

## CLIMATE CHANGE

# No Way to Cool the Ultimate Greenhouse

When the Clinton Administration announced its Climate Change Action Plan last week, some press accounts called it an effort to halt greenhouse warming. To greenhouse experts, however, cutting emissions of greenhouse gases to 1990 levels by the end of the decade—the goal of the plan—will only delay the inevitable. “It’s a good first step,” says Jerry D. Mahlman, director of the Geophysical Fluid Dynamics Laboratory in Princeton, New Jersey, “but it is important to remember that stabilizing emissions has nothing to do with stabilizing greenhouse gas concentrations” and thus stabilizing climate. Such modest conservation measures, as a recent study shows, will buy humanity valuable time to adapt to the greenhouse world, but they will have little effect on how warm the global climate ultimately becomes.

“Ultimately,” to these researchers, means something well beyond the decade-long horizons of politicians or the century-long time scale of most scientific discussions of greenhouse warming. To really size up what the world is facing, they say, you have to look hundreds of years down the road. That’s what James Kasting of Pennsylvania State University and James Walker of the University of Michigan did in their study, which appeared in the journal *Palaeogeography, Palaeoclimatology, Paleoeecology*. They found that nothing but the most draconian controls can prevent carbon dioxide from building up to four or more times its preindustrial level, causing perhaps 10°C of warming.

In tracing the rise of carbon dioxide into the far distant future, Kasting and Walker took into account the rate at which the ocean and vegetation remove the gas from the atmosphere. They also assumed that conservation may slow the depletion of fossil fuels but won’t stop them from being exhausted in the end. They then ran their model several times for different conservation scenarios.

If the rates of fossil-fuel and forest burning continue to increase as they have in the past few decades, Kasting and Walker found, carbon dioxide will pile up in the atmosphere until in the early 23rd century it reaches 7.6 times pre-industrial levels. If fossil-fuel burning is held to today’s level, the peak moves back to the year 2700, but it stays nearly as high: 7 instead of 7.6 times the pre-industrial value. Ending the destruction of forests would only lower the peak to a quadrupling of carbon dioxide. These conservation measures have little effect on the ultimate greenhouse because oceans and plants take up carbon dioxide so much more slowly than human beings release it. A modest slowing of emissions simply doesn’t give these natural sinks enough time to catch up.

Under scenarios like Kasting and Walker’s, says Mahlman, “it’s hard not to expect substantial change.” Along with dramatic warming, it might include tens of meters of sea level rise and a stagnation of the deep sea (*Science*, 30 July, p. 553). According to the model, the only way to limit the rise in carbon dioxide to a doubling of pre-industrial levels, expected to cause 3° to 5° of warming, would be to cut the present emis-

sion rate by a factor of 25—something neither the developing nations nor the industrialized ones are likely to contemplate.

Not that Kasting and Mahlman doubt the value of delaying the carbon dioxide peak, the one thing conservation measures such as the Climate Change Action Plan can do. After all, humanity will have to do quite a bit of adapting to the ultimate greenhouse, and the more time it has, the better. Says Mahlman, “The amount of adaptation [to global warming] is large. Fortunately, it takes a long time to get there.”

—Richard A. Kerr

## EPIDEMIOLOGY

# New Sellafield Study Poses a Puzzle

LONDON—Three years ago, an epidemiological study rocked the nuclear industry by suggesting a link between exposure to radiation among men and leukemia in their children. The study, by the late British epidemi-

ologist Martin Gardner, focused on workers at the Sellafield nuclear reprocessing plant in northwest England, a focus of cancer epidemiology.

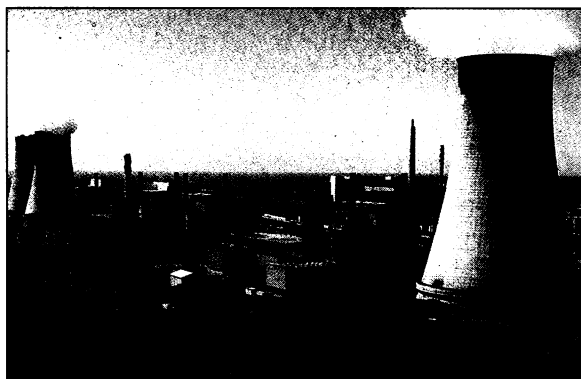
the government body that monitors health and safety in industry, that both supports and refutes Gardner’s findings.

Researchers sought out all children from West Cumbria (the area where Sellafield is based) who had been diagnosed with cancer before the age of 25 and whose fathers had worked at the plant before the diagnosis. As a control, they found Sellafield workers’ children who had not developed cancer by the age of 25. The researchers then compared the occupational histories of the two groups of fathers: Their exposure to internal and external radiation, exposure to chemicals and involvement in radiological or other incidents at the plant.

This comparison turned out only “fragile evidence,” the HSE says, that long-term cumulative exposure to radiation by fathers before the conception of their children was linked to an increased risk of the child developing leukemia and non-Hodgkin’s lymphoma. In particular, there was no association between external radiation dose in the 12 weeks before conception (the period during which the impregnating sperm would have formed) and the risk of cancer in the children.

But the HSE found a very different story in the village of Seascale, 3 kilometers south of Sellafield. The rate of leukemia and non-Hodgkin’s lymphoma among children whose fathers worked in Sellafield and lived in Seascale when they were born was about 14 times the national average. The HSE’s report says that it found a “strong association” with the cumulative dose of radiation that the fathers had received before conceiving the children who later developed cancer. In addition, these fathers had received “strikingly higher” radiation doses than other Sellafield workers who lived in Seascale.

According to the HSE report, the odds



**Center of controversy.** The Sellafield reprocessing plant in northwest England, a focus of cancer epidemiology.

ologist Martin Gardner, focused on workers at the Sellafield nuclear reprocessing plant in northwest England and had profound implications for the nuclear industry: If a causal link between exposure and cancer could be proven, occupational exposure limits to radiation would have to be tightened and British Nuclear Fuels, the operator of Sellafield, might be open to litigation from the affected children and their relatives.

The study was widely regarded as statistically sound and extremely well conducted, but scientists found its conclusions hard to swallow (*Science*, 6 April 1990, p. 24). And follow-up studies in several countries added to the skepticism when they all failed to provide a shred of evidence to support Gardner’s conclusions (*Science*, 2 October 1992, p. 31). But now comes a report\* from Britain’s Health and Safety Executive (HSE),

\*“HSE Investigation of Leukemia and Other Cancers in the Children of Male Workers at Sellafield.” Health and Safety Executive.