

Climate Change Policy Commitments: A Reality Check

Ronald J. Sutherland

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Executive Summary

The international community met in Kyoto, Japan during December 1997 with the objective of producing an agreement to reduce greenhouse gas emissions. Prior to the meeting, different governments proposed alternative targets and timetables. For example, the European Union proposed that developed countries reduce their emissions to 85 percent of their 1990 level by the year 2010. Several countries have proposed more modest goals. The U.S. proposed that emissions be limited to 1990 levels by 2008 to 2012. To reflect these alternative proposals, in this study we assume a goal of reducing carbon emissions to 85 percent of their 1990 level by the year 2010 and a second goal of reducing emissions to their 1990 level by the year 2015. These goals bracket the agreement reached in Kyoto. The U.S. has agreed to reduce greenhouse gas emissions to seven percent below their 1990 levels and to achieve this target by the 2008 to 2012 period. Evidence presented in this study applies to the terms of Kyoto as well as to more stringent and less stringent commitments, should they subsequently be considered. This study estimates the adjustments in energy markets in the U.S. required to reach these two targets during the proposed timetables and assesses the feasibility of achieving them.

The main conclusion is that each of these potential climate change commitments is unrealistic because the targets are too stringent given the relatively short time period. Policy efforts to attain either of these potential emission reduction goals would produce enormous adverse consequences to the U.S. economy. The results of this effort indicate that reducing and maintaining carbon emissions in the U.S. at the proposed levels would require unprecedented efforts to limit energy use, the feasibility of which is largely in doubt. These conclusions follow from considering numerous potential actions that may reduce carbon emissions relative to a reference case.

(1) In the Reference Case (no new climate change commitments), the retirement of a large amount of nuclear generating capacity and increases in fossil fuel use will increase future carbon emissions substantially. Achieving either of the policy goals requires the premature retirement of a large segment of the capital stock in the electricity generating sector. Even so, there are limited prospects that any carbon free generating source would be able to meet the required needs for future capacity.

(2) Optimistic, high technology scenarios estimated using the Energy Information Administration (EIA) modeling system indicate that, despite these technologies, carbon emissions will increase throughout the forecast period. Even with these high technology assumptions, the gap between projected emissions and the policy target continues to widen.

(3) The increases in energy prices required to attain the proposed emissions targets are so large as to impose significant costs on all economic sectors.

(4) The percent reduction in fossil energy use required to attain either goal exceeds the reduction that occurred during the 1970s where energy prices increased substantially and real GDP experienced four years of decline. Further, energy use rebounded after the crisis years, as energy prices declined. However, achieving the goals considered here requires reducing emissions from fossil fuel use and then indefinitely maintaining that lower level.

(5) Opportunities to reduce energy use in the commercial sector are rapidly being exploited by energy service companies to the extent profitable. With this new private sector effort, Government efforts are less likely to pass a benefit-cost test.

(6) Opportunities to reduce energy use in energy intensive manufacturing industries are limited by the processes of production. Energy conservation typically requires the substitution of capital for energy. In the industrial sector, capital and energy are used together (as complements) in the production process. New investments are made with the objective of increasing the productivity of capital, labor and energy, and not merely reducing energy use.

The study begins by explaining the historical and projected trends in carbon emissions using a few key variables. To establish a basis for discussion, this study relies upon official government energy and carbon emissions data, especially projections by the EIA. In their Reference Case forecast, the EIA projects that the growth rate of carbon dioxide emissions will double during the forecast period of 1995 to 2015 compared with the historical period of 1980 to 1995. The increased share of nuclear power in the generation market contributed to the declining carbon/energy (C/E) ratio during the historical period. The retirement of a large share of the nuclear gen-

erating capacity contributes to an increasing C/E ratio and rapidly increasing emissions during the forecast period. The projected trends in nuclear power convey an important insight: *the future retirement of a carbon free generating source and its replacement by fossil fuels is an enormous obstacle to the attainment of any emissions reduction target.*

Trends in the C/E ratio and in energy use explain the historical and projected trends in carbon emissions. An energy demand equation explains energy use in terms of economic growth (GDP), energy prices and an autonomous variable that reflects the composite influence of all other factors. Potential climate change policies affect carbon emissions by affecting these variables. A carbon tax or a tradable permits program would increase the price of energy and thereby discourage its use. The development and adoption of new technologies would reduce the autonomous use of energy. The increased use of a carbon free fuel, such as nuclear power, would decrease the C/E ratio and thereby reduce carbon emissions. Each potential policy variable is assessed. The analysis of alternative policy options concludes that: *policy efforts to attain either of the potential emission reduction targets would produce serious adverse economic consequences.* Achieving the 1990 carbon emissions level by the year 2015 would require a large-scale premature retiring of existing productive energy using capital and its replacement by a carbon free energy source that is currently unavailable.

A "reinventing nuclear power" scenario is postulated for the electricity generating sector with the objective of reducing the C/E ratio. In this scenario, all of the demand for new and replacement capacity would be met by nuclear power. The conclusion of this analysis is: *even this dramatic increase in nuclear power plants -- or any other carbon-free technology -- is inadequate to meet proposed targets.* In contrast, the EIA projects almost all new capacity will be fueled by natural gas or coal and there are no realistic prospects for a carbon free technology to capture a large share of the generation market by the year 2015. Thus, carbon emissions in the electricity generation sector will continue to increase in the U.S. because: (1) the nuclear scenario is implausible in that nuclear units are being retired and not ordered, (2) the economics of natural gas units make them highly attractive, and (3) there are no carbon-free alternatives that are low in cost and capable of meeting market demand.

Prescriptions for reducing carbon emissions emphasize the development and use of advanced energy efficient technologies. This analysis is based on results from the EIA's National Energy Modeling System. Various high technology scenarios are postulated by the EIA where advanced, efficient technologies penetrate the market in each sector and increase energy efficiency. Even in their most highly optimistic technology scenarios, the EIA estimates that carbon emissions would continue to increase in each of four sectors over the forecast period (industrial, commercial, residential and transportation). Carbon emissions are lower under high technology scenarios than in the Reference Case, but emissions still increase. The conclusion of this analysis is: *Under highly optimistic assumptions about the cost, efficiency and market penetration of new technologies, energy use and carbon emissions continue to increase in each sector rather than decline.*

The adoption of new technologies affects carbon emissions by reducing energy use as indicated by the autonomous (intercept) term in the energy demand equation. Other variables also affect autonomous energy use. Some Government policy actions reduce energy use without affecting the price of energy. Voluntary Government programs, fuel economy and energy-efficiency standards and structural change within the economy affect the autonomous decline in energy use. The commercial and industrial sectors provide little opportunity for Government sponsored conservation measures to reduce autonomous energy use. In the commercial buildings sector, a rapidly developing industry of energy-service companies specializes in making profitable energy saving investments. The development of this industry implies that unrealized opportunities for "efficiency enhancing" Government conservation actions are rare. In the energy intensive segment of the industrial sector, capital and energy are used together in the production process. There are limited opportunities to substitute capital for energy to reduce overall energy use. Furthermore, if a climate policy increased energy costs to the U.S. (and other OECD countries), but not developing countries, U.S. industries would suffer a significant reduction in output and employment. The analysis of autonomous changes in energy use concludes: *To achieve either of the proposed climate change targets via a reduction in energy use, the autonomous variable would have to decline by a rate that is more than 20 times larger than the reference case. In addition, autonomous energy use would have to continue to decline indefinitely at a rate sufficient to offset the positive effects of economic growth.*

Potential climate change policies also include carbon taxes and tradable permits for carbon emissions. Each of these variables would increase the price of energy and thereby discourage energy use. The Energy Modeling Forum concludes that the demand for energy has become highly price inelastic, which implies that discouraging energy use requires large changes in energy prices. An analysis of changes in energy prices required to achieve emission reduction goals concludes that: *to achieve the proposed climate change targets, energy prices would have to increase by 75 percent or more initially and increase continuously thereafter to offset the effects of economic growth.*

Another way to assess the emission reduction goals is to compare required reductions in fossil energy use necessary to achieve proposed targets with the trend in energy use during the energy crisis of the 1970s. Such a comparison indicates that achieving

either of the proposed targets would require a much larger reduction in the use of fossil fuels than occurred during the 1970s. During this time, real energy prices increased by more than 300 percent and real GDP declined during four of the years. Following the crisis of the 1970s, energy prices declined and energy use increased. By contrast, achieving the proposed climate change targets requires reducing energy use for a 10 to 15 year period at a rate greater than experienced during the energy crisis and then maintaining the use of fossil fuels at the lower level. Maintaining a constant level of fossil fuel use requires continuously increasing restrictive policies to offset the increasing demand for energy due to economic growth. The conclusion of this comparison is: *attaining and then maintaining the use of fossil fuels at one of the proposed lower levels, would require a self-imposed energy crisis of much greater magnitude and duration than experienced during the 1970s.*

I. Introduction

A. Motivation and Purpose

The international community has now met in Kyoto, Japan with the objective of making binding commitments to reduce greenhouse gas emissions (GHG). With the wide press coverage of these negotiations, climate change policy issues have taken center stage. Achieving climate change policy goals requires a substantial reduction in carbon emissions. A contention in the policy debate is that low cost actions can achieve the likely targets. An alternative view asserts that the costs required to reduce emissions substantially in the near term would be prohibitive and would exceed any reasonable estimate of benefits. This analysis considers two specific periods: an historical period from 1980 to 1995, and a forecast period from 1995 through 2015.

Long term climate changes are a complicated reaction to a large number of factors that may include anthropogenic activity. Of the effects on climate caused by human activity, the combustion of fossil fuels is most important, but is only one of many variables. The combustion of fossil fuels results in the emission of several gases into the atmosphere: carbon dioxide, methane, nitrous oxide, halocarbons and others. Carbon dioxide accounts for the dominant share of anthropogenic global warming potential and is therefore the typical focus of attention. However, only about 4.4 percent of overall carbon dioxide sources are anthropogenic; the major sources are natural in origin.¹ The focus of this paper is on carbon emissions from fossil fuels; but we recognize that carbon is one of several greenhouse gases and anthropogenic activity is only part of the global warming issue.

Changes in the Earth's climate depend in part on atmospheric concentrations of carbon and other greenhouse gases, not on emissions in any given year. Even with annual emissions reduced to their 1990 levels, atmospheric concentrations would increase over time. The EIA asserts that stabilizing concentrations requires reducing carbon dioxide emissions by about 50 percent.² Similarly, Jenkins asserts that a reduction of emissions of over 60 per-

cent is required to prevent CO₂ concentrations from rising.³

This paper considers the economic feasibility of attaining a commitment consistent with the Kyoto agreement. We specifically consider an annual emissions target that is more stringent than agreed to and another target that is less stringent than agreed to. The specific question is: *What is the economic feasibility of achieving and maintaining an annual level of carbon dioxide emissions in the U.S. that an international treaty may require?* The actions to reduce emissions will be assessed with data applying to the U.S., and the results will apply to the U.S. economy.

The approach used in this study emphasizes a review of energy market data and of potential energy policy actions. This approach differs from macroeconomic modeling or the use of computable general equilibrium models. Macroeconomic modeling analyses indicate reducing emissions to 1990 levels would require a cost of about three or four percent of GDP (Weyant, 1993); or, perhaps be as low as one percent. Several analysts estimate the costs of attaining emission reduction targets as a required carbon tax, where estimates in the \$100 to \$200 per ton are common. The methodology of this study is first to describe the historical and projected trends in carbon emissions. Second, this study explains these trends with four key variables: the carbon energy ratio, autonomous energy use, GDP growth and energy prices. Third, this study assesses policy options through their affects on the key variables that affect carbon emissions levels.

B. Organization of Report

The approach begins by defining the problem. The first task is to depict the annual level of carbon dioxide emissions during recent U.S. history along with the projected trend in emissions in the Reference Case (which assumes no new international commitments). Potential new policy targets are compared to the base case to indicate the required changes in emission levels. New policy goals are defined as

¹Energy Information Administration, *Emissions of Greenhouse Gases in the United States, 1987-1994*, Washington, DC, October, 1995, DOE/EIA-0573(87-94).

²*Ibid.*, p. 3.

³Jenkins, Geoff, "The Scientific Basis for the Production of Impacts From Climate Change" in Brian P. Flannery, Klaus R. Kolhase and Duane G. LeVine, *Critical Issues on the Economics of Climate Change*, International Petroleum Industry, Environmental Conservation Association, Westbourne Grove, London, 1997, p. 25.

targets and timetables. The international community is considering several targets and timetables. One possible target, proposed by the European Union (EU), is a level of emissions 15 percent below the 1990 levels. In the EU proposal, participating nations would achieve this target by the year 2010. Several participating countries are expressing reservations about such a strict target and timetable. A more moderate target of a 1990 emissions level, achieved by the year 2015, reflects these alternative views.

After describing the carbon emissions trend and proposed targets, the second task (Section II) is to explain the trends in carbon emissions. The explanation focuses on two separate time periods: (1) the historical period of 1980 to 1995, (2) the forecast period of 1995 to 2015. A few key variables can explain the historical behavior of carbon emissions and their future projections. The required changes in these variables indicate the market adjustments required to attain the proposed target levels.

Carbon emissions equal the product of the carbon/energy (C/E) ratio and the amount of energy use (E). Three variables can account for changes in the carbon energy ratio: carbon coefficients for each fuel, changes in the share of each of the fossil fuels and changes in the share of fossil energy relative to total primary energy. The analysis in Section II indicates that carbon coefficients for each fuel have remained about constant over time. Shifts in fossil fuel shares (between natural gas and coal) also fail to explain the trends in the C/E ratio. The C/E ratio decreased historically because of the increased market share of nuclear power. The C/E ratio will increase in the forecast period because of the retirement of a large number of nuclear units and their assumed replacement by fossil fueled plants.

Changes in aggregate energy use can partially explain carbon emissions trends. An energy demand equation, proposed in Section II, accounts for energy use in terms of three variables: GDP growth, energy prices and autonomous changes in energy consumption. This demand equation accounts for the projected growth rate of energy use during the forecast period. The main factor that contributes to the growth of energy demand is overall economic growth, as measured by real GDP. Such a relationship is expected because the expansion of economic activity and increasing use of energy typically occur together. Autonomous declines in energy use may partially offset the income effect produced by eco-

nomic growth. Historically, changes in the price of energy have had a major influence on energy use; however, the EIA projects energy prices to be nearly constant. Thus, as documented in Section II, the main factors contributing to future carbon emissions are projected economic growth and an increasing C/E ratio. The projected increase in the C/E ratio is caused by the retirement of nuclear plants and their replacement by fossil fueled plants.

Section III assesses various policy options that may affect carbon emissions via their affect on the key variables defined in Section II. A "reinventing nuclear" scenario assumes that all future generating capacity additions are nuclear. In this case, increased electricity use does not result in increased carbon emissions. The result of the assessment is that the projected path of carbon declines, though not at a rate sufficient to achieve a climate change goal. Thus, the nuclear scenario would not produce the required reduction in carbon emissions.

The climate change policy that is most often discussed is the development and adoption of new and efficient conservation technologies. The results from a modeling analysis performed by the Energy Information Administration as part of their long term energy forecasts are reported in Section III. In the EIA analysis, new and efficient technologies enter the capital stock as older and less efficient capital is retired. However, the analysis indicates that carbon emissions continue to increase in each of four sectors: residential, commercial, transportation and industrial. Thus, a technology based climate policy would leave the U.S. far short of achieving proposed emissions reduction targets.

Climate policies could attempt to reduce energy use by increasing the cost of energy, or by reducing autonomous energy consumption. Carbon taxes and tradable permits are potential policy actions that would increase energy prices. Fuel efficiency and energy efficiency standards are examples of policies that would produce an autonomous decline in energy use. An aggregate energy demand model is used to estimate the magnitude of energy price increases and autonomous energy decreases required to achieve the proposed targets. Achieving either of the proposed targets requires major adjustments in energy markets that include investments in new capital.

The proposed emission reduction targets are more ambitious than the U.S. can reasonably expect to

achieve. To illustrate this point, the potential targets are compared with the reductions in energy use that occurred during the energy crisis years. The reductions in fossil energy required by the targets are larger than what occurred during the 1970s. Energy markets recovered from the disruptions of the 1970s as prices gradually fell and energy use increased. In contrast, climate policy targets are meant to be permanent and gradually become more stringent. Reducing the demand for energy on a permanent basis requires that energy prices rise continuously.

C. Carbon Emissions -- Historical Experience and Projections

This study makes extensive use of Government data, mostly obtained from the Energy Information Administration (EIA). The EIA is the official provider of energy data and is generally regarded as objective and reliable. Most of the historical data is obtained from the EIA's, *Annual Energy Review 1996*, which is referred to here as AER96. Most of the data for the

forecast period is from the EIA's *Annual Energy Outlook 1997*, which is referred to as AEO97. The EIA presents some additional projections in their *Issues in Midterm Analysis and Forecasting 1997*, which is referred to as *Midterm Analysis97*. A previous volume, *Midterm Analysis96*, also is referenced. The EIA, in *Emissions of Greenhouse Gases in the United States 1987-1996*, provides some additional data on carbon emissions.

The historical and projected trends in annual carbon emissions in the U.S. provide an important insight into the challenge of a climate change policy. The EIA projects carbon emissions in the U.S. to grow in the future at twice the rate of the recent past. During the historical period of 1980 through 1995, the growth rate in emissions averaged only 0.6 percent per year (see Figure 1). In AEO97, the EIA estimates a Reference Case that describes a most probable future, but one without new international commitments. In the Reference Case, annual carbon emissions in the U.S. will increase by 1.2 percent per year

Figure 1
Total Carbon Emissions In The U.S. Under Alternative Scenarios
(Million Metric Tons)

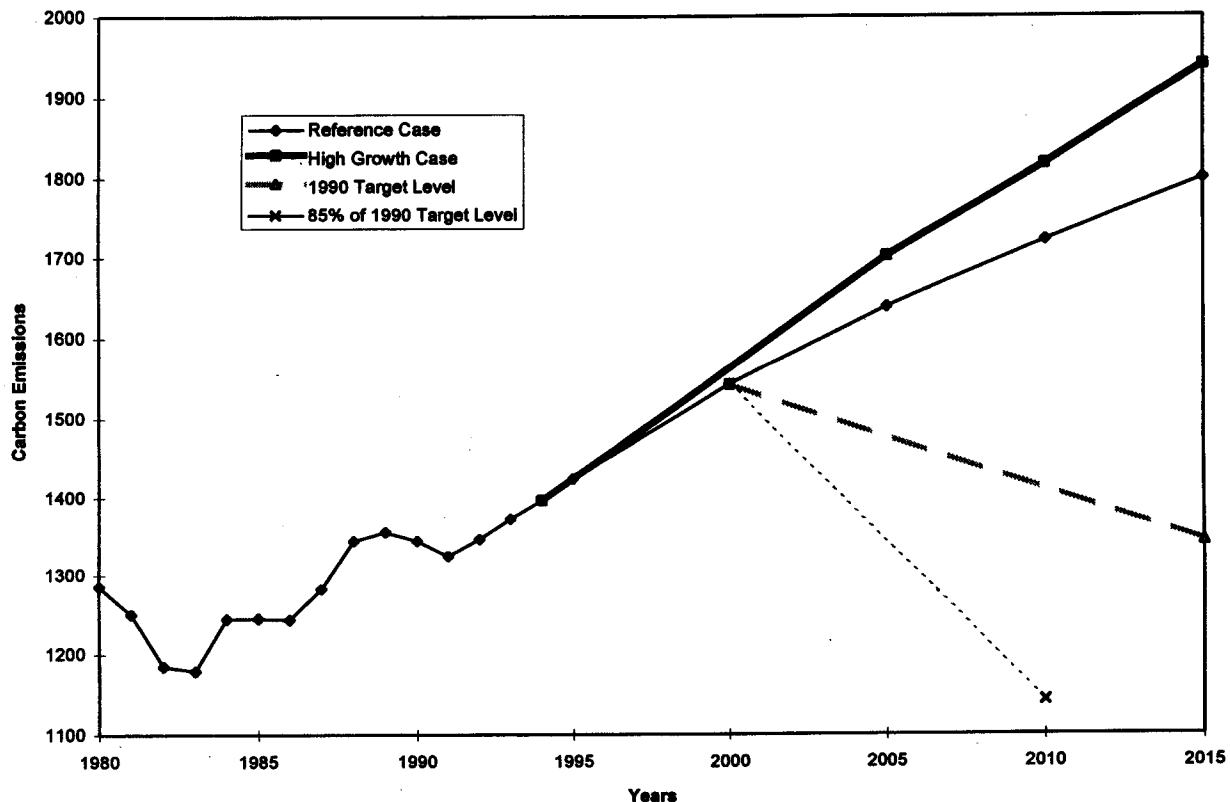


Table 1
Required Reduction In Carbon Dioxide Emissions
From Projected Levels In Year 2015 Or Year 2010

Required Emission Reduction	Million Metric Tons	Percent Change
Base Case Growth to Year 2015 (1990 emissions level target)	455.1	-25.3%
Base Case Growth to Year 2010 (.85 x 1990 emissions level target)	579.8	-33.7%
High GDP Growth to Year 2015 (1990 emissions level target)	596.4	-30.7%
High GDP Growth to Year 2010 (.85 x 1990 emissions level target)	675.3	-37.2%

Note: The emissions data used to construct these estimates include 1799.3 million metric tons, which is the EIA Reference Case projection for 2015, and 1344.2 million metric tons, which is the 1990 level of these emissions.

through the forecast period of 1995 to 2015. A doubling of the emission rate in the base case requires an explanation and raises concerns about the magnitude of the task of achieving future emission reduction targets.

The EIA projection of carbon dioxide emissions in the Reference Case reflects assumptions about future world oil prices, population growth, existing climate change policies and other variables. In the Reference Case projection, the EIA assumes a growth rate of real GDP of only 1.9 percent per year. The DRI forecast for the same period is 1.9 percent per year, while the WEFA forecast is a little higher at 2.2 percent per year (AEO97, p. 76). The growth rate of real GDP over the 1980 to 1995 period was 2.53 percent per year (AER96, p. 15). A high growth rate scenario, as defined by the EIA, is also considered. As depicted in Figure 1 in this scenario, the level of carbon emissions in the year 2015 is considerably higher than in the Reference Case.

Figure 1 also depicts the emission levels of the two targets and illustrates the attainment of these levels with a linear path. Even if participating nations reach an agreement in the Fall of 1997, some time lag would exist until the international agreement is ratified, implemented and begins to reduce emissions. The effect of potential new policies is illustrated by allowing for a policy adoption lag of about two years. Emissions begin to decline in the year 2000 and decline (linearly) until the target goal is reached in the year 2015 or 2010. The linear path simply connects the initial emissions level with the target

level. This analysis focuses on the potential targets and timetables and not the interim path. Achieving the target of a 1990 emissions level requires first that emissions stop increasing, and second, that emissions actually decrease. The policy actions that would achieve either of these goals would be much different from the current policies that are part of the base case projection. Indeed, the message from Figure 1 is that achieving either policy goal would require major adjustments in energy markets.

Table 1 depicts the required reduction in emissions to meet the targets in both absolute and percentage terms. The two targets are the 1990 emissions level, to be achieved by 2015 and 85 percent of the 1990 level, to be achieved by 2010. In the EIA Reference Case, the annual level of carbon emissions in the U.S. will be 1799.3 million metric tons (mmt) by the year 2015. Achieving the 1990 target requires a reduction in emissions of 455.1 mmt, or 25.3 percent of the projected Reference Case level. Achieving the more ambitious target in the year 2010 requires a reduction in emissions of 579.8 mmt of the Reference Case. However, GDP, energy use and carbon emissions may grow at a faster rate than assumed in the EIA Reference Case. For instance, in the Stanford University, Energy Modeling Forum 13, the baseline growth rate in real GNP is projected to be 2.3 percent per year, versus the EIA's 1.9 percent per year.⁴ Using the higher GDP growth rate, the required re-

⁴ Energy Modeling Forum, *Markets For Energy Efficiency*, EMF Report 13, Volume 1, Stanford University, September 1996, page 5.

ductions in emissions to achieve the 2015 and the 2010 targets are 30.7 and 37.2 percent, respectively.

The rate of decrease needed to achieve such percentage reductions is beyond anything experienced in U.S. history.