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POLICY BRIEF

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Climate change policies and energy use in developing countries, Central Europe and the Commonwealth of Independent States

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Climate Change: The Unwanted Consequences

The concentrations of several atmospheric gases are increasing as a result of human activities. These gases[1] affect the global energy balance by partially absorbing outgoing infrared radiation, resulting in increased global surface temperatures. This is the basic mechanism commonly called the greenhouse effect.

There is no question that the greenhouse effect is real. Without carbon dioxide in the atmosphere, the planet would be cold and lifeless with average atmospheric temperatures 33 degrees Celsius colder than today. The real concern is what will happen as concentrations of key greenhouse gases increase. Venus is the extreme example as more than 90% of its atmosphere is CO_2; its surface temperature is 477 degrees Celsius.

On earth, atmospheric concentrations of CO_2 began increasing during the Industrial Revolution, beginning in 1860, from 270 ppm (parts per million) to the current 353 ppm. For a doubling of CO_2 over preindustrial levels (540 ppm), scientists predict a warming of 1.5-4.5 degrees Celsius. At current rates, this doubling will occur sometime around the middle of the next century.

Some countries may well adapt to these changes, while for others the changes will likely cause massive hardship. Unfortunately, those countries with the fewest resources and who have contributed the least to the problem, are the ones who may suffer the most.

There is no question that the greenhouse effect is real.

Countries such as Egypt and Bangladesh will not find it easy to escape the damage of rising oceans. But countries with more resources may find it possible to adapt by using technology or by relocating population and economic activity. Also higher temperatures and lower soil moisture will make it even more difficult to grow crops in drought-ravaged Africa where thousands starve every year.

Detecting evidence of increasing global atmospheric temperatures is complex and is difficult because these temperature changes do not occur immediately. The huge thermal mass of the oceans delays the temperature change from the time that CO_2 enters the atmosphere.

Thus, we often refer to this expected temperature change as a temperature change commitment, meaning that the future global temperature will increase as a result of past carbon emissions. Estimates of the magnitude of these lags range from one to several decades. Fierce debate rages over whether or not we can detect a signal that temperatures are rising because of CO_2 accumulation in the atmosphere.

The National Academy of Sciences reports that temperature has increased from 0.3 to 0.6 degrees Celsius over the last 100 years but stops short of blaming the change on the greenhouse effect: "This temperature rise could be attributable to greenhouse warming or to natural climate variability..."[2]

Effects of Increasing Temperatures:

- An increase in the number of extreme weather events, such as droughts, extended hot periods, hurricanes, and tropical storms.
- A sea-level rise brought about by the melting of the polar ice packs and thermal expansion of the oceans.
- Changes in soil temperatures and soil moisture requiring major adjustments in current agricultural practices.

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What Causes Climate Change?

While several gases are responsible for altering the planet's climate, the largest single source is carbon dioxide.

The primary source for CO_2 is the combustion of fossil fuels. As oil, gas, and coal burn, they release carbon that has been in the earth for thousands of years. The continued buildup of CO_2 in the atmosphere ties directly into the use of fossil fuels for transportation, generating electricity, and other industrial and consumer uses. A secondary source is deforestation; forests act as a large carbon sink. Removing trees eventually results in the release of their carbon, either through decomposition or burning.

The importance of the individual gases as contributors to climate change depends on three factors: the quantity of emissions, their absorption capacity, and their atmospheric lifetime. Obviously, the greater the emissions of any one gas, the larger a contributor it is.

The absorption capability of the gases refers to the ability to change the global solar balance by trapping outgoing infrared radiation.[3] By this measure, the CFCs are most effective, and CO_2 the least. Because of this capability, very small quantities of CFCs can have the same effect as large quantities of CO_2.

Finally, atmospheric lifetime is an important, but often overlooked, factor. Methane has a short atmospheric duration (10-14 years) compared to CFC-12 (130 years) and CO_2 (50-200 years). So while methane may have greater absorption capability, it does not last as long as some other gases. This reduces its overall impact.

Many suggest that any action to limit climate change should include all gases. Under a comprehensive approach, such action might include weighting different gases by some measure of their effectiveness. Then each country would have to decide how to reduce its total greenhouse emissions. However, we may have to limit upcoming action to controlling CO_2 emissions for several reasons.

CFC Phaseout

There is international agreement to phase out CFC use by 2000[4] but not because of the threat of climate change. Instead we realize that when CFCs break down in the upper atmosphere, their chlorine molecules destroy ozone molecules. And this results in increased levels of ultraviolet radiation reaching the earth.

The discovery of the ozone hole over Antarctica in 1987 dramatically exposed the pace of this destruction. Recent satellite data indicates levels of chlorine high enough to result in springtime ozone losses of 30 to 40% over the Arctic in the next few years[5]. The area affected would reach populated regions over northern Europe. This has led to calls for an even

Figure 1: Historical Emissions of CO_2 from Fossil Fuels, 1950-1988

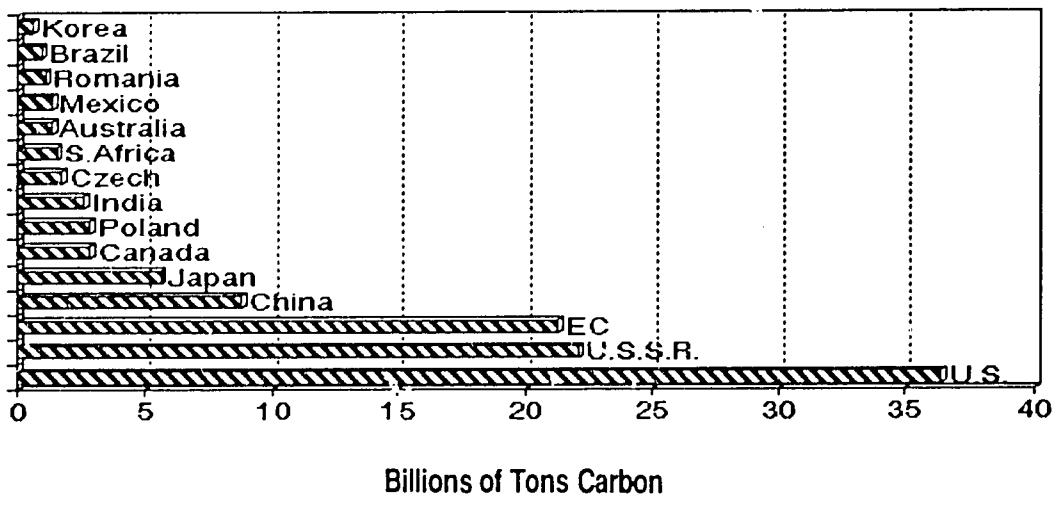
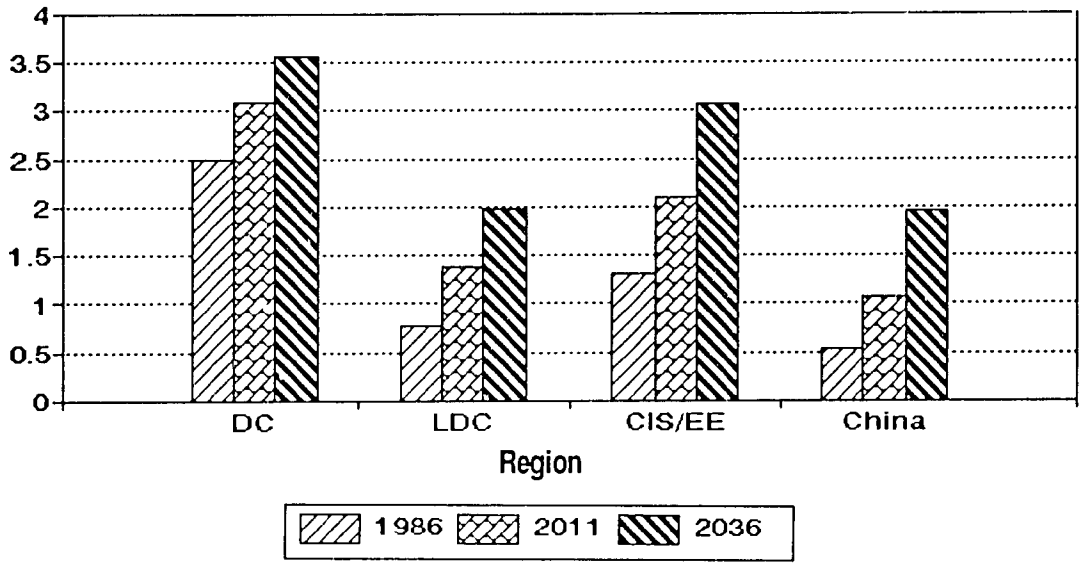


Figure 2: Current and Projected CO_2 Emissions (Billions of tons Carbon)



faster phase-out of the ozone-depleting substances.[6] Although substitutes also may prove to be greenhouse gases, their greenhouse effect is now uncertain.

Uncertainty: the Possible Importance of Agriculture

While the sources and sinks of carbon are fairly well-known, this is not true for many of the other gases, particularly methane and nitrous oxides. There are various sources of methane. These include coal mining, transmission of natural gas, decomposing garbage in landfills as well as from biotic sources such as swamps, termites, cattle, and rice paddies.

There are rough estimates of how much methane these sources release; however, much uncertainty exists. Further, recent research shows that we have overestimated the importance of biological methane sources since previous estimates have ignored the recycling of carbon. For example, to calculate the greenhouse impact of methane emitted from cattle, one also must consider the CO_2 that their feed-growing process removes from the atmosphere.[7]

The primary source of nitrous oxides is the decomposition of nitrogen fertilizers. Future emissions depend not only on future agricultural practices, but also on the rates of decomposition. Some studies suggest that it will take hundreds of years for the full nitrogen release to occur.[8]

The Role of Central Europe and the Commonwealth States

Future actions of this region are a large unknown in figuring future climate. The former Soviet Union and Eastern European countries were notoriously inefficient users of fossil fuels, using far greater quantities per unit of GNP than the industrialized countries. In the short term, the economic decline of this region may result in lowered emissions. Future emissions will depend on a variety of factors.

If the region reached Western-style GNP levels without improving overall energy efficiency levels, emissions would be vastly larger than those from the West. It is more likely that, as fuel subsidies disappear, awareness of past inefficiencies will increase. This would make it possible for this region to achieve high levels of economic growth without increasing overall emissions. This should be the goal for these countries.

The Response of Developing Countries to Climate Change

Climate change is clearly a global problem. Several questions arise about developing countries' role in limiting climate change.

Is Their Role Important?

Historically, emissions of CO_2 from developing countries have been relatively unimportant (Figure 1). The U.S., followed by the former USSR (now the Commonwealth of Independent States (CIS)) and the European Community (EC) were the largest contributors from 1950 to 1988. However, developing countries will play a more important role over time because of their projected population growth rates (Figure 2)[9]. A secondary cause will be their increased demand for energy products as their income levels increase.[10]

Citizens of the industrialized world are responsible for emitting 11.9 tons of CO_2 per capita per year, 10 times more than their counterparts in developing countries (1.1 tons).[11] And 50 years from now, projections show that people in industrialized countries will be emitting 15 tons per capita. But, even with optimistic assumptions of income growth, it is unlikely that per capita emissions in developing countries will be greater than 2.2 tons per capita.

However, because of expected population increases, emissions of CO_2 from the developing world, including China, will exceed those of the industrialized world. So while per capita emissions may be low, total emissions will become very important. The implication is that we need global action. Unilateral action by any one group or country will be ineffectual.

Where Should the CO_2 Reductions Come From?

To be fair and effective, industrialized countries must take the lead in reducing emissions. These countries have created the problem and also can greatly reduce per capita emissions, a task not so simple in many subsistence-level countries. Two examples help clarify this point.

The average U.S. auto emits 1 lb of CO_2 for every mile driven. In one year, each car will contribute as much to global warming as does the total energy use of five people in a developing country. Similarly three normal 100 watt light bulbs used for a year result in emissions of CO_2 equal to that of the energy use of one person in a developing country[12]. Various options exist for reducing the emissions from these two sources, including efficiency improvements, fuel switching, conservation, and car pooling.

For developing countries, limiting future emissions may require using efficient energy products, reducing population growth rates, and slowing the rate of deforestation.

Efficient use of energy products requires that developing countries begin using the most efficient technologies available for lighting, cooking, transport, and other daily uses. It also requires that countries end subsidies of such energy products as gasoline and electricity. Subsidies give an artificial stimulus to their use. Removing subsidies lessens growth in demand and increases economic efficiency.

Population growth rates have an important connection with environmental degradation. Even if countries manage to reduce current per capita emission levels significantly, projected increases in world population will more than offset the effect of these reductions.

Slowing deforestation is important for reducing CO_2 emissions. Estimates of carbon released from deforestation for the top 10 countries show that most of the world's deforestation occurs in the developing regions, Table 1. Slowing this rate is highly desirable since the world's forests are a huge source of carbon, and deforestation emissions account for 20 to 25% of total world-wide emissions. Emissions of CO_2 from Amazon forests were the largest single deforestation source in 1988, producing about 1.6 billion tons of CO_2, or about 2.3 times the amount from U.S. cars.[13]

Who Should Pay?

Should African nations make cash payments to the U.S. to produce less CO_2? That's not fair. But what about payments in the other direction? The rationale is that since the industrialized countries created the problem, they should pay the costs of fixing it. Is this still a valid argument given that industrialized nations were unaware of the effect of their actions until only recently?

In one year, each car will contribute as much to global warming as does the total energy use of five people in a developing country.

Developing countries will require assistance if they are to reduce their emissions. This assistance could either be in the form of direct payments or technology transfer. Direct payments would allow developing countries more latitude on spending the money but would not ensure that money would go to the intended purpose. If aid included transfer of technology, there would be more control over spending and a larger portion would remain in the donor countries.

Financial aid could come from international taxes on fossil fuels and include such items as:

•Providing compact fluorescent light bulbs to developing countries. An 18 watt compact fluorescent compares favorably with a 75 watt incandescent in light output but costs a fraction to operate. But developing countries will not begin using them because they cost about $20 per bulb.

•Helping develop energy systems that release no CO_2. Examples include biomass fuels, wood-fired electrical generation, hydro facilities, solar power, and nuclear energy.

•Providing technology and funding for mass transit and for increasing the overall efficiency of motor fleets.

•Financing reforestation projects or efforts to slow deforestation.

Will These Measures Stop Climate Change?

The Intergovernmental Panel on Climate Change (IPCC) says that we need to reduce CO_2 emissions by at least 60% to stabilize the atmosphere at the current concentration.[14] Given estimates of future emissions it will be very difficult to slow the onset of global warming significantly without radical changes in energy consumption and population growth rates (Figure 2).

Table 1: Estimates of carbon released from deforestation for top 10 countries, 1989, in millions of tons carbon. (Source Andrasko)

Brazil	454
Indonesia	124
Burma	83
Mexico	64
Thailand	62
Colombia	59
Nigeria	57
Zaire	57
Malaysia	50
India	41

Are such radical changes likely? A recent National Academy of Sciences report shows that the United States has technology to cut its emissions by 1/3 at very low costs.[15] Clearly, if the U.S. undertook such a program, there would be a diffusion of technology and political enthusiasm around the world. The results would likely have a major impact on future worldwide emissions.

A Model to Analyze Policy

Comparing policies for slowing climate change is a difficult process. Several computer-based models have been developed to do this. A simulation model for the PC has been tested at Cornell University. This Model of Economic Development and Climate Change[16] is designed for easy interactive use. It allows the user to explore the complex relationships between energy use, forestation, technological change, economic growth, and climate change. In addition, the model allows the user to see what impact international agreements, such as emission freezes or reductions, or emission trading schemes may have on future climate. The model is ideal for classroom use, providing detailed graphic output summarizing the results of user-defined simulations. The model is available from the authors.

Notes

[1]The major greenhouse gases include carbon dioxide (CO_2), methane (CH_4), chlorofluorocarbons (CFCs), and nitrous oxide (N_2O).

[2]National Academy of Sciences. 1991. Policy Implications of Greenhouse Warming. Washington: National Academy Press, p. 2.

[3]The absorption capability is commonly referred to as instantaneous forcing weights. The instantaneous forcing weights for selected gases on a per unit weight basis are: CO_2, 1; CH_4, 58; N_2O, 206; CFC-11, 3970; and CFC-12, 5750.

[4]The terms of the agreement are laid out in the Montreal Protocol and subsequent London Amendments. See: Montreal Protocol 1987. "Montreal Protocol on Substances that Deplete the Ozone Layer," International Legal Materials, 26: 1541; and London Amendments 1991. "Adjustments to the Protocol," International Legal Materials, 30: 537.

[5]The 1992 thinning was limited to 20% due to warmer than average winter temperatures. See: Kerr, R. 1992. "Not over the Arctic - for Now," Science, p. 734, May 8; and "New Assaults Seen on Earth's Ozone Shield," Science, 797-798, February 14.

[6]Hilts, P. 1992. "Senate Backs Faster Protection of Ozone Layer as Bush Relents," The New York Times, p. A1, February 7. The U.S. has announced the goal of complete phase-out of all CFCs by 1995.

[7]Drennen, T. and D. Chapman 1992. "Biological Emissions and North-South Politics." In J. Reilly and M. Anderson (eds), Global Climate Change: Agriculture, Forestry, and Natural Resources. Washington: Westview Press, (Forthcoming).

[8]Liu, S., R. Cicerone, and T. Donahue 1977. "Sources and Sinks of Atmospheric N_2O and Possible Reduction Due to Industrial Fixed Nitrogen Fertilizers," Tellus 29, p. 251.

[9] Drennen, T. 1992. "A Model of Economic Development and Climate Change: A Tool for Analyzing International Policy," Ph.D. dissertation, Cornell University, (Forthcoming).

[10]Chapman, D. and T. Drennen 1990. "Equity and Effectiveness of Possible CO_2 Treaty Proposals," Contemporary Policy Issues, July.

[11]This does not include biotic emissions, such as deforestation.

[12]Car example assumes 5.35 lbs of carbon per gallon of gas, an efficiency of 20.9 mpg, and annual use of 10,550 miles. Lighting example assumes each light is used 8 hours daily, releasing 700 lbs of CO_2 annually. Assumes coal-produced electricity, and a coal carbon content of coal of 66%.

[13]This implies Brazilian per capita emissions of 11.3 tons of CO_2 from deforestation alone. See: Food and Agricultural Organization of the UN 1990. Climate Change and Global Forestry: Current Knowledge of Potential Effects, Adaptation, and Mitigation Options. Based on the work of K. Andrasko, Rome, p. 12, October.

[14]Houghton, J.T., G.J. Jenkins, and J.J. Ephraums 1990. (eds) "Intergovernmental Panel on Climate Change." In Climate Change: the IPCC Scientific Assessment. Cambridge: University Press, p. xviii.

[15]NAS, p. 63.

[16]Drennen, T. and D. Chapman 1992. "Model of Economic Development and Climate Change," Cornell University. The model runs on IBM compatible computers. For efficient use, the model requires at least an AT (286) class machine.