effects.⁴³ This is more than three times the cost estimated by CEF for incremental emission reduction — for the same reduction target.

What is especially surprising is that CEF actually used the NEMS modeling framework — although with many adjustments — as the integrating framework for their analysis. How is it possible, one might wonder, that two studies can start with the same model and end up in such different places? As is often true, “the devil is in the details” — and there are lots of them.⁴⁴

OVER-OPTIMISTIC ASSUMPTIONS ABOUT POLICY IMPLEMENTATION

To begin with, many of the more than 50 assumed CEF policies require legislative or regulatory actions that are unlikely to be implemented. The Bush Administration's generally reluctant stance on climate mitigation and the United States Senate's recent refusal to raise CAFE standards strongly suggest that skepticism on the political realism of the CEF policies is well grounded. Of course mere political impracticability does not in itself mean that the CEF policies might not be desirable. It does, however, raise a credibility problem for proposals to evaluate S.556 based on the assumption that the CEF policies will actually be implemented.

Some important specific policies assumed by CEF seem especially unlikely. For example CEF assumes national electricity industry restructuring and pay-at-the-pump motor vehicle insurance. Naturally, to the extent that some of the more than 50 policies in CEF are not enacted or are enacted at later dates than assumed in CEF, the positive effects of the CEF analysis would be reduced.

OVER-OPTIMISM ABOUT THE EFFICACY OF SOME POLICY INSTRUMENTS

Even if, however, the CEF policies were implemented, there is serious doubt about whether policies of the kind hypothesized by CEF would accomplish the predicted results. For example, as pointed out by the EIA,⁴⁵ the effects on technology cost and quality of research and development funding for new technologies are notoriously difficult to quantify. For example, some of the proposed R&D funding may achieve benefits only in a long time frame or may not achieve success at all, and predicting which developments will succeed is highly speculative.

Looking to the future, a specific link cannot be established between the particular levels of funding for R&D assumed in CEF, and the specific improvements in technology characteristics and availability assumed in CEF. Because this link between funding and technology development is tenuous at best, the suggested technology improvements are also questionable. Put differently, in several cases CEF presents little evidence distinguishing the R&D impacts they *did* assume from those that they *might have* assumed.

At a general level, future technology development cannot be known with certainty. Even the technology improvements assumed in the NEMS "business-as-usual" case, although likely, are uncertain.⁴⁶ The much more rapid technology development assumed in CEF is much more uncertain still implying a far higher risk that the predicted technology improvement will not, in fact, materialize or not materialize on time. Perhaps more importantly, the *simultaneous* success of the wide range of technology projects and programs assumed in CEF seems highly unlikely.

Another way of stating this is that CEF compares a "sunny day with policy" to a "rainy day without policy". As such, it is impossible to distinguish the costs and effects of specific policies as distinct from assumptions about the rate of technological advance. A different, but related problem is that the CEF study does not typically separate the costs and effects of individual policies, so it is nearly impossible to distinguish the relative merits of specific policies.

EIA's analysis of CEF also indicates that many of the assumed technology developments, particularly in the industrial sector, relied on voluntary and information programs whose impacts are difficult to quantify.⁴⁷ As with increased R&D funding, it is difficult to assess the future impacts of information programs, voluntary initiatives, and partnerships on technology adoption. And as a result, there is little evidence put forth by CEF that distinguishes the impacts they *did* assume for many of these programs from those that they *might have* assumed.

In addition, many of the gains, which are ascribed to the effect of voluntary programs, would probably have occurred even in the absence of those programs. These gains are typically captured in “business-as-usual” baseline emission forecasts. Including such gains in the impacts of proposed policies is therefore double-counting efficiency improvements.

In addition, CEF projects that voluntary programs, state market transformation programs, and regulations (such as a commercial transformer standard) will reduce the growth rates for miscellaneous electricity uses in both the residential and commercial sectors — a significant and growing source of demand. In the residential sector, miscellaneous electricity uses include small heating elements, motors, and electronic devices, while in the commercial sector it includes a multitude of devices such as transformers, automated teller machines, traffic lights, telecommunications equipment, and medical equipment. EIA found that these reductions in growth rates appear unrealistic because it is unlikely that the use of these categories of equipment will be greatly reduced.⁴⁸ Although there is some potential for efficiency improvements, EIA found it unlikely that efficiencies could improve enough to reach the consumption levels predicted in CEF.⁴⁹

OVER-OPTIMISM ABOUT THE COST OF ADOPTING NEW TECHNOLOGY

CEF is also subject to the criticism leveled earlier that engineering studies do not fully account for so-called “hidden costs.” The costs for higher-efficiency equipment included in CEF in fact come largely from underlying engineering cost studies conducted by the DOE laboratories for the “Five-labs study” and other analyses. As stated earlier, these cost estimates tend to focus on equipment purchase costs and tend to ignore costs and uncertainties associated with transitions to new technologies, such as installation, adjustment, maintenance, and personnel training costs. Anyone with a home or a car understands the rationale behind the old adage “If it ain’t broke, don’t fix it.” Changing even small aspects of large investments can easily open a “can of worms” producing much higher than anticipated costs. Even the best “bottom-up” technology model cannot hope to capture these types of costs.

A related issue is how CEF accounts for the “indirect costs” of policies, particularly the \$50 carbon fee. This includes the myriad of product, process, labor, and material substitutions and price effects that one would expect a sizeable carbon policy to have. One can get a sense of how well CEF accounts for these costs by looking at the CEF sensitivity case with *only* a \$50 carbon fee. Since — even in the eyes of the CEF authors — there are not any “energy-efficiency market failures” being corrected in this scenario, and since the CEF relied on NEMS for its basic architecture, the costs of this policy should be comparable to those from EIA for the same fee. They are not. The CEF estimates only a \$3 billion cost in 2010 for a \$50 carbon fee, which actually declines to a \$2 billion *net saving* in 2020.⁵⁰ This is in contrast with an estimate from EIA, using almost the exact same model, of about \$11 billion in 2010 for a similar carbon fee.

The EIA has also found that certain of CEF’s specific projected reductions in technology costs are unrealistic.⁵¹ For example, for some residential appliances the cost of the most efficient unit was reduced to the cost of the least efficient. EIA found it unlikely that either R&D or voluntary programs could reduce technology costs to that level. ***In effect, this is equivalent to assuming away the costs of carbon mitigation.*** Other technology assumptions also appeared unrealistic to EIA — for example, the assumption that generating plants using carbon sequestration would achieve the same combustion efficiency as those that do not.

OVER-OPTIMISM ABOUT CHANGES IN CONSUMER AND PRODUCER BEHAVIOR

The success of several CEF programs was based on assumed changes in behavior of consumers and firms that are not consistent with historic behavior patterns.⁵² Most importantly, in this respect, in the residential, commercial, and industrial sectors CEF dramatically reduced consumer and producer hurdle rates. These hurdle rates represent consumers' willingness to spend more up-front for energy-efficient equipment in return for lower future operating costs. Reducing the hurdle rates, therefore, implies greater effectiveness of energy-efficiency programs because more consumers are assumed to want to adopt energy-efficient products.

In practice, hurdle rates are often much higher than the direct cost of borrowing money, for reasons related to option values on irreversible investments and other factors.⁵³ Although these hurdle rate reductions in the CEF analysis were attributed to voluntary programs and other policies, EIA found them to be optimistic in their valuation of consumer desire for energy efficiency, resulting in hurdle rates of 15 percent, which are less than the interest rates charged by many credit cards and much lower than the 30% or higher hurdle rates commonly used by businesses.⁵⁴ Thus, CEF assumed behavior that is inconsistent with behavior that is actually observed.

The discussion of option values in the previous section of this paper suggests that the consumer behavior that the CEF is suggesting will change is at least in considerable measure economically rational. And there is also no clear scientific or analytical basis for the link between the magnitude of "hurdle rate reduction" and the type and magnitude of the policies assumed to be generating these gains. These assumed changes also influence the effectiveness of the \$50 carbon fee in the CEF advanced scenario, making each increment of fee increase much more effective in encouraging technology adoption and reducing energy demand.

OVER-OPTIMISTIC VALUATION OF ENERGY SAVINGS

Furthermore, the estimated savings to society from reduced energy consumption in CEF overstates the actual savings that would occur because CEF employs average energy prices rather than incremental cost savings to estimate resource savings. This overestimate will be especially serious for final consumption of electricity — where about one-third of the price is fixed transmission and delivery (T&D) costs — and natural gas, where about one-half of the delivered price represents T&D costs. This implies that the estimated savings would be overestimated by about one-third and one-half, respectively, just due to this one error.

Again, as with the misuse of the earlier five-labs study, the problem is not with the idea behind the Clean Energy Futures study, itself. It is perfectly valid to assess what might be accomplished through a vigorous set of energy-reducing policies. The difficulty is with an attempt to use entirely hypothetical technological scenarios as the basis for policy making. The result is policy "analysis" that is prefaced with an implicit "let's pretend".

CONCLUDING THOUGHTS

The high costs of climate change mitigation policies certainly do not imply that action is unnecessary. But high costs, especially when juxtaposed to the public's limited willingness to pay, do imply that the proponents of mitigation policies face a far greater need to craft only cost effective policy prescriptions than has been the case with previous environmental problems. How they respond will profoundly affect the prospects of avoiding harmful climate change.

Unfortunately, some advocates fear that admitting the high cost of carbon emission abatement might delay implementation of emission controls. This fear has so far beclouded discussion of the

abatement cost issue. But the evidence of the high cost of carbon abatement cannot *plausibly* be denied or refuted. And the costs of truly effective action are too big to be hidden by public policy slight-of-hand. In the event, therefore, acknowledging high abatement costs and forthrightly minimizing them is likely to be the best strategy for making progress.

Denying the reality of high costs, moreover, increases the risks that the political process will institute inefficient policy mechanisms. This risk is already evident in the many proposals to “solve” the climate problem with CAFE standards, energy efficiency standards, renewables portfolio standards, demand side management schemes, and an elaborate panoply of tax and direct subsidies for “approved” technologies. Long run, reliance on such inefficient policies would hobble the pursuit of the already fast receding goal of avoiding climate change. And in the short run, moving swiftly to implement policies that are doomed to long run failure is a dubious kind of progress.

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initiate some speculative R&D and conservation programs and impose a \$50 per ton carbon emissions tax. With these assumptions, the estimated cost of reducing an additional ton of carbon emissions fell from the base case estimate of \$138 per ton to \$86 per ton. Hence, the R&D and conservation produce an estimated cost reduction of about \$2 per ton. The remaining \$50 a ton of “cost reduction” results from the assumption that \$50 of the \$138 per ton tax that is already in place and should not, therefore, be ascribed to the proposed controls on power plants. See U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Atmospheric Programs, “Economic Analysis of a Multi-Emissions Strategy,” (Washington, DC: October 31, 2001), p.18

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