CHAPTER 1

# A Vision of a Clean Energy Economy and a Climate-Friendly Future

The writing is on the wall: the United States needs to shift away from using fossil fuels and build its economy with clean sources of energy. Many factors are driving the nation in this direction, from the need to reduce our dependence on foreign oil and head off the most devastating impacts of global warming, to calls for government investment in technologies that will spur American innovation and entrepreneurship, create jobs, and keep the United States globally competitive.

The growing threat of global warming makes this transition urgent. Global warming is caused primarily by a buildup in the atmosphere of heat-trapping emissions from human activities such as the burning of fossil fuels and clearing of forests. Oceans, forests, and land can absorb some of this carbon, but not as fast as humanity is creating it.

U.S. heat-trapping emissions have grown nearly 17 percent since 1990, with most of this increase the result of growth in $CO_2$ emissions from fossil fuel use in the electricity and transportation sectors. To keep the world from warming another 2°F above today's levels[10]—the level at which far more serious consequences become inevitable—the United States and other industrialized countries will have to cut emissions at least 80 percent from 2005 levels by 2050, even with swift and deep reductions by developing countries (Gupta et al. 2007; Luers et al. 2007).

We can and must accomplish this transition to a clean energy economy alongside a strong and growing U.S. economy. *Climate 2030: A National Blueprint for a Clean Energy Economy* assesses the economic and technological feasibility of meeting stringent near-term (2020) and medium-term (2030) targets for cutting global warming emissions. We analyze U.S. energy use and trends—as well as energy technologies, policy initiatives, and sources of U.S. emissions—to develop a well-reasoned, thoroughly researched, and comprehensive blueprint for action the United States can take to meet these targets cost-effectively.

## 1.1. The Climate 2030 Approach

Our analysis uses a modified version of the U.S. Department of Energy's National Energy Modeling System (NEMS) and supplemental analyses to conduct a comprehensive assessment of a package of climate and energy policies across multiple sectors of the economy between now and 2030. The NEMS model allows us to capture the dynamic interplay between energy use, energy prices, energy investments, the environment, and the economy, as well as the competition for limited resources under different policy scenarios.

**Modeled solutions in the Climate 2030 Blueprint include more efficient buildings, industries, and vehicles; wider use of renewable energy; access to better transportation choices; and a cap-and-trade program that sets declining limits on carbon emissions.**

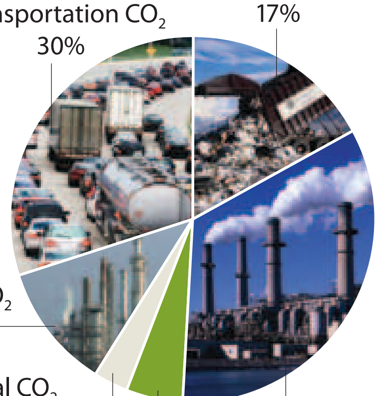
10 Earth has already warmed by about 1.4°F, or 0.8°C, above the levels that existed before about 1850. An average temperature increase of 2°F above today's level is the same as a 3.6°F or 2°C increase above pre-industrial levels.

Modeled solutions include more efficient buildings, industries, and vehicles; wider use of renewable energy; and more investment in research, development, and deployment of low-carbon technologies in the electricity sector. Our model also included a cap-and-trade program that sets declining limits on emissions of carbon dioxide and other heat-trapping gases, and that makes polluters pay for "allowances" to release such emissions. A cap-and-trade program can include a provision that allows capped companies to "offset" a portion of their emissions rather than cutting them directly, by paying uncapped third parties to reduce their emissions or increase carbon storage instead. In our model, a provision for a limited amount of such offsets leads to more storage of carbon in agriculture lands and forests. (Apart from allowing for a limited number of offsets, we were unable to fully analyze the potential for storing carbon in forests and on farmland, although several studies indicate that the potential for such storage is significant [CBO 2007; Murray et al. 2005]).

Chapter 2 explains our modeling approach and major assumptions. The next four chapters then explore our major solutions in depth. Chapter 3 explains the need for an economywide price on carbon as a key driver of emissions cuts. Chapters 4–6 examine the major sectors responsible for most U.S. global warming emissions: industry and buildings, electricity, and transportation. These chapters analyze the potential savings in energy and emissions from solutions that are commercially available today, or that will very likely be available within the next two decades. The chapters also identify the challenges these solutions face in reaching widespread deployment and the policy approaches that can help overcome those challenges. (Those chapters also describe the key assumptions underlying our analysis.)

Chapter 7 presents the overall results of our analysis, while Chapter 8 provides recommendations to policy makers and other decision makers. (Our report also includes technical appendices available online, to allow readers to delve more deeply into our methods, assumptions, and results.)

**FIGURE 1.1. The Sources of U.S. Heat-Trapping Emissions in 2005**




Data source: EIA 2008.

**The United States was responsible for approximately 7,180 million metric tons $CO_2$ equivalent of heat-trapping emissions in 2005, the baseline year of our analysis. Most of these emissions occur when power plants burn coal or natural gas and vehicles burn gasoline or diesel. The transportation, residential, commercial, and industrial shares represent direct emissions from burning fuel, plus "upstream" emissions from producing fuel at refineries.**

## 1.2. Building on Previous Studies

Our analysis builds on earlier analyses of clean energy technologies and policies by university researchers, UCS, and other national nonprofit organizations over the past 15 years (Clean Energy Blueprint 2001; Energy Innovations 1997; and America's Energy Choices 1992).

Some of these reports have found that a diverse mix of energy efficiency, renewable energy, and other low-carbon technologies have the *potential* to significantly reduce heat-trapping emissions (e.g., Greenpeace International and the European Renewable Energy Council 2009, McKinsey & Company 2009, Flavin 2008, Google 2008, ASES 2007, Pacala and Socolow 2004). However, this report takes the analysis further by analyzing the costs and benefits of achieving the reductions—as well as some of the trade-offs and competition among different technologies and sectors. This report also focuses on the policy options that will enable the nation to cost-effectively meet the near-term and mid-term climate targets critical to avoiding the worst consequences of climate change.

Government agencies and university researchers have also conducted economic analyses of proposed U.S. cap-and-trade legislation (such as ACCF and NAM 2008; Banks 2008; EIA 2008; EPA 2008a; and Paltsev et al. 2007), and have analyzed the costs and benefits of implementing low-carbon technologies in specific economic sectors (such as APS 2008; EIA 2007; and EPRI 2007). However, this report again provides a more complete approach by evaluating the impact of implementing a cap-and-trade program *and* a full set of complementary energy policies and low-carbon technologies across all major sectors of the economy.

This suite of policies and technologies focuses primarily on sharply reducing U.S. emissions, with limited provisions for offsets from carbon storage in domestic lands and forests and in tropical forests. The resulting recommendations do not include every step the United States must take to address climate change. However, they establish a clear blueprint for U.S. leadership on this critical global challenge.

Addressing climate change will clearly require the participation and cooperation of both developed and developing countries. Under such a global partnership, the United States and other industrialized nations will help developing nations avoid fossil-fuel-intensive economic development and preserve carbon-storing tropical forests. The partnership will also require developed countries to fund strategies to help developing countries adapt to unavoidable climate changes.[11] Such international engagement will allow U.S companies to be at the vanguard of developing and supplying clean technologies for a global marketplace.

Although this international dimension of U.S climate policies is essential, it is beyond the scope of this report.

**Tropical deforestation is one of the major causes of global warming, accounting for nearly 20 percent of global carbon emissions. The United States must therefore invest in efforts aimed at helping developing countries preserve their carbon-storing tropical forests, such as setting aside a small portion of the auction revenues from a U.S. cap-and-trade program.**

## 1.3. A Clean Energy Economy: A Solution for Many Challenges

The nation must enlist many technologies and policies if we are to meet our energy needs while addressing global warming. We propose a broad array of practical solutions to achieve our climate goals at low cost. As this report shows, many of our solutions deliver not only cost-effective cuts in global warming emissions but also consumer and business savings and other social benefits.

For example, energy efficiency technologies and measures can save households and businesses significant amounts of money. Many strategies for reducing emissions also create jobs and inject capital into the economy, while others enhance air quality, energy security, public health, international trade, and agricultural production, and help make ecosystems more resilient.

While our analysis considered most of the technologies now available to combat climate change, we focused on those that reduce emissions at the lowest cost, and with the fewest risks to our health and safety and the environment.

## 1.4. Setting a Target for U.S. Emissions Cuts

Most climate experts agree that the world must keep average temperatures from rising another 2°F above today's levels (or 2°C above pre-industrial levels) to avoid some of the most damaging effects of global warming (UCS 2008; Climate Change Research Centre 2007). Some scientists now argue that even that level is too high (Hansen et al. 2008).

In 2001 the Intergovernmental Panel on Climate Change (IPCC) identified several reasons for concern

11 Because global warming emissions have already accumulated in the atmosphere, the planet will undergo a certain amount of climate change regardless of future efforts to lower emissions.

regarding the world's growing vulnerability as global temperatures rise (Smith, Schellnhuber, and Qadar Mirza 2001). The arresting visual representation of this information has come to be known as the "burning embers" diagram (see Figure 1.2, left). Smith et al. (2009) drew on a 2007 IPCC report and subsequent peer-reviewed studies to update this diagram (see Figure 1.2, right).

The 2009 version highlights the much greater risk of severe impacts from rising average global temperatures than peer-reviewed studies indicated only a few years ago. The considerable evidence summarized in

**BOX 1.1.**

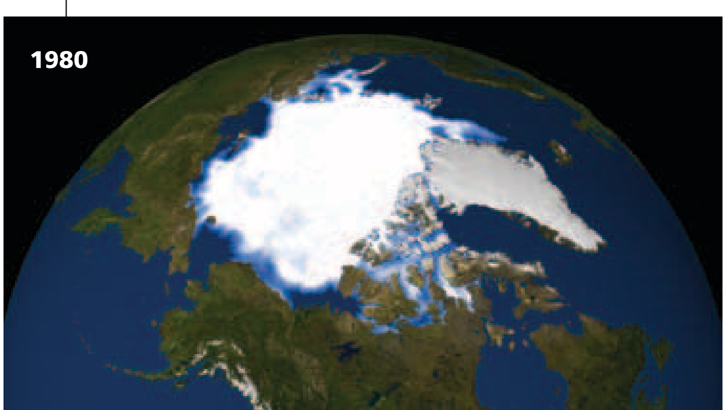
## Causes and Effects of Global Warming

In 2007 the Intergovernmental Panel on Climate Change released a report finding that it is "unequivocal" that Earth's climate is warming, and that the planet is already feeling the effects (IPCC 2007). The primary cause of global warming is clear: burning fossil fuels such as coal, oil, and gas as we generate electricity, drive our cars, and heat our homes releases carbon dioxide and other gases that blanket the earth and trap heat. Deforestation is another major source of such emissions. To dramatically curb global warming, we will have to dramatically reduce those emissions.

Today the atmospheric concentration of two important heat-trapping gases—carbon dioxide and methane—"exceeds by far the natural range over the last 800,000 years," according to two key reports (Loulergue et al. 2008; Luthi et al. 2008). In fact, while the atmospheric concentration of heat-trapping gases was around 280 parts per million of $CO_2$ before 1850, it is now around 386 parts per million, and rising by almost two parts per million per year (Tans 2009).

As a result, the global average temperature is now 1.3°F (0.7°C) above pre-industrial temperatures. And the accumulation of heat-trapping gases already released ensures that the planet will warm about another 1°F (0.6°C) (Hansen et al. 2005; Meehl et al. 2005; Wigley 2005). If humanity fails to substantially reduce global emissions, the IPCC projects global average temperature increases of as much as 11.5°F (6.4°C) by the end of the century (IPCC 2007a). Such changes will likely lead to wide-ranging consequences that exceed humanity's ability to cope, including rising sea levels, widespread drought, and disruption of agriculture and global food supplies (IPCC 2007b).

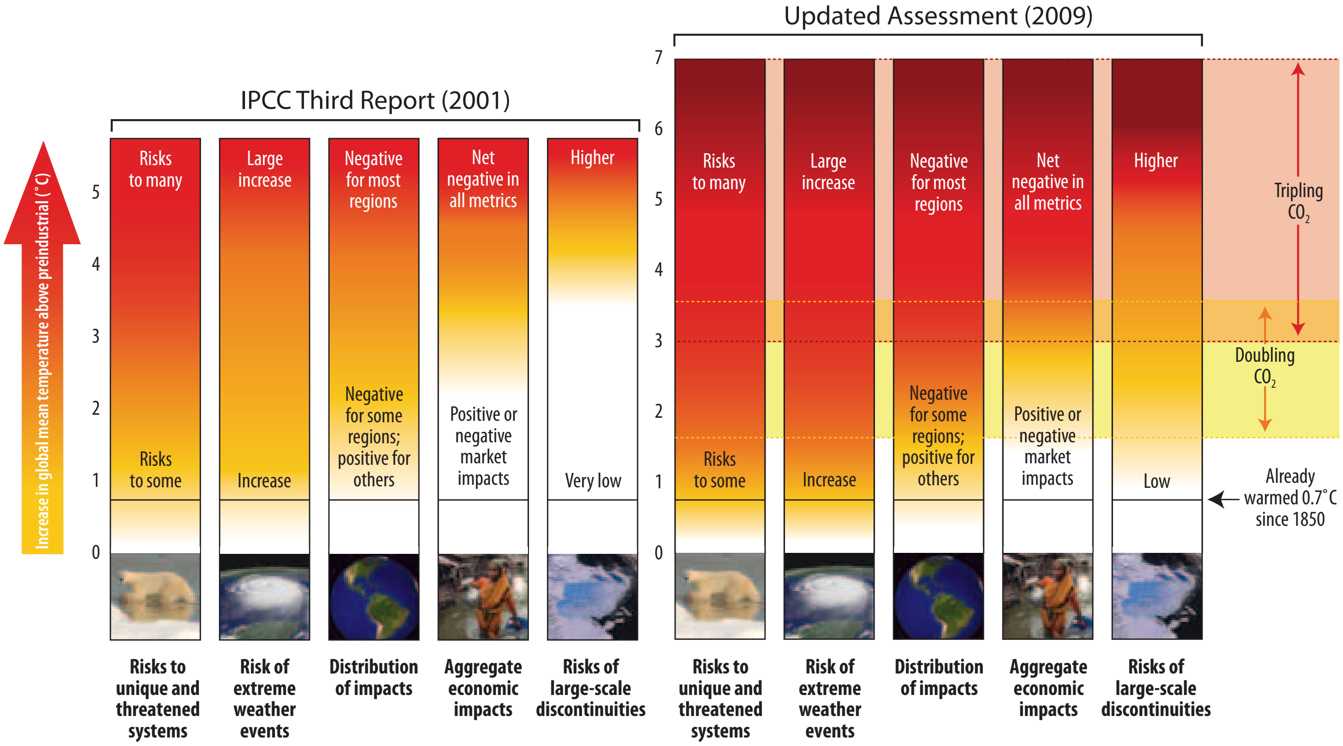
Since the 2007 IPCC report, other studies have shown that climate impacts are occurring at a faster pace—and are often more intense—than IPCC projections (Rosenzweig et al. 2008; Rahmstorf et al. 2007; Stroeve et al. 2007). For example, the observed rates of both sea level rise and summer Arctic sea ice decline are higher than the IPCC anticipated in its projections.





**Observed and measured climate change impacts are occurring at a faster pace and are often more intense than previously projected. One example is the loss of Arctic sea ice and snow, which help reflect the sun's energy. This loss is leading to even more warming. Just 27 years after the 1980 satellite image shown here, scientists were surprised by the extent to which the minimum area of sea ice had shrunk.**

**FIGURE 1.2. The Risks of Climate Change: The "Burning Embers" Diagram**




Source: Adapted from Smith et al. 2009; Schneider 2009.

**The risks of harmful effects from global warming rise with its magnitude. This figure shows that even a 2°C change in global temperature poses significant risks. The left-hand panel is based on the 2001 *Third Assessment Report* (TAR) of the Intergovernmental Panel on Climate Change. The right-hand panel is an updated version from 2009.**

these figures reveals that a rise in global average temperature of more than 2°F above where we are today (or 2°C above pre-industrial levels) would put many natural and human systems at grave risk.

In 2007 UCS analyzed what the United States would have to do to help keep global temperatures from rising more than 2°C above pre-industrial temperatures (Luers et al. 2007). Other studies noted that humanity has about a 50-50 chance of meeting this temperature target if we stabilize atmospheric concentrations of global warming emissions at no more than 450 parts per million of $CO_2$ equivalent[12] by the end of this century (Meinshausen et al. 2006). The UCS analysis therefore proposed this concentration as a maximum allowable target.

Because carbon dioxide—the primary heat-trapping gas—remains in the atmosphere for a long time, setting a target concentration also requires setting a limit for total cumulative emissions. Recent studies have shown that cumulative global emissions must not exceed about 1,700 gigatons of $CO_2$ equivalent[13] from 2000 to 2050, to keep atmospheric concentrations below 450 parts per million of $CO_2$ equivalent (van Vuuren et al. 2007; Baer and Mastrandrea 2006; Meinshausen et al. 2006).

The 2007 UCS analysis showed that the U.S. share of this budget would range from 160 to 265 gigatons $CO_2$ equivalent during this period, even if other nations—both industrialized and developing—acted aggressively to reduce their emissions.[14] The United States

12 Parts per million $CO_2$eq—a measurement that expresses the concentration of all heat-trapping gases in terms of $CO_2$.

13 Gigatons $CO_2$eq is a measure of the amount of any greenhouse gas—including $CO_2$ and non-$CO_2$ gases—based on its global warming potential compared with that of $CO_2$. This measure also takes into account the amount of time each gas lingers in the atmosphere. One GT$CO_2$eq equals 1,000 million metric tons $CO_2$eq.

14 The analysts developed the range for cumulative U.S. emissions by comparing the U.S. gross domestic product, population, and current emissions with those of other industrialized nations. The upper end of the range implies heroic cuts in emissions by developing countries. The prudent U.S. approach would be to stay within the mid-range of this carbon budget.

now emits about 7.1 gigatons $CO_2$ equivalent per year, and that amount is expected to continue to rise unless the nation establishes sound climate and energy policies. In fact, to stay within its "carbon budget," the United States would have to reduce its emissions *at least* 80 percent below 2005 levels by 2050 (Luers et al. 2007).

### 1.5. 2020 Targets: The Importance of Near-Term Goals

This long-term U.S. goal for reducing emissions reflects the fact that we need to plan decades in advance to limit our emissions and the severity of their consequences, because heat-trapping gases linger and accumulate over very long periods. Setting short-term and interim targets for 2020 and 2030 is therefore critical—both to ensure that we can meet our long-term goals, and to provide the incentives and certainty that will spur firms to invest in clean energy technologies instead of locking us into high-carbon choices.

The 2007 IPCC report did not recommend specific short-term goals for cutting emissions. However, it did analyze a number of studies to determine an appropriate range of reductions for industrialized nations, to help keep global average temperatures within the 2°C target. The IPCC set this range at 25–40 percent below 1990 levels by 2020 (or 35–48 percent below 2005 levels).

One study published a year later suggested that U.S. reductions of 15–25 percent below 1990 levels by 2020 (or 27–35 percent below 2005 levels)—combined with efforts by other industrialized countries and support for developing countries to keep their emissions substantially below baseline levels—could keep global

**BOX 1.2.**

SUCCESS STORY

## Reinventing Pittsburgh as a Green City

In the late 1860s, as hundreds of factories belched thick black smoke over Pittsburgh, author James Parton dubbed it "hell with the lid off" (Parton 1868). By the 1970s, as the city's industrial economy faltered, Pittsburgh's leaders made "green" buildings part of their revitalization plan. A few decades later, Pittsburgh was named the tenth-cleanest city in the world (Malone 2007).

Today Pittsburgh is a leader in green buildings, and has turned its abandoned industrial sites, known as brownfields, into assets through extensive redevelopment. Pittsburgh has shown that building green can reduce energy demand, curb global warming emissions, save consumers money on utility bills, and stimulate a green economy.

Pittsburgh's David L. Lawrence Convention Center, for example, built on a former brownfield site, is the world's first Gold LEED-certified convention center.[15] Natural daylight provides three-fourths of the lighting for the center's exhibition space, and it has reduced the use of potable water by three-fourths. Sensor-controlled lights, natural ventilation, and other efficiency measures cut energy use by 35 percent—saving the building's owners an estimated $500,000 each year (DLCC 2009; SEA 2008).

Built on an abandoned rail yard, the PNC Firstside Center is the nation's largest Silver LEED-certified commercial building. It uses about 30 percent less energy than a traditional design, and is located near public transportation (EERE 2009). "When we see energy costs going up . . . as much as 20 percent, we think it [energy efficiency] makes fiscal sense for shareholders, employees, and the communities we do business [with]," says Gary Saulson of PNC corporate real estate (The Pittsburgh Channel 2008).

As of July 2008, Pittsburgh had at least 24 LEED-certified buildings, ranking it fifth among U.S. cities (USGBC 2008). Spurred by an initial investment from private foundations such as the Heinz Endowments and Richard King Mellon Foundation, Pittsburgh officials are now actively encouraging such efforts. In 2007, for example, the City Council adopted incentives that allow green buildings to be 20 percent taller than others in their zoning districts (City of Pittsburgh 2007). The city also created the Mayor's Green Initiative Trust Fund in 2008 with money saved through bulk power purchases

15 The Leadership in Energy and Environmental Design (LEED) and federal EnergyStar standards provide a framework and strategies for reducing the environmental impact of new and existing buildings, and can apply to a range of building sizes and uses.

average temperatures within the 2°C target (den Elzen et al. 2008). This analysis accepted the political reality that the United States must be allowed to start from higher baseline emissions, and set much more aggressive targets for Europe, Canada, and Russia to enable the world to remain below the maximum temperature.[16]

Another analysis, the Greenhouse Development Rights framework, considers each country's historical responsibility and current capacity to act. That framework assigns the United States responsibility for financing emissions cuts equal to 60 percent of its 1990 emission levels (or 66 percent of 2005 levels) by 2020. Some 20 percent of those cuts would come from domestic sources, and 40 percent from efforts by other countries to reduce their emissions, funded by the United States (Baer et al. 2008).

Scientific studies alone cannot provide a specific short-term goal for cutting U.S. emissions. However, the urgency of the scientific evidence should compel the United States to set a 2020 goal that preserves our future ability to make even more aggressive reductions as we learn more about what will be necessary to stave off the worst climate impacts. **We therefore recommend that the United States reduce its global warming emissions at least 35 percent below 2005 levels (or 25 percent below 1990 levels) by 2020, primarily through domestic action.**

16 Having not ratified the Kyoto Treaty, the United States has experienced a steady rise in emissions since 1990.

**Pittsburgh's David L. Lawrence Convention Center, which opened in 2003, uses about 35 percent less energy than a conventionally designed building of comparable size—saving the city an estimated $500,000 or more a year.**

(City of Pittsburgh 2008). The fund's mandate includes the launch of a Green Council to oversee Pittsburgh's five-year plan for green initiatives.

Investing in a green economy does more than save energy: it also attracts businesses and creates jobs. The Pittsburgh region expects to see 76,000 jobs related to renewable energy during the next two decades (Global Insight 2008).That trend has already begun with the recent announcement that EverPower Wind Holdings was opening an office in the city (Schooley 2008), and with the startup of two solar manufacturing companies (Plextronics 2009; Solar Power Industries 2009).

Cities and towns play an important role in encouraging more energy-efficient buildings. Stringent energy efficiency standards for buildings, zoning incentives, and tax rebates can encourage a clean economy. Support for targeted education and training for engineers, architects, builders, and other skilled tradespeople will ensure that the local workforce can meet growing demand for employees knowledgeable about green building.

When Pittsburgh's future seemed bleak, architect Frank Lloyd Wright was asked how to improve the city. His answer: "Abandon it!" (University of Pittsburgh 2009). Yet Pittsburgh has shown that a "green" vision, political ingenuity and persistence, and the support of private institutions can revitalize a region's economy, reduce global warming emissions, and provide a stewardship model for the nation.