Global Warming and the Primary Metals Industry

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Editor's Note: Global warming is the subject of a position paper being developed by an ad hoc committee of the American Institute of Mining, Metallurgical, and Petroleum Engineers. The paper, expected in early 1992, will attempt to provide an unbiased evaluation of the issues surrounding CO2-induced climate change. For more information, see the June 1991 edition of TMS News, page 42.

This article is expanded from a unpublished presentation given at the TMS-sponsored Second International Symposium on Recycling of Metals and Engineering Materials, held October 28-31, 1990, in Williamsburg, Virginia.

Author's Note: It is inevitable that, as interest in the global warming problem increases, the specific role of the primary metals industry will be brought into question. We hope that this article provides some helpful perspectives.

The case for global warming due to anthropogenic sources of greenhouse gases is compelling, but its quantitative effects are still scientifically unproven. Today, the U.S. primary metals industry's carbon emissions account for slightly less than one percent of the global total. Further reductions are possible through the implementation of existing energy conservation measures, through more extensive recycling, and by the development and implementation of alternative processing technologies.

INTRODUCTION

The phenomenon of global warming and its consequences received widespread public attention and concern during the 1980s. The scientific community has made a considerable effort to study the situation, but there is still wide debate over how quickly the Earth's average atmospheric temperature is changing and what the consequences of that change will be. Nevertheless, the growing body of evidence indicates that human activities are causing some degree of global warming.

This article reviews the current knowledge of global warming, quantifies the relative contribution of the U.S. metals processing industry to this problem, and shows that recycling and alternative processing technologies can help to reduce carbon dioxide emissions.

A GLOBAL WARMING PRIMER

The Greenhouse Effect

The Earth's surface is the same as the amount radiated and reflected back to space (see Figure 1). The greenhouse effect makes the Earth's surface 33°C warmer than it would be otherwise.11,12 From space, the Earth would appear to be at an average temperature of -18°C. This is because long-wavelength radiation from the Earth's surface is absorbed by clouds and greenhouse gases, and much of that is re-radiated back toward the Earth, making the true surface temperature (obscured from space by the clouds and gases) a comfortable 15°C on average.

Global Sources and Sinks of Greenhouse Gases

The two largest contributors to the greenhouse effect are water vapor and carbon dioxide. Other gases, which contribute an additional 50% of the warming effect of carbon dioxide by itself, include methane, nitrous oxide, ozone, and the chlorofluorocarbons (CFCs).14

Trapped bubbles of air in Antarctic ice core samples provide records of atmospheric CO2 levels over long periods, and measurements at Mauna Loa, Hawaii, provide accurate data from 1958 to date. The carbon dioxide concentration reached a maximum of 300 µl/l about 130,000 years ago and fell to 200 µl/l at the height of the last glaciation, 20,000-40,000 years ago.15 (The drop in CO2 was more likely a consequence of the ice age rather than a cause of it. Although the causes of ice ages are not fully resolved, one explanation is periodic variations in the Earth's tilt and orbit. As the Earth cooled, ice sheets grew and sea levels went down; nutrient runoff from newly exposed coasts increased phytoplankton productivity and trapped more CO2 in the ocean; carbon was also trapped under the advancing glaciers, in frozen ground, and in bogs. While not the primary cause, reductions in CO2 probably enhanced the cooling effects.) From about 1,000 years ago until about 150 years ago, CO2 concentration was fairly constant at 280 µl/l. Since then, CO2 levels have increased 25% (to over 350 µl/l) due to human-related activities such as fossil fuel burning, natural gas flaring, cement production, cattle ranching, rice paddies, deforestation, mining, and organic matter changes in the soils.16 Similarly, methane concentrations have doubled in the last 200 years largely due to cattle and sheep ranching (43% of that increase) and rice paddies (34% of that increase).18

The burning of fossil fuel is the dominant source of carbon emissions result-
Evidence of Global Warming

There is wide agreement among scientists that greenhouse warming keeps the Earth’s surface at its current temperature. There is some debate over the predicted increases in CO₂, and there is considerable debate over the projected climatic changes resulting from those increases. Arrhenius seems to have been the first to calculate the temperature rise due to a doubling of CO₂; he estimated a 4-6°C increase in average temperature. Modern climate models predict an increase in average surface temperature of 1.5-4.5°C. They also predict that, based on known CO₂ emissions, the Earth should be about 1°C warmer than it was 100 years ago. In fact it is about 0.5°C warmer, when surface temperature data are corrected for the “urban heat island” effect, so the models seem accurate to within a factor of two.

There are many difficulties in developing good mathematical climate models, known as general-circulation models (GCMs), due in part to an incomplete understanding of the physical processes involved. To wit:

- We are currently unable to balance all the fluxes of the global carbon cycle over the past 200 years.
- We do not have a good understanding of ocean uptake and circulation of CO₂.
- We do not have good estimates of the “biological pumping” contribution in the oceans (when fecal pellets and dead organisms sink to deep waters).
- The effects of reduced sea ice at high latitudes (due to warming) are unknown—this may enhance biological production and increase ocean uptake of CO₂.

A recent study showed that photosynthetic organisms in seawater may produce up to twice the previously accepted value of dissolved organic compounds. At an estimated production rate of 4.3 Gt/y, changes in this source (due to global warming) could significantly alter the calculated ocean-atmosphere CO₂ exchange rate.

A possible explanation for the unusually warm temperatures of the Cretaceous period (about 100 million years ago, when alligators roamed at Arctic Circle latitudes) is greenhouse warming from much higher levels of CO₂. Because of the successes, many researchers believe that the models can provide reasonable estimates of temporal and spatial variations of future climates, depending on the accuracy of assumptions about future CO₂ emissions.

The actual temperature data are somewhat ambiguous. Figure 4 shows that the average surface temperatures rose from 1860 to about 1945, cooled from 1945 to about 1975, and then increased rapidly through the 1980s (1990 was the warmest year on record). If anthropogenic sources are causing a global warming, there are other factors present which appear to mitigate that to some extent. Possible explanations for why the GCMs do not predict this include variation in solar output, volcanoes injecting more dust than is known, errors in modeling ocean effects, or coal combustion releasing SO₂, which might nucleate droplets of sulfuric acid and increase the reflectivity of the atmosphere. Efforts to determine whether global warming is being caused by increasing CO₂ have been unsuccessful—