

CONGRESSIONAL TESTIMONY

May 16, 2007

The State of Climate Change in 2007

*Findings of the Fourth
Assessment Report by the
Intergovernmental Panel on
Climate Change, Working
Group Three: Mitigation
of Climate Change*

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Prepared for the U.S. House of
Representatives Committee on Science
and Technology

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Thank you, Mr. Chairman, for the opportunity to offer testimony before the committee on the Working Group III contribution to the IPCC Fourth Assessment Report: *Climate Change 2007: Mitigation of Climate Change*, on which I served as one of more than 100 lead authors. Over the past decade, I have had the privilege of working on energy and environment issues for organizations as diverse as the President’s Council of Economic Advisers and the National Commission on Energy Policy. Currently, I am a senior fellow at Resources for the Future (RFF), a 55-year-old research institution headquartered here in Washington, D.C., that specializes in energy, environmental, and natural resource issues. RFF is both independent and nonpartisan and shares the results of its economic and policy analyses with members of all parties, environmental and business advocates, academics, members of the press, and interested citizens. RFF neither lobbies nor takes positions on specific legislative or regulatory proposals, although individual researchers are encouraged to express their opinions, which may differ from those of other RFF scholars, officers, and directors. I emphasize that the views I present today are mine alone and do not necessarily reflect those of any group with which I am affiliated, including the IPCC.

On May 4, the IPCC released the Fourth Assessment Report (AR4) Working Group III Summary for Policymakers (SPM). While the underlying report contains literally hundreds of pages surveying estimates of mitigation costs over the past six years, three tables in the SPM summarize this information, reproduced below. Those tables are then further summarized in the text of bullet points #5 and #6:

- Both bottom-up and top-down studies indicate that there is substantial economic potential for the mitigation of global GHG emissions over the coming decades, that could offset the projected growth of global emissions or reduce emissions below current levels.
- In 2030 macro-economic costs for multi-gas mitigation, consistent with emissions trajectories towards stabilization between 445 and 710 ppm CO₂-eq, are estimated at between a 3% decrease of GDP and a small increase, compared to the baseline. However, regional costs may differ significantly from global averages.

It goes without saying that condensing information so dramatically can leave the end product open to misinterpretation. The further question of what a statement like “a 3% decrease of GDP” really means can create additional confusion. With that in mind, I would like to start by taking some time to interpret the three tables in the SPM. Then I would like to make three additional points that are not emphasized in the summary bullet points but are discussed elsewhere in the SPM and underlying chapters.

First, the range of estimates should not be interpreted as being a “likely” range—for the most part, it generally reflects a range of “best estimates” produced in the literature. Second, there are a couple of reasons why we might want to be cautious about the low end of the cost estimates. And third, all these estimates assume an efficient global climate policy; to the extent that actual policies deviate from this benchmark—which remains useful and quite standard—it is almost certain that costs will be higher.

I would like to conclude by making a few remarks about how we might use all of this information to think about our near-term policy choices in the United States.

What does the SPM say about costs?

There are a variety of ways to think about the cost of reducing greenhouse gas emissions. One is to think about how much we have to pay for each ton being reduced. Another is to think about the impact of making those payments on other things we care about—like our income, consumption, or well-being. Alternatively, we might ask about effects on employment or energy prices, or about the distribution of these various impacts on different regions, sectors, or demographic groups.

Most studies of mitigation costs focus on the first two measures—payment for tons reduced and the impact on income—and do so with relatively little disaggregation. For that reason, the IPCC similarly focuses on these two measures in the SPM and the underlying report.

Table SPM.1: Global economic mitigation potential in 2030 estimated from bottom-up studies.

Carbon price (US\$/tCO ₂ -eq)	Economic mitigation potential (GtCO ₂ -eq/yr)	Reduction relative to SRES A1 B (68 GtCO ₂ - eq/yr) %	Reduction relative to SRES B2 (49 GtCO ₂ - eq/yr) %
0	5-7	7-10	10-14
20	9-17	14-25	19-35
50	13-26	20-38	27-52
100	16-31	23-46	32-63

Table SPM.2: Global economic potential in 2030 estimated from top-down studies.

Carbon price (US\$/tCO ₂ -eq)	Economic potential (GtCO ₂ -eq/yr)	Reduction relative to SRES A1 B (68 GtCO ₂ eq/yr) %	Reduction relative to SRES B2 (49 GtCO ₂ eq/yr) %
20	9-18	13-27	18-37
50	14-23	21-34	29-47
100	17-26	25-38	35-53

Source: AR4, Working Group III, SPM

The two tables above, reproduced from the SPM, summarize and synthesize work completed over the last six years examining how much we would have to pay, per ton, for different volumes of reductions. The rows categorize opportunities based on maximum estimated cost. As we move down the table to higher maximum estimated costs, we see more opportunities, as they necessarily include preceding, cheaper opportunities. The columns then report the volume of reductions available at or below the per-ton cost indicated in each row, first in actual tons (column 2) and then in relation to two different

estimates of what emissions might otherwise be in 2030 (columns 3 and 4). All estimates reflect calculations for 2030.

Reading the bottom row of Table SPM 2, for example, we find that the literature published over the last six years indicates between 17 and 26 billion tons of carbon dioxide—or the carbon dioxide equivalent of other greenhouse gases—is available at or below \$100 per ton.

This kind of data—schedules of emissions reductions and price—are useful for several reasons. First, these prices on carbon dioxide can be converted relatively easily into prices on things like electricity and gasoline. One dollar per ton of carbon dioxide is roughly one penny per gallon of gasoline, one-tenth of a cent per kilowatt-hour for coal-fired electricity, and one-twentieth of a cent per kilowatt-hour for gas-fired electricity. Thus, \$20 per ton of carbon dioxide would be an increase of about 20 cents per gallon of gasoline, 2 cents per kilowatt-hour for coal-fired electricity, and 1 cent per kilowatt-hour for gas-fired electricity. Second, this data can be used to gauge how much harder it is to squeeze out more and more reductions. Note that going from \$20 to \$50—a 150 percent increase in price—brings out about 50 percent more reductions. Yet, doubling again to \$100 brings out only another 20 percent. Emissions reductions get harder the more you do. Finally, they can be used to make crude calculations of overall costs, calculations that later can be checked against estimates from more sophisticated models. The calculation is usually made as one-half the price times the volume of reductions, where the “one-half” accounts for the fact that these are maximum prices; many of the reductions would cost less. Applying that to the bottom row of Table SPM 2, for example, we could estimate the cost of 26 billion tons of reductions at $\frac{1}{2} \times \$100 / \text{ton} \times 26 \text{ billion tons} = \1.3 trillion .

While this simple approach is a good starting point for thinking about costs, one advantage of a top-down model is its ability to internally and consistently add up costs, to consider the interaction of mitigation policies with other fiscal policies, trade, and possible market failures, and to consider how costs are spread out over time. Top-down models can also model emissions pathways that stabilize greenhouse gas concentrations in the atmosphere. With that in mind, we turn to Table SPM 4.

Table SPM.4: Estimated global macro-economic costs in 2030¹⁶ for least-cost trajectories towards different long-term stabilization levels.^{17, 18}

Stabilization levels (ppm CO ₂ -eq)	Median GDP reduction ¹⁹ (%)	Range of GDP reduction ^{19, 20} (%)	Reduction of average annual GDP growth rates (percentage points) ^{19, 21}
590-710	0.2	-0.6 – 1.2	< 0.06
535-590	0.6	0.2 – 2.5	<0.1
445-535 ²²	Not available	< 3	< 0.12

Source: AR4, Working Group III, SPM

This table shows, along different rows, the estimated cost of stabilization at three different ranges of concentrations of carbon dioxide and other gases, expressed in carbon dioxide equivalent. These ranges are given in the first column. Costs in the second and third column are expressed as a share of global GDP, which is a measure of the income

flowing to the world's inhabitants in the form of wages, capital income, and the sale of natural resources. That is, it is the fraction of income that is no longer available for consumption or investment by individuals, firms, or governments, because it is being used to reduce greenhouse gas emissions.

The fourth column indicates the corresponding effect on growth, a measure that I personally find confusing. Any effect on income, when viewed far enough into the future, or from far enough in the past, will be a small fraction of annual growth. To put this into perspective, a policy decision conducted in 1983 concerning a \$120 billion cost today—1 percent of U.S. GDP—could have been expressed as a 0.05 percent reduction in annual growth (much like the first row of Table SPM 4). Had we viewed the decision in 1960, however, the effect would be half, a 0.025 percent reduction in growth. Regardless, the cost is \$120 billion or 1 percent of GDP today, which is why I tend to focus on columns 2 and 3.

The range of estimated costs summarized in columns 2 and 3 is defined by the range of top-down modeling estimates published over the last six years, excluding the highest and lowest 10 percent of the estimates. In the case of the lowest range, 445–535 ppm carbon dioxide equivalent, there are too few studies to say anything more than that the estimated costs in all the available studies are below 3 percent of GDP.

What does “3 percent of GDP” mean?

Today, 3 percent of GDP in the United States would mean \$360 billion. (For the world, it would be about 5 times higher.) These costs are annual, so that would be \$360 billion per year. In terms of households, we could consider the effect on the median household—that is, the household for which half the population is wealthier and half the population is poorer. According to the Census Bureau, median income in 2005 was about \$46,000. Three percent would then mean a cost of about \$1,380, per year, for the median household. Of course, household income will be a lot higher in 2030, right? Yes and no. Mean household income has grown at almost 1.3 percent per year for the past 40 years. However, *median* household income has only grown at 0.7 percent. Projecting forward at the historic rate suggests median income would be about \$55,000 and 3 percent would amount to \$1,650.

More importantly, whether we believe \$1,650 is a lot or a little—or whether we believe a different number is a lot or a little—to a large extent hinges on what we think it is worth to mitigate the predicted effects of climate change and by how much. We return to this issue at the end of my testimony. First, we need to go back to the numbers and make a few important points.

The range of estimates does not have a likelihood or probability associated with it

A somewhat misleading feature of providing a range of estimates, as we see in Tables SPM 1, 2 and 4, is that it suggests the true outcome will likely fall in that range, and the question is simply where. This is particularly true in Table SPM 4, where the range is

explicitly referred to as representing a “10th and 90th percentile range of the analyzed data.” A probabilistic interpretation, however, is not right. The range of estimates, particularly in Tables SPM 2 and 4, reflects the range of best estimates provided by different experts in the literature. In some cases, the same model is included with different assumptions, but generally each estimate represents the researchers’ best attempt to estimate future emissions and mitigation costs. As such, there is relatively little effort to quantify uncertainty in the estimate.

As an analogy, suppose you asked a group of experts to estimate the number of “heads” in 100 coin flips. Most likely, they would all say 50, which is the most likely outcome, and the “range” of estimates would be exactly 50. However, it is a straightforward statistical exercise to show that there is a 1 in 4 chance that the number of heads will exceed 55 or be less than 45. And there is a 1 in 20 chance that it will be at least 60 or no more than 40. The range of expert estimates says little about the actual spread of outcomes. In other words, there is a difference between a range of best guesses and a range that represents some notion of likely outcomes. While there are well-established procedures for expert elicitation that generate ranges with probabilistic interpretations, those procedures have not been applied to this question of mitigation costs.

There are reasons to be cautious about the low end of the cost estimates

A question that might have arisen in the context of Tables SPM 1 and 2 is why two separate tables contain what is apparently the same information. Table SPM 1 makes use of a particular kind of study, referred to as “bottom up.” Researchers itemize different actions or technologies that could be applied to reduce emissions. They estimate the cost per ton of that action or technology, as well as the volume of reductions that could be reduced. Adding up the volume of reductions available at or below different price points yields these bottom-up estimates.

Table SPM 2 summarizes results from an entirely different kind of study, referred to as “top down.” In these studies, researchers have constructed complete, though necessarily approximate, models of the global economy that include emissions of greenhouse gases. These models are designed to replicate the (historically) observed responsiveness of consumers and businesses to changing prices—including energy and other activities causing greenhouse gas emissions. These models can be used to simulate what will happen if the price of greenhouse gases is increased and, in particular, how emissions of greenhouse gases will be reduced.

Both kinds of approaches have strengths and weaknesses. Bottom-up approaches can include a wider variety of specific technological options that are often too numerous and detailed to be incorporated in a top-down model. Top-down models, meanwhile, better represent historical patterns of behavior and responsiveness. They also enforce accounting consistency—all the flows of goods and services are tracked and supply must equal demand in every market. Bottom-up analyses are often tabulations of opportunities that run into difficulties when some opportunities, like energy efficiency, interact with others, like fuel switching, to create the risk of double counting. Bottom-up analyses are

also not forced to use the same baselines; indeed, the different sectoral analyses compiled in Table SPM 1 used different baselines, as detailed in the notes to Figure SPM 6.

But the most significant concern about bottom-up analyses, acknowledged in the definition of “economic potential” given in Box SPM 2, is that they assume the removal of barriers that often prevent or increase the costs of actions being represented. This is especially true for the “zero-cost” opportunities, often energy efficiency projects, highlighted in Table SPM 1. For example, it is often hard to capitalize energy efficiency investments in buildings, making such investments less profitable for investors who might sell the building. Similarly, increased fuel economy in automobiles may pay for itself—but those same technologies can often be used to increase power and size, keeping fuel economy unchanged. If consumers put a higher value on these other characteristics, the proper way to value the cost of higher fuel economy is not the actual cost of the technology, but the forgone value to consumers of not having these other characteristics. Regardless of what barrier is preventing a zero-cost option from being adopted, it is sensible to imagine that it will not be entirely costless to remove it. Similar concerns arise for the positive cost opportunities, where the presence of barriers similarly tends to raise costs above the bottom-up estimates. Whether this concern is an argument for supplemental policies to remove barriers, for higher cost estimates, or for both, is unclear. It is worth noting that Chapter 11 qualified the bottom-up estimates as having “medium agreement and medium evidence.”

Meanwhile, none of this is to say that *no* zero- or low-cost opportunities exist; rather, it leads me to put less confidence in the lower end of the bottom-up range of estimates. It also raises the question of exactly what kinds of policies are going to be required to remove barriers and to get at these opportunities. Market-based policies that put a price on carbon dioxide emissions are clearly not enough, as the zero-price opportunities reflect, suggesting the need for direct regulation or other interventions.

It should be noted that almost by construction, top-down models ignore the possibility of zero-cost mitigation opportunities—as reflected by the absence of a “\$0” line in the Table SPM 2. While viewed as a strength by economists like myself, those who have greater confidence in the zero-cost opportunities and the possibility of policies to achieve them, see this as a weakness.

Given these observations about differences between top-down and bottom-up models, it is remarkable that the range of estimates is quite similar across the estimates, as presented in Tables SPM 1 and 2. In the previous, Third Assessment Report (TAR), the top-down estimates tended to show higher costs and lower mitigation potential. Chapter 11 attributes this to two changes in top-down models since the TAR: inclusion of other greenhouse gases and endogenous technological change, both of which would be expected to lower costs. Let’s look briefly at how AR4 top-down estimates compare to the TAR.

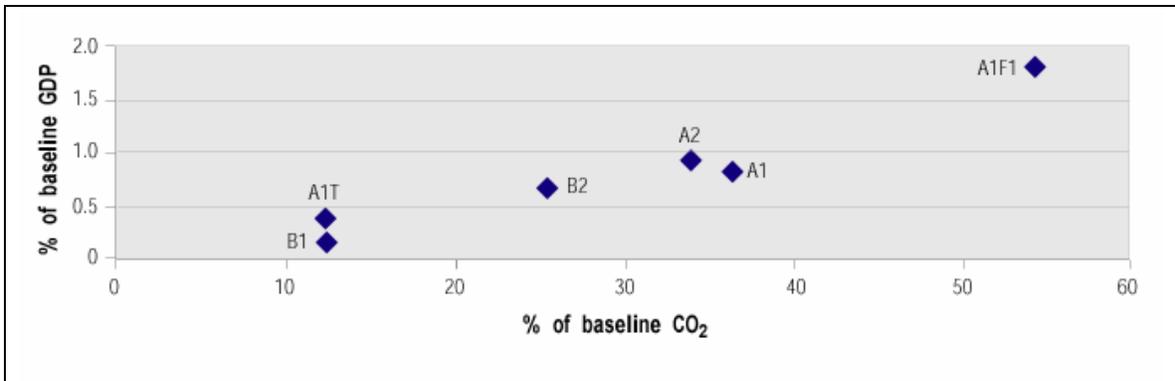


Figure 8.19: Average GDP and CO₂ reductions in 550 ppmv stabilization scenarios; year 2050 (labels identify different scenario groups).

Source: TAR, Working Group III, Chapter 8

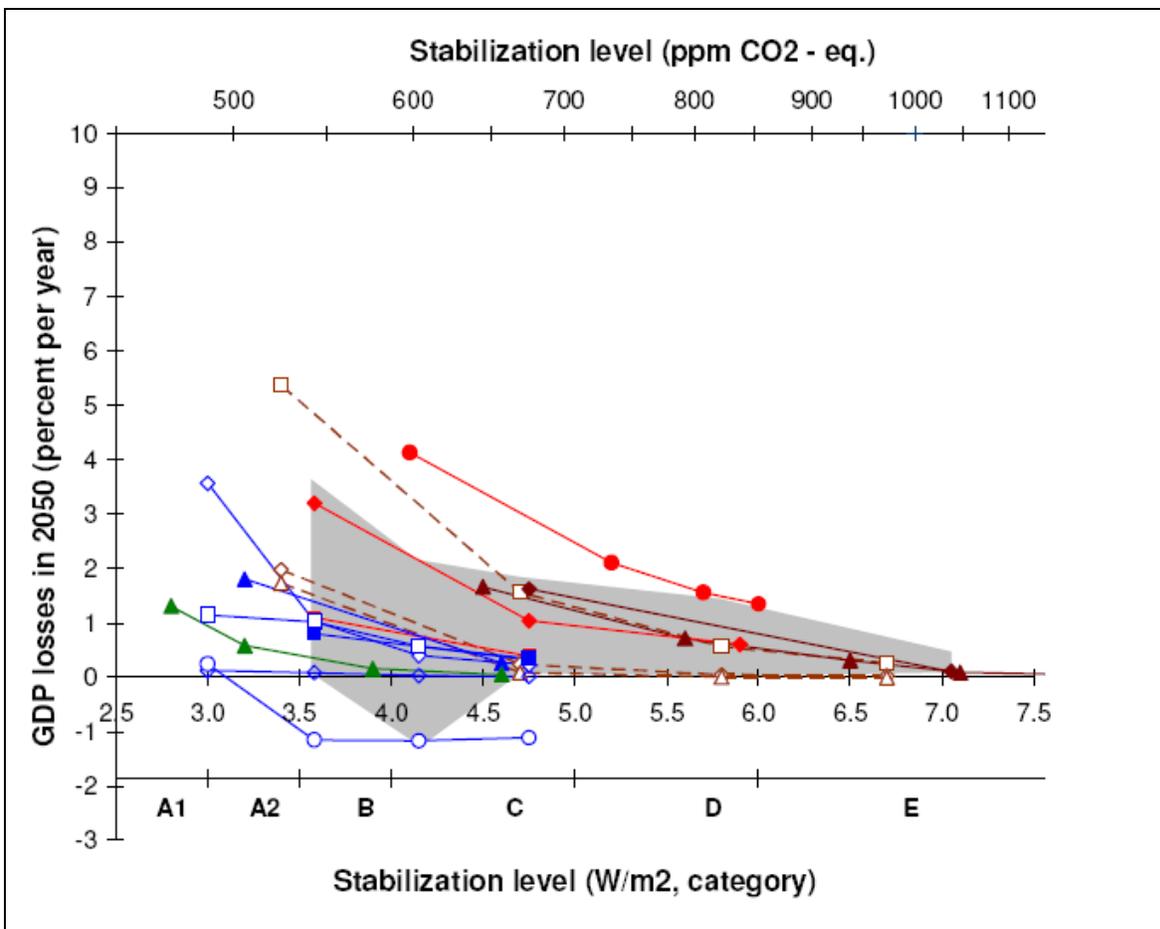


Figure 3.25(a), 2050: Relationship between the cost of mitigation and long-term stabilization targets (radiative forcing compared to pre-industrialization level, W/m² and CO₂-eq concentration).

Note: Individual lines show selected studies; grey shaded region represents the 80th percentile of scenarios.

Source: AR4, Working Group III, Chapter 3

Compared to the TAR, the new AR4 presents a range of estimates with a similar upper bound, but with a new lower bound including possible economic gains

Only two pages (section 8.4.3) in the TAR focus on the cost of stabilization comparable to the new AR4 review. Figure 8.19, reproduced from that section above, shows an average of results from six models for stabilization at 550 ppm carbon dioxide (that is, excluding other gases) and using different baselines. The figure provides a snapshot of reductions and costs in 2050. The horizontal axis indicates the different volume of reductions required to meet the 550 concentration target, based on the different baseline emissions scenarios. The vertical axis shows costs as a percent of global GDP. The figure suggests costs of between one-tenth of 1 percent and almost 2 percent of global GDP, depending on the baseline.

For comparison, we can examine Figure 3.25(a) in the Fourth Assessment Report. Unlike the TAR, this figure shows some models independently while the full range of results, excluding the top and bottom 10 percent, is shaded grey. Here, there is no attempt to draw out the effect of different baseline emissions assumptions, as in the previous figure; instead we see the GDP effects along the vertical axis for different levels of eventual stabilization along the horizontal axis. For comparison with the TAR review, we focus on the “category C” levels, or about 650 carbon dioxide equivalent (i.e., including the other gases that were excluded in the TAR). What we see is that the upper end of the range is still around 2 percent, but now the lower end includes a *net gain* of 1 percent.

What explains this difference? As noted previously, two reasons are given in the text. One is that the new scenarios include studies with multiple greenhouse gases, which generally lowers costs because they offer cheaper mitigation opportunities in percentage terms. While true, it does not explain negative costs—in top-down models, as also noted earlier, negative cost options typically do not exist, even for other greenhouse gases. Instead, negative costs can arise in models where technological change is endogenous, a point we now examine in more detail.

Assumptions about technological change can lower costs and even make them negative—but we should be cautious

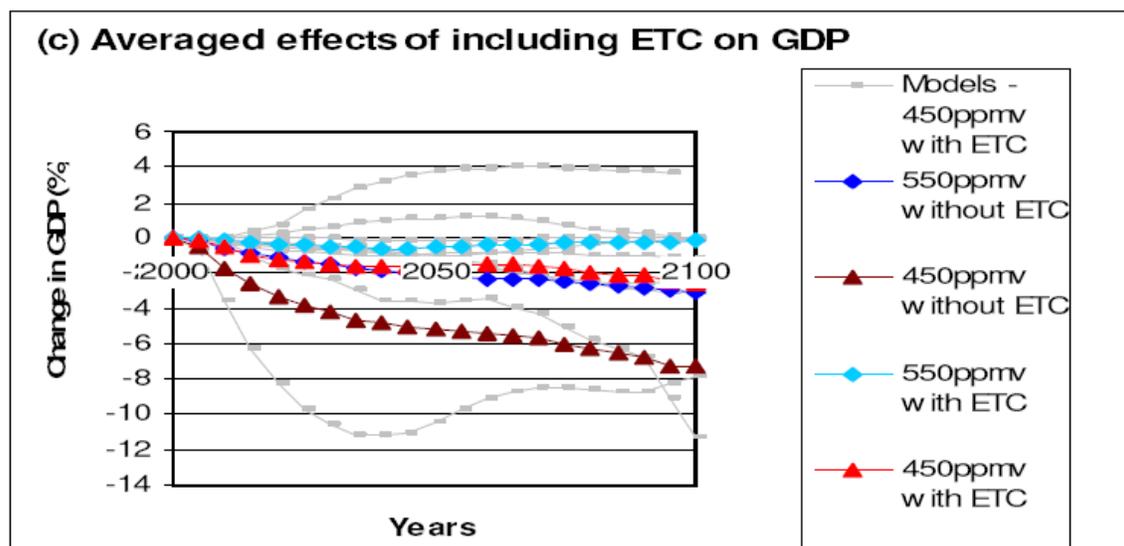
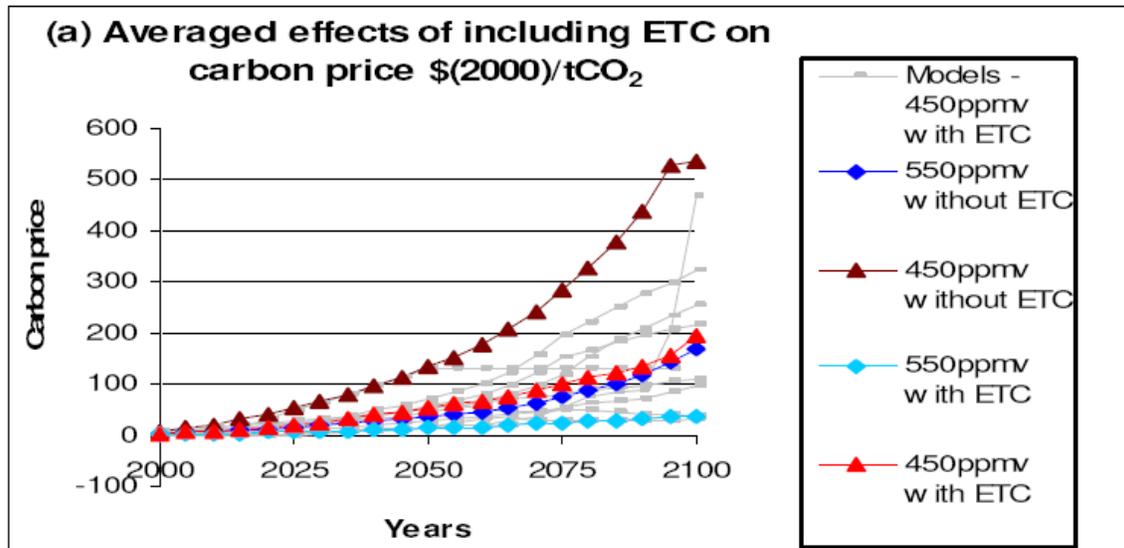
Assumptions about technology have always been viewed as critical to the estimate of mitigation costs—this was a key observation in the TAR. A new development since the TAR is use of endogenous technological change (ETC) in some models. What is endogenous technological change? Most models used to estimate the cost of mitigation take the process of technological change as given; that is, the availability of new technologies at particular times and at particular costs is one of the assumptions that researchers plug into their model. An alternative is to have the model figure out when these technologies become available and at what cost, typically in response to spending on research and increased demand. At first blush, this makes all the sense in the world: of course, technologies and costs should be responsive to policies and behavior. The problem, of course, lies in the details.

More specifically, the problem is that there is relatively little empirical evidence about how technological change will respond to increased spending or increased demand for emissions reductions. On the one hand, there is evidence in the literature on spillover effects that increased spending on emissions-reducing research will yield net economic gains because the return to research spending is extremely high. On the other hand, there is evidence in the literature on crowding out effects that increased spending emissions-reducing research will come at the expense of other high-return research, such as health care. How these two competing effects play out determines the extent to which ETC reduces costs or even produces negative costs.

In yet another modeling arena, we often see the costs of various technologies decline almost naturally with increased use and production—for example, the spectacular decline in the cost of computing power over the past three decades. It is easy to imagine implying such a relation to the costs of new emission-reducing technologies as experience accumulates. Yet, it is hard to isolate what causes that decline – namely production and use alone, or possibly unmeasured and coincident spending on research – and to know whether similar declines will occur for other technologies.

Despite these unresolved empirical questions, researchers have produced a large volume of work over the past six years in which they have experimented with making the availability and cost of new, emissions-reducing technologies responsive to additional research and demand. The two figures below, taken from Figure 11.9 in the underlying Working Group III report, summarize a major synthesis study looking at the consequences of this “endogenizing” of technological change—that is, making it responsive to additional research and demand. These figures summarize a collection of results from different models, with the dark colored lines showing averages across different for each of four scenarios and the light grey lines showing the spread across different models for one scenario. The first figure, Figure 11.9(a) shows carbon prices, analogous to those reported in Tables SPM 1 and 2, associated with two different levels of stabilization, 550 and 450 ppm carbon dioxide, both with and without endogenous technological change. The second, Figure 11.9(c) shows the effect on global GDP, similar to Table SPM 4.

The figures are complex, but highlight two important points. The first is seen by comparing the brown triangles (“450 ppmv without ETC”) to the red triangles (“450 ppmv with ETC”). The “with” and “without” ETC refers to whether technology is allowed to adjust in response to a constraint on carbon dioxide emissions. The obvious point is that it makes a huge difference, more than halving the costs in 2030, whether viewed as the price of carbon dioxide or the loss of GDP. The second point is that there are widely divergent results across models—the light grey lines show the individual model results for the “450 ppmv with ETC” case. Some models show gains, other show losses; even excluding the extremes, the range is from a 1 percent gain in GDP to a 3 percent loss in 2030.



Source: AR4, Working Group III, Chapter 11

My view is that while the estimates holding technology availability and cost fixed are clearly wrong, we do not have a sufficient understanding of the empirical relationship between research spending, demand for emissions-reducing technology, and eventual decreases in technology cost to give equal weight to the cost estimates produced by models where technology is endogenous. Both the significantly different estimates across models and the large effect on the central values of switching endogenous technological change on and off make this a very important point. It is precisely these models with endogenous technological change that drive the lower end of the range of estimates in Tables SPM 2 and 4. Therefore, I tend to be cautious about the plausibility of these lower-end estimates, especially so for the estimates suggesting negative costs in Table SPM 4.

The assumption of global least-cost strategies means costs are likely to be higher

My last point about the SPM cost estimates, highlighted in Box SPM 3, is that the estimates in these tables generally assume a global, least-cost strategy. That means all nations are engaged in market-based policies that put a single price on emissions reductions in all sectors throughout the world. Deviation from that—for example, the lack of participation (or least cost participation) of key developing countries or use of less efficient sectoral policies—will raise costs, according to some estimates, by a factor of two or more.

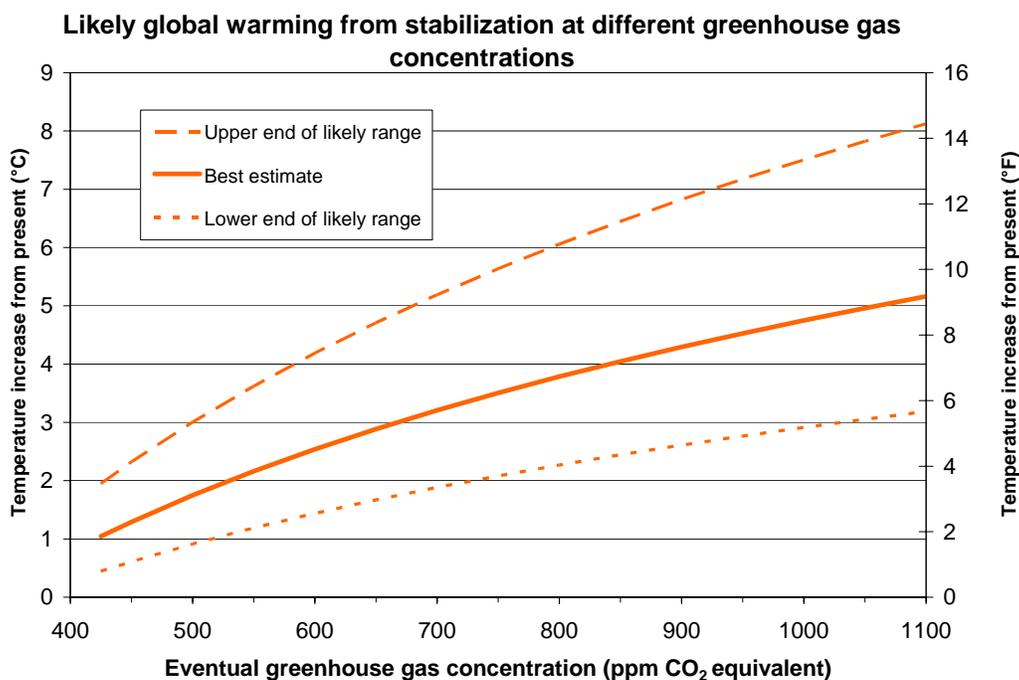
None of this means “do nothing;” it simply means we need a thoughtful consideration of costs and benefits

In summary, Table SPM 4 provides perhaps the simplest relationship between various long-term environmental goals and the economic impact, in terms of forgone income, estimated to result in 2030. According to that table, stabilization in the 650 ppmv carbon dioxide equivalent range will cost between -0.6 and 1.2 percent of global income, in the range of 550 ppmv between 0.2 and 2.5 percent, and in the range of 450 ppmv less than 3 percent. Alternatively, we could use Tables SPM 1 and 2 to assess the mitigation possibilities at different carbon dioxide prices. My three observations on these results are that (1) given my indicated concerns about the low-end estimates in the SPM, my own view about mitigation costs lies at the middle to higher end of the estimated ranges, (2) our uncertainty about costs is not represented by the given range, which is a collection of best estimates, and (3) actual policy implementations are likely to be more expensive than the indicated range because the global, least-cost benchmark is at best an ideal.

Given my view of these cost estimates—that our best guess is somewhere from a few tenths of a percent of GDP up to 3 percent, depending on the stabilization target—how do we choose a course of action, especially in the near term? Here I would offer five possible suggestions.

First, consider what these concentration targets will do to the environment. A colleague of mine, Richard Newell, put together the figure below relating concentration targets to the likelihood of different changes in temperature. Across the horizontal axis are various concentration goals; the vertical axis shows the range of likely temperature increases. Combined with the Figure SPM 1 from Working Group II, reproduced at the end of this document that shows the impacts associated with different levels of warming, we could make decisions about how much we are willing to pay, in terms reduced GDP based on Table SPM 4, to reduce the risk of various outcomes.

Second, consider what cost-benefit analysis suggests. Recent work by William Nordhaus has suggested that near-term benefits of reducing carbon dioxide emissions are about \$7 per ton of carbon dioxide. These estimates are very sensitive to assumptions about future interest rates and/or how to value consequences over long periods of time. My own work with colleague Richard Newell on uncertainty and discounting suggests roughly doubling his estimates to about \$15 per ton of carbon dioxide.



Note: "Likely" is defined as greater than a 66% probability of occurrence. Source: IPCC Fourth Assessment Report.

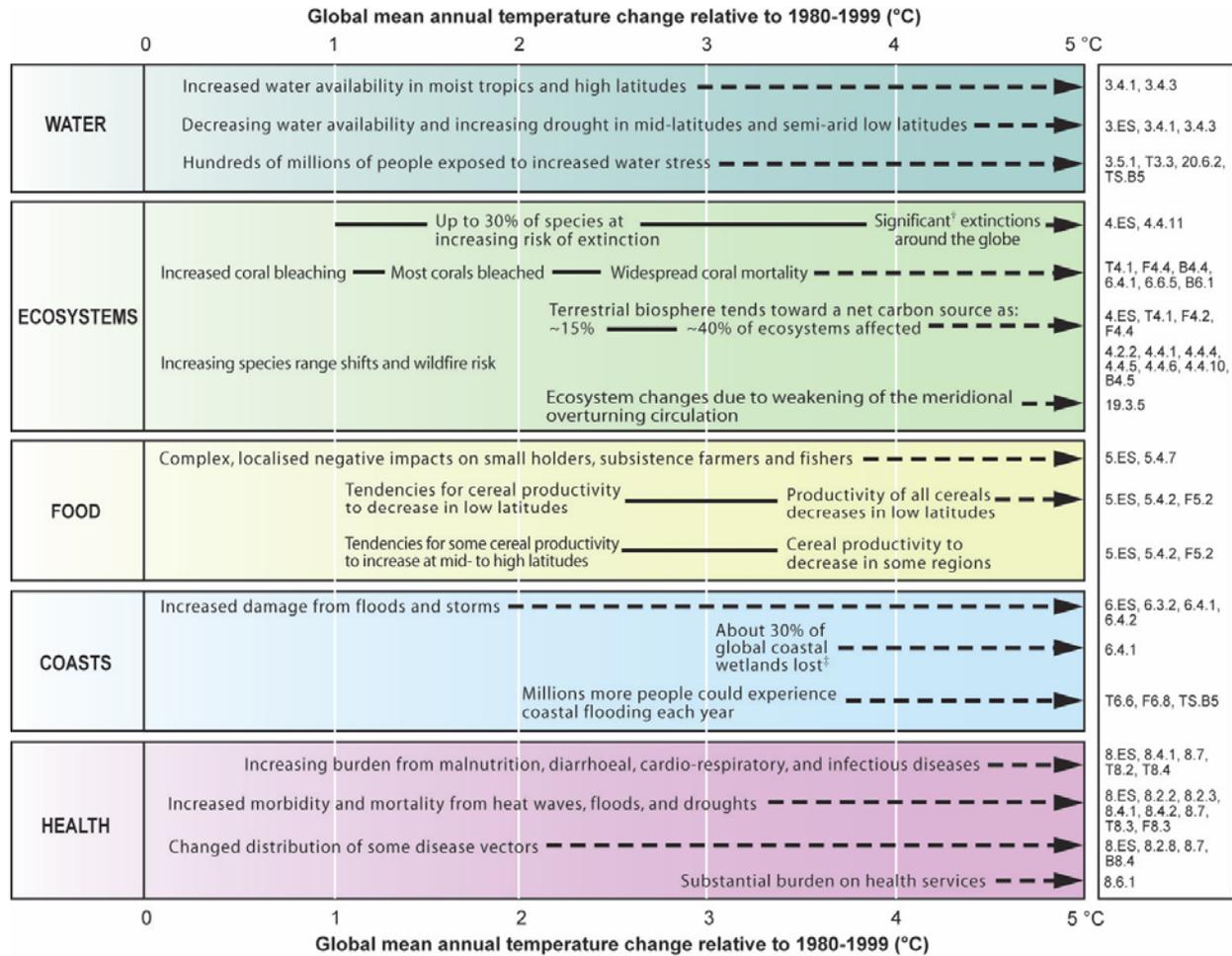
Source: *U.S. Climate Mitigation in the Context of Global Stabilization, RFF Backgrounder*

Third, consider practical near-term constraints. Earlier, I mentioned the effect of carbon dioxide prices on gasoline and electricity prices. One limit to efficient market-based approaches that put a price on carbon dioxide is consumers' willingness to pay higher energy costs. If \$15 per ton of carbon dioxide implies 15 cents per gallon and something slightly less than 1 cent per kilowatt-hour, that is useful information for calibrating a domestic policy. Another useful benchmark is the effect on coal use. For a variety of reasons—energy security, regional economic interests, pressure on natural gas prices—the effect on coal use is a useful metric. According to the Energy Information Administration, a price of \$15 per ton of carbon dioxide in 2020 implies relatively constant coal use compared to current levels.

Fourth, look at what other countries are doing. The price in the EU Emissions Trading Scheme, the only significant carbon dioxide emissions trading program in the world, has fluctuated between \$12 and \$35 per ton and is currently around \$25. These prices give some estimate of what is possible without appreciable dislocation.

Finally, recognize that the most significant lesson in this exercise is the role of technology and technological change. Addressing climate change is not just about picking an emissions target or a price—unquestionably an important part. It is also about designing a suite of policies that support technology development and deployment over time.

I thank you again for the opportunity to appear before this committee, and I would be pleased to answer any questions.



¹ Significant is defined here as more than 40%.

² Based on average rate of sea level rise of 4.2 mm/year from 2000 to 2080.

Source: AR4, Working Group II, SPM