Climate Change for Policymakers and Business Leaders

Peter A. Darbee & Christopher B. Field

"I cannot stop my life the next 2 to 10 years to become an expert on the environment or sustainability....I can only use my experience and best judgment."

John Naisbitt, author of *Megatrends*

"Don't focus on probability. Focus on consequences."

Nassim Taleb, author of *The Black Swan*

Introduction

As we write, the decade just ended has gone down as the warmest on record. Almost daily we read of new scientific reports about melting glaciers, rising sea levels, loss of habitat, and other consequences of climate change. At the same time, we hear impassioned claims by critics who question the science and warn that proposed steps to curb climate change will cause economic catastrophe.

Americans can't help but ask if it makes sense for the United States to embrace a complex set of new environmental and energy policies based on what we know now about the risks of climate change and the costs and benefits of measures to address it.

Any number of articles, whitepapers, books, and documentaries already address this issue. But this document, co-authored by a scientist with many years of experience understanding these issues and a corporate CEO who grapples with these issues every day, is intended especially for business leaders, policymakers, and other busy professionals who seek a rigorous basis for understanding the central issues but lack the time to plow through long reports and technical papers.

More than providing an overview of these issues, this document aims to stake out a compelling, commonsense case for action by the United States to begin decreasing greenhouse gas emissions through smart policies and wise investments in clean-energy technologies and infrastructure.

This paper, the product of a partnership between a science leader and a business leader, provides an interesting illustration of how science and policy interact. Science discovers facts and elucidates trends; it provides a window for understanding what is (e.g., the present climate and how it is changing), as well as a framework for projecting what will be (future climate change and associated risks). The policy decisions made by businesses and governments are based on science, but also on economic and human factors that are beyond the realm of science. This paper represents a merging of policy-relevant scientific information with policy conclusions based on that information and judgments about acceptable risks. We have tried in this paper to make this distinction clear.

Above all, we hope readers will come to appreciate that the risks of climate change are not merely academic or theoretical. Pacific Gas and Electric Company is just one company where these challenges are dramatically altering plans for the future. They are driving new multibillion-dollar investments in more efficient energy delivery networks and renewable energy and customer energy efficiency initiatives. They are also shaping long-range planning in preparation for a world in which new climate patterns threaten resources and infrastructure and impact customers and workers.

PG&E faces the prospect of future declines in one of its core generation resources, hydroelectric power, as warming reduces California's snowpack. Exceptionally hot summers are driving up demand for air conditioning in the state's Central Valley, taxing the utility's resources. Heat and drought have fueled intense fire seasons that put transmission and distribution lines at risk.

These and similar climate-related risks extend well beyond the energy business. Virtually every sector of America's economy will be exposed to the physical and financial impacts of climate change and the policies that will sooner or later have to be adopted to confront this challenge.

How extensive these impacts will be depends largely on the decisions leaders make today and in the immediate future. As this document shows, even with uncertainties, current scientific and economic information can provide support for good business and policy planning. It is up to leaders to understand the issues and the available information, grasp the risks and opportunities, and be prepared to make the right choices.

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Is the science on climate change sound?

Yes. Climate change is real, and human activities are the major cause.

The global scientific consensus on the reality and causes of climate change is extremely strong. The strength of this consensus is a reflection not of ideology, argument, or opinion. It reflects the collective weight of thousands of thoroughly reviewed studies reporting real-world observations, carefully tested hypotheses, and verifiable measurements.

In recent years, authoritative assessments of the science have been conducted by panels of experts at the international level and within the U.S. These panels have concluded that the world's average temperatures are increasing and that the primary cause is emissions of heat-trapping greenhouse gases (GHGs) from human activities.

The most thorough, carefully evaluated, and internationally vetted analysis of climate change has been conducted by the Intergovernmental Panel on Climate Change (IPCC), created with the support of the United States and other countries by the United Nations to evaluate the science on climate change and assess the risks. The IPCC's most recent comprehensive report on the science concluded that climate change is unequivocal. It further stated that there is now more than 90 percent probability that most of the warming since the mid-1950s was caused by GHG emissions from human activities.

The IPCC came to its conclusions after evaluating thousands of published studies using a high standard of evidence and rigorous, transparent procedures, with careful attention to the level of confidence in key conclusions and the level of consensus among the scientists involved.

Independent confirmation of this consensus has been provided by the National Academy of Sciences and the United States Global Change Research Program, whose work reflects the input of scientific experts across multiple departments and agencies of the federal government.

Confidence in the attribution of warming to human activities has increased over time, and continues to increase. The Earth has warmed dramatically in the last 30 years, making long-term warming trends increasingly separable from the "noise" of natural climate variability. Human-induced warming is now detectable in all continents around the world and in the major oceans.

Additionally, scientific understanding of the climate system has improved such that it is possible to identify "fingerprints" that unambiguously point to the role of humans in changing climate. Examples include changes in the temperature gradient with height above the ground, changes in ocean heat content, and changes in the lifecycles and ranges of many plants and animals.

Although some skeptics dismiss climate change and its risks as highly uncertain, the core elements of climate change science have been known for over a century. The basic physics of the greenhouse effect and the way in which greenhouse gases change the climate are as well understood as, for example, the physics governing the electric motor, the radio, or the transistor. Moreover, nobody has presented an alternative hypothesis that can explain the magnitude, time course, or spatial pattern of the warming that has actually occurred.

This highlights an important distinction: the remaining questions regarding climate change concern details, and not the core phenomenon and the overall trend. For example,

- While the link between increased greenhouse gases and warming is clear, the extent of warming associated with a given increase in GHG concentrations is difficult to forecast precisely, because the climate system has many incompletely known feedback mechanisms that can amplify or diminish the greenhouse effect.
- While it is clear that the melting of major ice sheets in Greenland and Antarctica is contributing and will continue to contribute to sea level rise, the rate at which this will occur is difficult to predict. Recent melting has been more rapid than projected by current models, suggesting the risk may be higher than assumed. Current estimates of global average sea level rise by the end of the century range from less than one foot to more than five feet.

Climate experts openly acknowledge these uncertainties. Indeed, their projections typically reflect ranges of potential outcomes reflecting various scenarios. The overall trend, however, remains consistent.

Lastly, to the extent to which questions over the pace and impact of climate change do remain, prudence would argue that the risks from low-probability but high-impact outcomes should be given special consideration when the potential consequences are as grave and irreversible as those of climate change.

How significant are the risks of climate change?

The impacts of climate change will be profound and will affect every sector of the economy.

The global scientific consensus on the reality and current projections, increasingly corroborated by evidence from real-world observations, point to far-reaching, expensive, and potentially catastrophic impacts due to climate change.

The US Global Change Research Program's (USGCRP's) 2009 report "Global Climate Change Impacts in the United States" stated the following:

"Climate-related changes are already observed in the United States and its coastal waters....Climate changes are already affecting water, energy, transportation, agriculture, ecosystems and health. These impacts are different from region to region and will grow under projected climate change."

Among the observed or anticipated effects of climate change in the United States are the following:

- Increasing numbers and severity of extreme weather events (e.g., heat waves, heavy storms)
- Increasing numbers and severity of droughts, floods, and wildfires
- Increasing scarcity of water for drinking, irrigation, energy, and commerce
- Increasingly vulnerable coastal population centers and infrastructure, due to rising sea level, coupled with increasing storms
- Shifting agricultural productivity as temperature and precipitation patterns change the location of fertile land, and potential decreases in the productivity of land currently farmed
- Threats to public health due to increasing heat-related illnesses and spreading infectious diseases

For example, climate change is already altering patterns of precipitation and evaporation. In California's Sierra Nevada mountains, climate change–induced reductions in snowpack have already begun, with a transition to more rain and less snow over the last 50 years. The snowpack has long been a natural and reliable reservoir for water throughout the dry summer, as it gradually melts. Warmer temperatures are also causing earlier melting of snow. This is already affecting water for agriculture, hydroelectric power production, and ordinary consumers.

The impacts of climate change on other parts of the world, such as Africa and South Asia, are potentially much greater than on developed countries. Populations that lack access to capital for adaptation will experience some of the most severe impacts of climate change, including more frequent heat waves, storms, drought, infectious diseases, water shortages, wildfires, and coastal flooding, potentially leading to disruption of food production systems, sociopolitical instability, population dislocation, and ecosystem collapse.

Numerous reports detail forecasts of these and other, similar regional impacts. Yet an equally important concern is the impacts that cannot be predicted so readily. The potential for surprises as complex ecological, social, and economic relationships are disrupted by climate changes represents one of the greatest risks to be considered.

Is there an opportunity to address the problem?

Effective policy and action can limit the extent of the consequences to which we'll have to adapt.

The severity of the impacts of climate change depends largely on future emissions.

Since the middle of the 19th century, the earth has warmed over 1.3°F, and a total temperature increase of double that is anticipated as a result of greenhouse gases already emitted. Based on available scientific information, nations, including the U.S., are now focusing on limiting global temperature increase to a total of 3.6°F (2°C) in order to avoid severe, widespread, and irreversible impacts. To have a good chance—although not a guarantee—of limiting temperature increase to this level, it has been estimated that atmospheric concentration of carbon dioxide would need to stabilize in the long term at around 450 parts per million, a level we could reach in 20 years or less.

Currently, however, greenhouse gas emissions are continuing to increase at a rate equal to or even exceeding that of recent decades. These emissions will cause additional temperature increases. The longer we wait to act, the more additional warming becomes unavoidable, the more damaging the impacts will be, and the more we will need to invest to adapt to those impacts and get GHG emissions under control.

There are two ways to respond to climate change: adaptation, the alteration of personal, business, and societal practices to cope with climate change; and mitigation, the reduction of greenhouse gas emissions to limit climate change. Adaptation and mitigation are not mutually exclusive; in fact, any strategy for dealing with climate change will undoubtedly incorporate elements of both.

Mitigation can reduce the extent of temperature change and therefore the burden and cost of adaptation. Without mitigation, we are very likely to see large temperature changes and impacts beyond our ability to adapt.

Even with mitigation, however, some adaptation will be necessary as temperatures continue to rise. Adaptation is a necessary complement to mitigation; it addresses the impacts we cannot avoid. Adaptation may include reducing the energy and water demands of agriculture, moving away from areas prone to floods, and better preparing for extreme events such as heat waves or hurricanes.

A number of possible strategies can be effective in limiting climate change, focused on decreasing the release of greenhouse gases to the atmosphere. Examples include reducing the power demands of the building sector by investing in greater energy efficiency; decreasing the emission of CO_2 from motor vehicles or fossil-fuel power plants through improving fuel efficiency; greater adoption of renewable energy to replace fossil fuels; and finding reliable and cost-effective ways to capture and store carbon dioxide from power plants. Reductions in other greenhouse gases are also important, since some (like methane) are much more potent than CO_2.

Aggressive mitigation incurs more costs in the short term, but leads to lower temperature increases, a lower cost of adaptation, and a lower probability of irreversible consequences beyond our ability to cope. Postponing mitigation and allowing additional carbon-intensive infrastructure to be built increase the cost of lowering emissions to a given level.

What is the cost of taking action?

Emissions can be reduced at a reasonable cost and without jeopardizing economic growth, job creation, or competitiveness.

Any viable solution to lowering greenhouse gas emissions must also be capable of sustaining economic growth, job creation, and competitiveness. The proposals being considered seriously today go to great lengths to take these economic considerations into account.

Recent legislative proposals to address climate change include measures to buffer consumers against sudden price increases, protect trade-sensitive businesses, phase limits in over time, and allow flexibility for business to meet the goals at the lowest possible cost.

A number of government, business, and independent organizations have analyzed the projected costs of these proposals, using widely accepted economic forecasting tools and techniques. The results indicate strongly that such costs are well within manageable bounds, both from a macroeconomic perspective and in terms of impacts on individual consumers.

The 2007 IPCC Fourth Assessment Report estimated that, globally, the cost of controlling carbon emissions to limit concentrations to approximately a doubling of pre-industrial levels would be on the order of 0.2–2.5 percent of global GDP by 2030, with a best estimate of 0.6 percent. A 2008 study by McKinsey made similar cost estimates of 0.6–1.4 percent of global GDP by 2030 to limit concentrations to below 500 parts per million. This report puts this figure into perspective by stating: "If one were to view this spending as a form of insurance against potential damage due to climate change, it might be relevant to compare it to global spending on insurance, which was 3.3 percent of GDP in 2005."

In the United States, most of the recent economic forecasting has focused on the impacts of a cap-and-trade program, along the lines of the legislation passed in 2009 by the House of Representatives, which would ratchet down U.S. emissions by 80 percent by 2050.

These analyses—by groups as diverse as the Congressional Budget Office, the Energy Information Administration, the U.S. Environmental Protection Agency, the National Association of Manufacturers and the U.S. Climate Action Partnership—all project that the U.S. economy will continue to expand substantially under the constraints envisioned in this legislation. Jobs continue to be created. Household income and purchasing power continue to rise steadily.

The cost of cutting carbon emissions, according to the analyses, appears as a slight reduction from a baseline of robust future growth in each of these indicators. This context is critically important. These cost projections have occasionally been misunderstood to suggest the economy would shift into reverse and shrink. No study projects such a dire outcome.

For example, the independent Congressional Budget Office analysis that under a carbon emissions cap, U.S. economic output would rise 250 percent by 2050. The CBO estimates that this growth is only 1 percent to 3.5 percent less overall than it would be in a "business as usual" scenario—a comparatively modest cost when viewed correctly against the backdrop of 250-percent growth.

In effect, these costs simply defer to a slightly later date the achievement of a certain level of economic output.

For example, studies show that in 2030, the economy reaches the same level of output with or without cap-and-trade legislation; with the legislation, it just achieves that level two to four months later than it would under the "no policy" scenario. In fact, even one of the most pessimistic assessments, conducted by the National Association of Manufacturers, shows a delay of only 8–9 months in reaching this level of output.

Real household disposable income in 2030 (personal income less taxes), according to the USCAP model, is projected to be $54,500 higher than in 2010. Without climate legislation, income in 2030 would be $55,000 higher. Based on this analysis, aggressive action on climate change will cost on the order of $500 per household per year, or about 1 percent of the new income from economic growth.

Remember, these modest numbers reflect only one side of the equation—costs. They don't measure the significant economic, social, and environmental benefits, which are likely to be much greater. It also should be noted that such projections likely underestimate the benefits of future innovation, which would probably lead to even lower costs. Perhaps most significant, they do not take into account the likely enormous costs of inaction.

Do we have the technology to tackle the problem?

Substantial greenhouse gas emissions reductions can be achieved in the immediate or near term using technology that is here today.

The principal challenge to realizing potential energy savings and emissions reductions relates to policy, not technology.

However, it is a fact that very substantial greenhouse gas emissions reductions can be achieved in the near term using technology that is here today—and at zero or net-negative life-cycle cost. Many carbon-cutting measures actually generate net savings. Examples include more efficient lighting, better insulation in new buildings, improved automobile fuel efficiency, more efficient appliances, and equipment upgrades in factories.

For example, aluminum producer Alcoa is pursuing energy efficiency improvements through an internal program that has identified more than $80 million of potential energy savings opportunities. Chip maker Intel has realized more than $50 million in energy savings through the installation of more efficient lighting and other improvements, such as upgrades to heating, ventilation, and air-conditioning systems. And McDonald's is integrating electrical control systems across its restaurants worldwide in an effort that it expects will yield a 14 percent cut in energy usage and annual savings of $1.5 billion.

The principal challenge to realizing these potential energy savings and emissions reductions relates to policy, not technology. Specifically, achieving many of these gains requires coordinating incentives and regulations to shift business and consumer investment to take advantage of such opportunities.

A study by McKinsey in 2009 focused specifically on the potential for energy efficiency gains in the U.S. economy. The research showed that the United States could reduce annual non-transportation energy use by roughly 23 percent by 2020. This would eliminate an estimated more than $1.2 trillion in waste—far exceeding the $520 billion up-front investment (not including program costs) that would be required. The resulting greenhouse gas emissions reductions would equal those of taking every car and light truck in the country off the road.

Again, the key barrier identified in the 2009 study is not the need for more technical innovation, but rather the need to coordinate policies and align incentives to drive adoption of existing technologies.

This is not to suggest that reorienting policy to drive low-carbon choices would be simple. But the challenges and opportunities are well known and well understood, and there are easily adaptable models already working in places like California that show how to address the issues.

Do we have a policy solution to climate change?

A national cap on carbon emissions is the most cost-effective, flexible way to drive substantial emissions cuts.

The principal policy alternatives under consideration in the United States to drive reductions in carbon emissions are regulation and carbon pricing.

Today, business leaders broadly agree that command-and-control regulation of greenhouse gas emissions sources by the U.S. Environmental Protection Agency is the most expensive and least efficient option. Far more effective is a strategy that puts a price on carbon emissions and allows businesses the flexibility to pursue the lowest-cost options to reduce emissions. A market-based cap-and-trade program is one way to achieve this; another is a carbon tax.

A cap-and-trade program establishes a ceiling on total emissions across the economy and creates an emissions allowance for each ton of emissions under the cap. Businesses whose emissions are greater than their allowances have the option of cutting emissions or buying surplus allowances from other businesses through a market. Over time, the cap and the number of allowances are lowered to achieve overall emissions-reduction goals by a set timeline.

A carbon tax is a fixed charge per ton of greenhouse gas emissions. While it provides greater price stability than a market-based approach, it lacks the certainty—which the cap provides—that overall emissions targets will be achieved according to a predictable timeline. A carbon tax may look like a simpler approach, but a real-world carbon tax policy is unlikely to be any less complex than a cap-and-trade program. Both will inevitably involve myriad policy considerations that must be carefully integrated and balanced.

Importantly, cap-and-trade has been implemented successfully in the United States to address sulfur dioxide emissions from power plants. The Clean Air Act's Acid Rain Program created a cap-and-trade program that cut such pollution by 50 percent relative to 1980 levels as of 2007.

Moreover, under the sulfur dioxide program, the emissions reductions goals were achieved well ahead of schedule and at a fraction of the forecasted cost. When the policy was being debated, some electric utilities warned that the emissions allowances would cost $1,000–$1,500 per ton. The U.S. EPA estimated they would cost $750 per ton. In fact, allowance prices consistently ran below $250 per ton between 1990 and 2003, and most recently have been below $100 per ton.

A carbon cap-and-trade program would necessarily be much broader and more complex than the sulfur dioxide program. As evidence of this challenge, many critics point to the challenges Europe has faced in its efforts to implement a carbon market, known as the European Trading Scheme (ETS). Lacking quality data about current emissions, policymakers set emissions caps too high and the market price for allowances crashed.

Europe has since taken steps to correct the problems and improve the performance of the market. According to a 2008 study by the Massachusetts Institute of Technology, the ETS probably reduced emissions by 2 to 5 percent per year in each of its first three years.

The ETS experience also serves as a valuable source of lessons that U.S. policymakers could draw upon to avoid the same pitfalls. The United States will be starting from the basis of a verified inventory of current emissions. Current cap-and-trade proposals in the United States also would avoid other pitfalls seen in Europe—for example, limiting the distribution of free allowances and setting a trading band on emissions prices to limit market volatility and provide businesses with greater predictability.

Should the U.S. act if others do not?

It is in the United States' self-interest to take action, regardless of whether other nations immediately follow our lead.

Science tells us that climate change will be with us for the foreseeable future, but choosing among policy alternatives requires considering the science in a broader context. Beyond the climate challenge, early commitment to aggressive investments in clean-energy technology and infrastructure makes policy and business sense for a number of reasons.

In the near term, sending a clear signal on future energy policy offers the potential to spur job creation and private-sector investment at a time when the economy needs both. Many companies today are delaying large capital investments. Uncertainty around energy and climate change legislation is making it impossible, or at least dangerously imprudent, to guess which future clean energy and infrastructure investments will be the right ones.

For example, the nation's utility sector expects to make an estimated $2 trillion of infrastructure investments over the next 20 years. Utilities make capital spending decisions on a 30- or 40-year time horizon. Power plants cost billions of dollars and last for decades. Until there is greater certainty regarding America's future energy agenda and about how carbon pollution will be addressed, many companies will simply refuse to make major investments.

Longer term, smart climate and energy policies that drive investment and innovation in the United States can help achieve other critical goals, such as greatly curbing America's dependence on foreign oil, reducing its substantial international trade deficits, and competing more effectively with China and Europe for leadership in the emerging global clean energy industry.

Many Americans believe, however, that action on climate change should be postponed until countries such as China and India also commit to legally binding agreements to significantly curb their future emissions.

There is no dispute that emissions from China and other developing economies must be reduced significantly in order to hold global greenhouse gas concentrations to acceptable levels. Indeed, recently, China has overtaken the United States as the world's largest producer of greenhouse gases.

Nevertheless, U.S. emissions remain extremely high. The U.S. remains the world's second-largest emitter. Per-capita emissions in the United States are still four times higher than in China. In terms of historical emissions, the United States still accounts for the largest share of emissions, with 26 percent of the total output. (By comparison, China's share of historic emissions represents about 6 percent of the total.)

Moreover, China is already making noteworthy efforts to curb its emissions and build its leadership in the global clean energy economy. China is already the world's leading producer of renewable electric power. It is also working to cut the energy intensity of its economy by 20 percent by the end of 2010, a goal it appears to be on track to hit. The emissions reductions actually exceed those that would be achieved in the next 10 years under the climate bill passed by the U.S. House of Representatives in 2009.

The need to ultimately reach a binding international agreement that engages all of the major emitting nations is clear. But it would be a mistake for the U.S. to delay action until such an agreement can be reached. Not only would we be sacrificing important near- and long-term economic opportunities, we would deny ourselves the critical leverage to press others that can come only from an unequivocal commitment here at home.

Can't we afford to wait?

Time is of the essence. Both the science and the economics of climate change argue strongly that we should begin acting now.

Levels of CO_2 in the atmosphere have already increased by more than 35 percent from pre-industrial times, and they continue to increase substantially. There is no debate that these trends will persist unless and until action is taken to reduce emissions.

In its assessment of best-case and worst-case scenarios for future CO_2 emissions, the IPCC projects that by the end of the century, the global average temperature is likely to increase by between 4° and 11.5°F under the highest emissions scenario, and between 2° and 5°F under a scenario with lower emissions. Actual CO_2 emissions from 2000 to 2008 grew at the pace of the worst-case (highest) scenario.

Greenhouse gases accumulate and linger for centuries in the atmosphere. The closer greenhouse gas levels get to the upper limits of what scientists consider manageable, the more difficult and expensive it will become to pull back and prevent crossing dangerous and costly thresholds. Acting now allows businesses and policymakers the opportunity to pursue a broad range of mitigation options whose costs can be spread out over time while emissions are gradually slowed and reversed. In contrast, if emissions have to be stopped and reversed more quickly and substantially at a later date, the impact would almost certainly be more Draconian.

As discussed already, the costs of the mitigation measures available today appear to be well within reasonable bounds. These costs become even more reasonable when compared against the potential costs and risks associated with delaying our response or doing nothing about rising carbon emissions.

One of the most significant attempts to assess the costs of inaction came from the British government in its 2006 report known as the Stern Review on the Economics of Climate Change. As the Stern Review acknowledges, "Modeling the overall impact of climate change is a formidable challenge….The limitations… demand caution in interpreting results, but projections can illustrate the risks involved—and policy here is about the economics of risk and uncertainty."

The Stern Review estimated that the costs of climate change grow gradually through time. By 2200, at the low end, "the overall costs and risks of climate change will be equivalent to losing at least 5 percent of global GDP each year, now and forever." At the high end, it estimates damage could rise to 14 percent of GDP or more.

Even with the many uncertainties inherent in such an estimate, it should be clear that the potential exists for the economic impacts of inaction to be astronomically high. Similarly, it should be clear that the scale of the potential impact is great enough to justify investments now as a form of insurance against a potential outcome that is unacceptable at any level of probability.

List of Key Source Documents and Material for Further Reading

Books

(listed in order of increasing complexity)

Elizabeth Kolbert: *Field Notes from a Catastrophe.* 2006. Kolbert writes for the *New Yorker*. A particularly readable book for someone who is not used to reading technical material.

Al Gore: Our Choice: *A Plan to Solve the Climate Crisis.* 2009. An excellent and forward-looking overview by the climate change advocate and Nobel Prize winner.

Robert Henson: *The Rough Guide to Climate Change.* 2007. Henson is a writer and meteorologist at the National Center for Atmospheric Research. This book is a good introduction to climate change research and draws strongly on the 2007 IPCC report.

Michael E. Mann and Lee R. Kump: *Dire Predictions: Understanding Global Warming.* 2008. Mann is a professor at Pennsylvania State University and a lead author on the IPCC reports. This book is focused on the 2007 IPCC report.

Gavin Schmidt and Joshua Wolfe: *Climate Change: Picturing the Science.* 2009. Schmidt is a climate scientist at the NASAS Goddard Institute for Space Science and a cofounder of www.RealClimate.org.

Lester Brown: *Plan B 4.0: Mobilizing to Save Civilization.* 2009. Brown is president of the Earth Policy Institute and has written numerous books. This book is more detailed and has a broader reach than the ones above.

Thomas Friedman: *Hot, Flat, and Crowded.* 2008. Friedman is a Pulitzer Prize–winning *New York Times* columnist. Perhaps the best integration of climate change with other political, economic, and social problems of the 21st century.

US Global Change Research Program: Global Climate Change Impacts in the United States. Available from www.amazon.com or from www.globalchange.gov. A comprehensive, readable survey.

IPCC: Climate Change 2007. The IPCC Fourth Assessment Report. Available from www.amazon.com, or can be downloaded from www.ipcc.ch. This is the most thorough, most authoritative source available.

Economic Impact Reports

Reducing U.S. Greenhouse Gas Emissions: How Much at What Costs? McKinsey & Company, December 2007. http://www.mckinsey.com/clientservice/ccsi/greenhousegas.asp

Unlocking Energy Efficiency in the U.S. Economy. McKinsey & Company, July 2009. http://www.mckinsey.com/clientservice/electricpowernaturalgas/US_energy_efficiency/

The Other Side of the Coin: The Economic Benefits of Climate Legislation. Institute for Policy Integrity, September 2009. http://www.sustainableprosperity.ca/story/institute-policy-integrity-other-side-coin

The Economic Benefits of Investing in Clean Energy: How the economic stimulus and new legislation can boost U.S. economic growth and employment. Center for American Progress, June 2009. http://www.americanprogress.org/issues/2009/06/pdf/peri_report.pdf

Climate Change Policy as an Economic Redevelopment Opportunity: The Role of Productive Investments in Mitigating Greenhouse Gas Emissions. American Council for an Energy-Efficient Economy, October 2009. http://www.aceee.org/store/proddetail.cfm?CFID=4648510&CFTOKEN=13040188&ItemID=469&CategoryID=7 (requires registration)

Clean Energy and Climate Policy for U.S. Growth and Job Creation: An Economic Assessment of the American Clean Energy and Security Act and the Clean Energy Jobs and American Power Act. University of California, Berkeley, College of Natural Resources, October 2009. http://are.berkeley.edu/~dwrh/CERES_Web/Docs/ES_DRHFK091025.pdf (executive summary only)

Task Force on America's Future Energy Jobs. National Commission on Energy Policy, October 2009. http://bipartisanpolicy.org/library/report/task-force-americas-future-energy-jobs

A Path to Greenhouse Gas Reductions in the United States: Economic Modeling of Interim National Targets. Nicholas Institute for Environmental Policy Solutions, September 2007. http://nicholas.duke.edu/institute/wp-greenhousegas.pdf

Websites

NOAA
www.climate.gov
The new U.S. government portal for climate information. The website of the new climate change bureau.

RealClimate
www.realclimate.org
Bills itself as "climate science from climate scientists," written by professionals but intended for the interested public and journalists. Large archive of essays and commentaries; nice page of links to help get up to speed on climate change ("start here").

The Daily Climate
www.dailyclimate.org
A news service that covers worldwide news stories related to climate and climate change; very good daily news post and a very large archive.

Pew Center on Global Climate Change
www.Pewclimate.org
Thoughtful and reliable summaries of a variety of aspects of climate. Well-prepared reports available for download.

Climate Central
www.climatecentral.org
Useful, reliable information in an accessible form.

Environmental Entrepreneurs
www.e2.org
A business voice for the environment; works closely with NRDC. Strong work in connection with California's AB32.

Encyclopedia of Earth
www.eoearth.org
An online encyclopedia devoted to a broad range of earth science and climate articles written by professional scientists.

Environmental Defense Fund
www.edf.org
A 40-year-old organization founded by scientists. Rigorous science, presented understandably.

Peter A. Darbee

Peter A. Darbee is Chairman of the Board, Chief Executive Officer, and President of PG&E Corporation. Since becoming CEO in 2005, Darbee has spearheaded major new initiatives to establish PG&E as an industry front-runner in customer satisfaction, operational excellence, and environmental leadership.

With a record of success in both competitive and regulated businesses, Darbee joined PG&E Corporation in 1999 as Senior Vice President and Chief Financial Officer. Before joining PG&E, Darbee was Vice President and Chief Financial Officer of Advanced Fibre Communications, Inc. Prior to that, he was CFO and Controller at Pacific Bell. Earlier, as an investment banker with Goldman Sachs, he was Vice President and co-head of the company's energy and telecommunications group. He also held positions at Salomon Brothers and AT&T.

Darbee is a member of the Boards of Directors of PG&E Corporation and Pacific Gas and Electric Company. He is a member of the Edison Electric Institute Executive Committee, serves as Chairman of the CEO Policy Committee on Public and Governmental Affairs, and is a member of the CEO board of the Clean Energy Group. Darbee also serves as the United States Co-Chair for the Global Leadership Technology Exchange, and the business Co-Chair of the Washington, D.C.–based Alliance to Save Energy. In these roles, he has become one of the industry's most active leaders on the issues of climate change, energy efficiency, renewable energy, the "smart grid," and other aspects of energy and environmental policy.

Darbee also is active in the Business Council, the California Business Roundtable, the California Commission for Jobs and Economic Growth, the San Francisco Committee on JOBS, and the San Francisco Symphony Board of Governors.

Darbee earned his bachelor's degree in economics from Dartmouth College and an MBA from the Amos Tuck School of Business at Dartmouth. He has also completed the Nuclear Reactor Technology Program at the Massachusetts Institute of Technology.

Based in San Francisco, PG&E Corporation is the parent company to Pacific Gas and Electric Company, which serves 15 million people throughout Northern and Central California.

Christopher B. Field

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Field is a world authority on the global carbon cycle. For more than 20 years, he has been a pioneer in developing new approaches to understanding the large-scale function of the Earth system. He has made major contributions to physiological ecology, ecosystem ecology, biogeochemistry, and climate science. He has authored more than 200 scientific publications and has briefed U.S. congressional committees on climate-change impacts.

In addition to directing Carnegie's Global Ecology department, Field is Co-Chair of Working Group 2 of the Nobel Prize–winning Intergovernmental Panel on Climate Change (IPCC). Field will oversee the Working Group 2 Report about climate change impacts, adaptation, and vulnerability for the IPCC Fifth assessment, scheduled to be published in 2014. Field was formerly a coordinating lead author on the 2007 IPCC report and a member of the delegation representing the IPCC at the 2007 Nobel Prize ceremonies.

Field is a member of the National Academy of Sciences. He is a recipient of the 2006 Stanford Skippy and Sidney Frank Prize for Outstanding Research in the Prevention or Reduction of Global Warming and the 2009 Heinz Award for his work to protect the environment.