

ENERGY DEMAND SCENARIOS FOR BUILDINGS AND THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE'S FOURTH ASSESSMENT REPORT

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ABSTRACT

This paper reviews the scenarios developed for the Intergovernmental Panel on Climate Change (IPCC) analysis. It pays particular attention to the applicability of these scenarios to the analysis of energy demand, energy savings, and reductions of CO₂ emissions for the buildings sector. It reaches the conclusion that the methodology involved in creating the scenarios presented in the IPCC's Special Report on Emissions Scenarios (SRES) – which contains little information about energy demand and efficiency – causes considerable difficulties in estimating energy efficiency gains or reductions in CO₂ emissions from the baseline.

We have developed an alternative approach which relies on studies of efficiency potentials in individual countries. These studies are disaggregated to the level of individual building energy end-use technologies. This appears to be a robust methodology. Using this technique, CO₂ reductions of 30 percent are estimated to be cost-effective in a 20-year time frame. We note however that such reductions are highly unlikely unless very significant policy efforts are instituted to bring them about.

KEYWORDS

IPCC, energy demand, climate change, CO₂ reduction

INTRODUCTION

There are many uses for scenarios. The scenarios developed for the IPCC, based on the SRES report, show a very wide range of trajectories for energy and energy-related carbon dioxide emissions over the next 90+ years. These scenarios raise particular difficulties in analyzing policies to reduce growth and/or absolute value of greenhouse gas emissions, because they are driven by macroeconomic and socioeconomic drivers and have little information about energy demand. I report here on our efforts to overcome these difficulties to estimate potential reductions in CO₂ emissions through energy efficiency and to a lesser degree renewable energy use in buildings in a 20 and 30-year time frame.

I am taking this opportunity to share some of my views about the role of scenarios in addressing climate change issues. I have concerns about many aspects of the scenario analysis, as exemplified by the IPCC 4th Assessment. I believe the scenarios presented yield such a multiplicity of results that they render policy analysis virtually impossible. In this paper, I report on our efforts to overcome these difficulties to estimate potential reductions in CO₂ emissions through energy efficiency and to a lesser degree renewable energy use in buildings in a 20 and 30-year time frame.

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DECRPTION OF SRES APPROACH AND RESULTS

The source of the scenarios for the IPCC reviews was the Special Report on Scenarios (SRES) in which many different modelers were asked to perform analyses using similar inputs for each of a series of four different future states of the world. (Note 1) The multiple scenarios created by a number of modelers were grouped into four families labeled A1, A2, B1, and B2. In simplified terminology, A1 represented a world of high economic growth in which, through rapid technological gains and openness in markets, education, and education the developed and developing worlds achieve increasing economic convergence. A2 represents a world in which nations "consolidate" into a series of economic regions. Economic growth is uneven, the gap between industrialized and developing countries remains wide, population growth is high, and per capita income is low relative to other cases (especially A1 and B1). The central elements of the B1 future are a high level of environmental and social consciousness combined with a globally coherent approach to a more sustainable development. In the B2 world, dynamics of technological change continue along historical trends ("dynamics as usual"). Increasingly, government policies and business strategies at the national and local levels are influenced by environmentally aware citizens, with a trend toward local self-reliance and stronger communities. International institutions decline in importance in this scenario.

Figures 1–3 presents results of applying a range of models, with generally unified assumptions about population growth, economic growth, patterns of economic growth among different regions, energy supply (including carbon intensity of supply) for each of the individual classes of scenarios.

Figure 1 presents the results for the A1 family of scenarios, the high economic growth case. There is a large variation in results for 2100 when all of the economic, population, and energy demand drivers are intended to be the same. This may not be so surprising, but it is noteworthy that the range of carbon emissions from these cases varies by a factor of 2 in 2020, a very large range for such a short period from the present. The IPCC notes that "rapid economic growth in the A1 family scenario leads to "high energy demand and hence to a steep increase in CO₂ emissions in the first decades of the 21st century. Structural changes in the energy supply become effective only in the longer term because of the inertia caused by long periods of capital turnover." With respect to alternative energy supply technologies, the A1B scenario group assumes a "balanced" approach, in which none of these technologies gain an overwhelming advantage. In addition to the A1 scenario group, variations that assumed fast advancements in specific energy supply sectors were explored (renewables, A1T; oil and gas, A1G; coal, A1C).

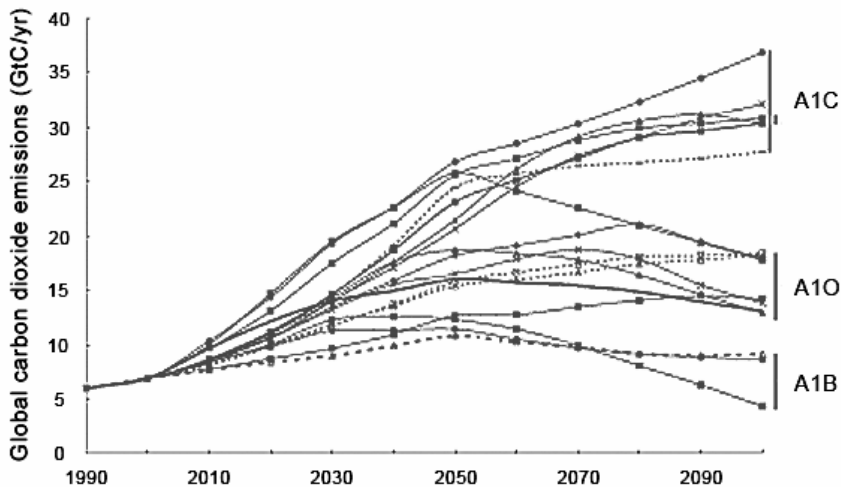


Figure 1: Global CO₂ emissions from fossil fuels and industry in the SRES A1 scenario family (standardized). The marker scenario is shown with a thick line without ticks.

Only the A1T (renewable) could yield an atmospheric concentration of CO₂ eq on the order of 450 ppm, a level that is thought to be acceptable by most scientists. A10 (oil and gas), and A1C (coal) are very far from the desired levels of CO₂ eq and A1B (balanced supply) might reach the dangerously high levels of 600 to 700 ppm (a wide range because of the large range of results for this case).

The problem with scenario A1T is that it is extremely unlikely. The high carbon emissions in the A1C and A10 cases (highest lines in the figure) represent the rapid growth in demand that is satisfied by coal, oil, and gas. To reduce emissions, A1T has to assume that virtually all additional energy supply – which is projected to triple by 2030 in the cases shown – would come from non-carbon sources. This is clear if one recognizes that the energy demand is similar in all the cases, with emissions reductions coming from different choices of energy supply.

We now turn to the B1 family of scenarios. These are the cases with the lowest emissions of all four of the families. Figure 2 presents the results for these cases. This Figure shows a wide range of carbon emissions for scenarios that are thought to be driven by the same variables. In 2050, the highest case is more than twice the lowest. It will lead to a CO₂ level of more than 650 ppm, a level generally thought to be a level with very serious consequences to mankind. This is particularly unnerving when one recognizes that the B1 family is the environmental case for the IPCC (albeit described as an environmental conscientiousness without explicit effort to reduce GHG scenarios). The lowest cases give results comparable to the renewable case for the A1 family, ~ 500 ppm CO₂. But we are led to ask: what is the difference between the high and the low scenario for these two “identical” cases. Because one result represents a calamitous situation and the other possibly

manageable, it seems that it would be important to know just what is happening. It is very difficult to know.

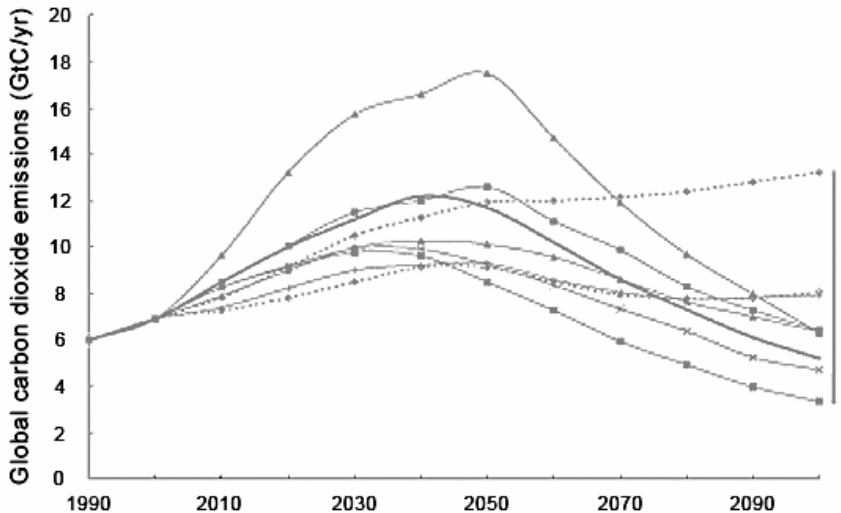


Figure 2. Global CO₂ emissions from fossil fuels and industry in the B1 scenario family (standardized). The marker scenario (Note 2) is shown with a thick line without ticks. The assumptions underlying the scenarios are similar or identical. The differences are due to the use of different models.

CRITIQUE OF THE SCENARIOS GENERATED IN THE SRES

The first critique has been stated, but is worth restating. The SRES results produce a large number of scenarios, and exercise many different models. It is, as the example of the A family of scenarios in Figure 1 demonstrates, possible to show differences in results on the supply side among the scenarios. Not surprisingly, the models demonstrate that scenarios emphasizing coal have higher emissions of CO₂ than oil and gas and that renewables have the least. However, Figure 1 also shows that the individual supply cases (i.e., A1O, A1C) have very large variations among different model runs. And in the case of the B1 family, the scenarios differ very markedly even though they are describing the same “reality.”

My second critique is the lack of transparency in the models. This may be an unavoidable feature of such models, but it is nonetheless distressing. It is important to understand the features of the models and their assumptions. I believe that per capita energy use and carbon dioxide emissions are likely to become valuable parameters in assessing long-term scenarios. It is people who use energy, either directly through heating and cooling houses and driving or indirectly through the embodied energy in all the products they consume. Such an approach may lead to useful insights.

The third critique brings us to the main point of the Chapter. With a multiplicity of scenarios to choose from – Figure 3 shows the entire array of scenarios generated in the SRES exercise – how is one to

evaluate the role of energy efficiency in energy futures? We know that energy efficiency is of great importance. But we are left with a bewildering array of scenarios and little guidance on how to use them to address a very important issue: how much could energy efficiency cut energy demand in a period of the next 20 to 30 years, our primary responsibility for the IPCC 4th Assessment.

Approach to addressing the problem

Credit for finding a way out of this morass belongs to Diana Urge-Vorsatz and Aleksandra V Novikova. Their reasoning was as follows. They had gathered studies from major countries throughout the world that estimated cost-effective energy efficiency potentials for the year 2020 as compared to a business as usual case. In most cases, the business as usual scenario was the official projection of the country of interest.

This approach has the following features:

- The scenario for a given country is based on the expertise that exists within the country
- The energy efficiency measures are not double counted; if they were in the business as usual case, then they would not be included in the policy case
- The approach makes clear that policies and energy-efficiency technologies make a difference – indeed a significant difference.

They then divided the world up into regions in which the analysis of reductions in CO₂ emissions for one country in the region is extrapolated to the entire region. (Note 3) This permits an estimate of the potential for CO₂ emissions in buildings without reference to a global scenario. Rather, the estimate is based on business as usual (BAU) cases for individual countries (extrapolated to regions). Once this process is completed for each region of the world, then the global reduction in CO₂ emissions are calculated as the sum of the regional emissions; reductions in emissions are calculated in the same way. The fraction savings for a given year is then the annual reductions in CO₂ emissions divided by the total CO₂ emissions in that year.

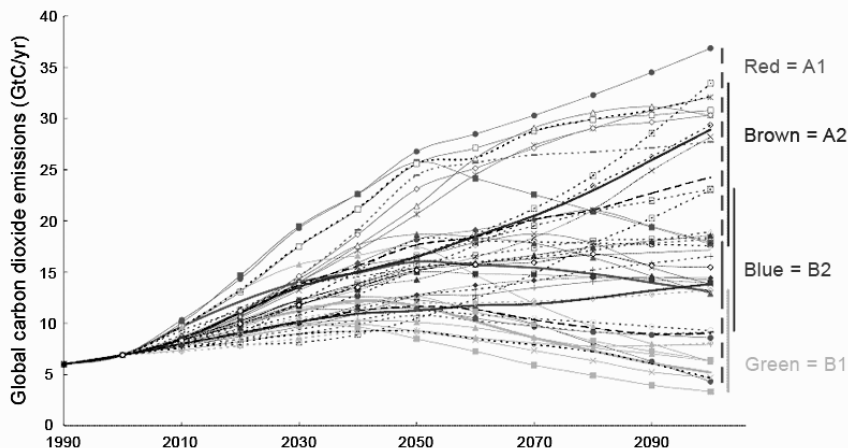


Figure 3. The range of BAU scenarios developed in the SRES.

In order to compare these results with the IPCC scenarios, we have chosen a high (A1B) and a low (B2) case. As shown in Table 1, the emission levels in these two cases are “moderately” high and low for the years of interest, 2020 and 2030; we ignore extreme cases in Fig 3.

Table 1. G tonnes CO₂ in year and different BAU scenarios indicated

2004	BAU Scenario	2020	2030
8.6	B2	10.2	11.4
8.6	Analysis of country studies	11.1	14.3
8.6	A1B	12.4	15.6

The key finding from the analysis of individual country studies presented in Chapter 6 of the Working Group III IPCC report is that approximately 30% of carbon emissions in the BAU cases can be avoided by 2020. Under these circumstances, comparing 70% of the 2020 BAU emissions with the 2004 emissions suggests that emissions in 2020 could be 7.8 Gt or 9 percent below today's levels. In the B2 case with 30% reduction in demand, carbon emissions in 2020 would be 17 percent below today's levels! Even for the high BAU (A1B), emissions in 2020 would be just slightly above the levels of today. Because energy efficiency gains compound, the same qualitative conclusions apply to 2030 as well.

There is one factor that suggests that considerably greater reductions in emissions are possible and another than tempers optimism. I'll start with the bad news: the energy efficiency measures are both real and cost effective. Unfortunately for a wide variety of reasons, they are generally not adopted. If they were, then our message about the large cost-effective savings and CO₂ would be impossible. They would have already been employed. Major policies – including building and appliance standards, regulations, incentives, and a wide variety of other programs are needed to remove barriers to the energy efficiency that can be removed.

The good news is that there are two ways to achieve CO₂ reductions in buildings, one of which is not included in the 30% savings estimates. Because most of the energy used in buildings is electricity (on a resource basis, 70 percent of energy used in buildings in the United States is electricity), any measures that decarbonizes electricity contribute to CO₂ reductions associated with energy use in buildings. There is considerable potential for decarbonizing electricity, which we have not addressed in our chapter and only peripherally in this paper.

Thus, it should be clear that buildings deserve serious attention when considering measures to reduce CO₂ emissions. The considerable complications associated with the myriad of scenario base cases may tend to obscure this fact; this paper, I hope, helps to sort through this complexity. After sorting through the complexity, I for one believe that the building sector offers significant opportunities for mitigating CO₂ emissions.

NOTES

1. Special Report on Emissions Scenarios, IPCC, Oxford University Press, 2000.
2. The marker scenario is taken to be representative of the family.
3. Our work concerned CO₂ emissions from energy use in buildings, so we do not address energy savings potentials in other end uses (industry, transportation, agriculture).