Environment

More groups address climate change

In a move timed for this week's Intergovernmental Panel on Climate Change meeting in Washington, D.C., several groups have issued reports addressing the potential environmental effects of a global warming and the need for governments to act as soon as possible to limit the pollutants responsible.

Late last month, the Environmental Protection Agency released a report to Congress on potential U.S. effects of global climate change, based on a range of conditions suggested by three major general-circulation climate models. The study's authors found that forests unable to cope with a warmer climate could begin dying back in 30 to 80 years, eventually moving the southern boundary of U.S. woodlands northward by about 400 miles. Even if these woodlands were to "migrate" northward at 60 miles per century — twice their fastest known rate — it's likely that the advance of their southern boundary would greatly outpace the forests' northern migration. A net loss of timberlands and the animal species inhabiting them could result, according to the report.

The EPA study also found that sea-level rise will probably outpace the ability of coastal marshes and swamps to migrate inland. A rise of just 1 meter — in the middle range of the predicted 0.5 to 2 meters — would likely result in a 26 to 66 percent loss of wetlands, the authors contend, "even if wetland migration were not blocked" by bulkheads, levees and other feats of human engineering. By 2055, annual U.S. demand for electricity might increase 4 to 6 percent above rates necessary without a global warming — at an estimated additional cost of $33 billion to $73 billion annually. The EPA report also asserts that air pollution — especially smog ozone — can be expected to increase dramatically.

Though the total cost of adapting to these changes will undoubtedly be high, the authors conclude that those costs should be "affordable" for industrial nations. And while crop yields could drop severely — at least on a temporary basis — the EPA analysis suggests they should "be adequate to meet domestic needs" even under the more extreme scenarios.

Last week, the Paris-based International Energy Agency (IEA) issued a 230-page report identifying economic and technological options for reducing emissions of the pollutants driving a threatened climate change. One of the easiest near-term targets, IEA suggests, would be to switch from conventional coal- and oil-fired electrical generating plants to nuclear and "clean" fuels, including some additional use of natural gas. Other measures for reducing emissions of carbon dioxide include heavy taxes on fossil-fuel use.

Rectifying inefficiencies in motor vehicles could also offer near-term gains. But the report notes that trends toward larger cars, more driving and increased road congestion have offset many recent gains in automobile efficiency. A recent study offers a striking illustration of this point. According to the South Coast Air Quality Management District in El Monte, Calif., vehicles idling in traffic burn one-quarter of all fuel sold in Los Angeles, Orange, Riverside and San Bernardino counties.

All options listed in the IEA report "imply radical changes at heavy cost, whether combined or considered separately," acknowledges IEA Deputy Executive Director John P. Ferriter. However, he says, "governments would be well advised to make an immediate start and build up their efforts [to stabilize carbon emissions] gradually."

A number of prominent U.S. scientists agree. Last week, the Union of Concerned Scientists sent President Bush an appeal — endorsed by 49 Nobel laureates and 700 members of the National Academy of Sciences — that argues: "Only by taking action now [to mitigate global warming] can we insure that future generations will not be put at risk."

Physics

Pinning down critical currents

One serious obstacle to the application of high-temperature superconductors, especially in the presence of strong magnetic fields, is the disappointingly low electrical current they can carry. Once the current exceeds a certain value known as the critical current, the material loses its ability to conduct electricity with zero resistance and no energy loss. Several recent advances suggest ways by which researchers may overcome this problem.

When a superconductor is placed in a magnetic field and its temperature lowered below its superconducting transition point, it abruptly expels the magnetic field. However, in Type II superconductors, including the recently discovered high-temperature compounds, the materials actually retain an internal magnetic field if the external field is greater than a certain value. This penetrating field exists within the material in the form of separate magnetic filaments, or lines of flux, called fluxoids. The fluxoids generally settle into a regular pattern, or lattice, often pinned in place by impurities or microscopic defects in the material.

When an electric current courses through such a superconducting material, it pushes against the fluxoids. If the current is strong enough or the fluxoids are only weakly pinned, they begin to move. The trouble is that naturally occurring defects in typical high-temperature superconductors don't pin fluxoids strongly enough to keep even low electric currents from shoving them aside (SN: 4/1/89, p.197). This phenomenon is known as flux creep. Because energy is needed to move the fluxoids, flux creep causes the material to lose all its superconducting properties.

Last fall, R.B. van Dover of AT&T Bell Laboratories in Murray Hill, N.J., and his colleagues reported that irradiating a single superconducting crystal with high-energy neutrons could raise the material's critical current. The neutrons apparently disturb the superconductor's atomic structure permanently, creating a high concentration of tiny structural defects that anchor the lattice more effectively. The researchers achieved a current density of 600,000 amperes per square centimeter at 77 kelvins (–195°C) in a modest magnetic field of 0.9 tesla, about 100 times larger than the current density in an unirradiated crystal.

Later, a team led by Sungho Jin at Bell Labs achieved a similar improvement by modifying the composition of an yttrium-barium-copper-oxide superconductor. The researchers heated a crystal of $YBa_2Cu_4O_8$ to 920°C, causing it to decompose into $YBa_2Cu_3O_7$. That process leaves a number of extra oxygen and copper atoms in the sample, which somehow act as defects and help hold the flux lattice in place. Jin and his colleagues measured critical currents as high as 100,000 amperes per square centimeter. Their flux-pinning method is simple enough to show promise as a commercially viable process, the researchers say.

Scientists have already produced relatively high current densities in thin films of superconducting materials. In the Jan. 15 Applied Physics Letters, a Japanese group reports the possibility of further improving thin-film performance by using X-ray irradiation and then oxygen annealing to create strong flux-pinning sites in a gadolinium-barium-copper-oxide superconductor.

In the Jan. 19 Science, researchers at Stanford University describe experiments showing that flux creep in thin films isn't necessarily a serious problem for certain applications, such as magnets that must carry a current for long periods of time. Their technique produces thin films that can maintain current densities as high as 1 million amperes per square centimeter at liquid-nitrogen temperatures (–195°C) for long periods of time without any measurable degradation.