



Every time some ecosystem is destroyed, it impacts people around the world. . . . It doesn't have to be in your backyard to cause you to be dismayed about it.

Gaylord Nelson, quoted in USA Today
29 March 1989

INNOVATIVE TECHNOLOGIES

Chinese Fridges Keep Food and the Planet Cool

An international project aims to boost the manufacture and purchase of green refrigerators—not those 1970s-style avocado-green fridges, but environmentally friendly refrigerators. According to the China State Statistical Bureau, over 12 million refrigerators will be manufactured for the Chinese market this year, and with them—at least, with traditional refrigerators—comes environmental pollution from greenhouse gases and ozone-depleting chemicals.

Refrigerators present a two-fold blow to the environment. First, they have traditionally relied on chlorofluorocarbons (CFCs) for use both as coolants and as an ingredient in the foam insulation that encases the storage compartment. During production and use, CFCs leak into the air. Because they are so chemically stable, they are swept intact into the stratosphere, where they are broken down by ultraviolet radiation from the sun, releasing chlorine atoms that react with and degrade ozone. Second, the generation of electric power by burning fossil fuels causes massive emissions of the greenhouse gas carbon dioxide (CO₂). Currently, coal-fired plants provide some 80% of China's electricity.

The first part of the China CFC-Free Energy-Efficient Refrigerator Project, begun in 1989, involved the development of a prototype refrigerator that used no CFCs and incorporated energy efficiency measures, yielding a model that works on 50% less energy than a conventional refrigerator-

tor of the same size. After the prototype was tested for a year in 100 households, Chinese officials felt confident to launch the second phase—a complete market transformation.

This second phase was launched in Beijing on 10 December 1999. Scheduled to take five years, this phase will focus on offering technical assistance and incentives to compressor and refrigerator manufacturers to produce energy-efficient designs and modifications and conversion of current factory production lines. The project also aims to establish national efficiency standards and a national labeling program and to offer consumer education on the benefits of the new refrigerators. Finally, the project includes plans to implement a consumer buyback and recycling program for older model refrigerators. The goal is to reduce CO₂ emissions by 100 million metric tons over the life of refrigerators produced from 2002 to 2012.

The number of refrigerators purchased in China has increased dramatically in the last 15 years, thanks to a changing Chinese lifestyle and rising affluence. The increase in the ownership of domestic appliances is a major factor driving the surge in residential electricity consumption, according to *The Sino-U.S. CFC-Free Super-Efficient Refrigerator Project Progress Report: Prototype Design & Testing*, published in 1997 by the U.S. Environmental Protection Agency (EPA).



The second phase of the \$40 million project is cofunded by the Chinese government and industry and the Global Environment Facility (GEF), a United Nations-administered fund established after the first Rio Conference on Climate Change to promote energy efficiency, biodiversity, and climate protection in the developing world. Formulated as a joint endeavor of the Chinese government and industry, the U.S. EPA, and the Environmental Energy Technologies Division of the Lawrence Berkeley National Laboratory in Berkeley, California, the project is being implemented by the United Nations Development Programme and

China's State Environmental Protection Administration.

The project stems from China's bid to join the Montréal Protocol on Substances That Deplete the Ozone Layer, an international treaty intended to protect the stratospheric ozone layer from further damage by compounds such as CFCs. Nandita Mongia, technical advisor and regional coordinator for Asia-Pacific at the GEF, says, "The Montréal Protocol funds any project that brings down CFCs, whereas GEF funds projects that reduce greenhouse gas emissions. On the China project, both are combined." For manufacturers, implementing new energy efficiency measures alongside the CFC phaseout allows them to reduce the total investment in retooling and production-line conversion.

David Fridley, a staff scientist in the Berkeley Lab Environmental Energy Technologies Division who managed the first phase of the refrigerator project, says, "I think the goals of the project laid out in the original application are quite conservative in retrospect. Given the enthusiasm of the manufacturers for energy efficiency as a competitive tool—the market in China is enormously oversupplied, so competition is fierce—I believe the market share for the efficient fridges could easily reach 40% during this period, effectively doubling the savings." —Susan M. Booker



CFC-free, energy-efficient fridge. A joint project between the United States and China has produced a new environmentally friendly refrigerator to be sold in China this year.

LEAD

The Core of the Candle Problem

A romantic evening at home surrounded by candlelight may pose a not-so-romantic health hazard. Some candles made with metal wicks emit lead into the air when burned, finds a study by environmental chemist Jerome Nriagu of the University of Michigan in Ann Arbor, scheduled for publication in an upcoming issue of *Science of the Total Environment*. The dark, shiny metal wick cores are used to make the wick more rigid and to slow burning, and are thus more common in large, poured candles (such as pillar candles and those in glass containers) and those where a longer burning time may be especially desirable (such as scented candles).

Nriagu tested 15 different brands of candles with metal wicks that were purchased in Michigan stores. The candles were made in the United States, Mexico, or China, and they ranged in size from 3.5 to 7.0 centimeters in diameter and from 5.0 to 15.0 centimeters in height. The candles were burned in a combustion chamber for 2–4 hours, and the fumes were captured in a trap containing nitric acid, which dissolved the lead aerosols. The amount of lead in solution was measured using an atomic absorption spectrometer.

The six candles made in the United States released 1.1–66.0 micrograms (μg) of lead per hour, the five Mexican candles released 0.5–5.9 μg per hour, and the four Chinese candles released 1.8–327.0 μg per hour. The amount of lead that would accumulate in a closed bedroom measuring about 12 feet by 15 feet by 10 feet, or 50 cubic meters (m^3) in volume, after burning each candle for 2 hours was calculated. Lead concentrations in the room after 2 hours of burning were estimated at 0.04–13.1 $\mu\text{g}/\text{m}^3$, in some cases far exceeding the U.S. Environmental Protection Agency's (EPA) ambient air quality standard of 1.5 $\mu\text{g}/\text{m}^3$.

An earlier Australian study found that several large Chinese candles released lead amounts averaging 779.0 μg per hour. Those results, published in the December 1999 issue of *Science of the Total Environment*, resulted in lead wicks being banned in Australia.

Lead aerosols released by burning candles may be deposited on walls, furniture, and floors. This deposition increases the likelihood that children may be contaminated through

hand-to-mouth activities. The central nervous system of children is particularly sensitive to lead poisoning. Chronic low levels of lead exposure cause learning disabilities, incoordination, and behavioral disorders. Lead also damages the heart, red blood cells, and digestive system. Overall, lead poisoning remains one of the most serious environmental health problems worldwide, especially among children.

Retail sales of candles in the United States grew during the 1990s at an average rate of 10–15% annually and reached \$2.3 billion in 1999. Although lead has been removed from gasoline, paint, plumbing, and pottery, candles represent a largely unrecognized source of lead. "Lead wicks should be banned in every country," says Nriagu.

In 1973, the Health Research Group of the consumer rights organization Public Citizen unsuccessfully petitioned the Consumer Product Safety Commission to remove candles with lead-containing wicks from the market. The commission did ask candle manufacturers to replace lead with zinc. But compliance is totally voluntary and imported candles are not checked. Pure zinc poses no health risk, but commercial-grade zinc and alloys used in wicks usually contain lead, too.

About 85% of the 200 candle manufacturers in the United States belong to the National Candle Association, a Washington, DC-based trade group that promotes lead-free wicks. "If you buy candles made in the United States, chances are good it won't have any lead," says Marianne McDermott, executive vice president of the association. However, on 24 February 2000, Public Citizen released the results of a survey in which 285 candles available in 12 different chain stores in the Baltimore/Washington, DC, area were examined. Some 30% of the candles were found to have metal wicks. One of each of these candles was purchased, and the wicks were analyzed to determine their lead content. Nine of the candlewicks contained as much as 85% lead by weight. According to the group's calculations, burning such candles could yield ambient air lead concentrations that are 9–33 times higher than the EPA standard.

Public Citizen has once again petitioned the CPSC to immediately ban and recall all candles with lead-containing wicks, candles in metal containers that contain lead, and wicks sold for candle making that contain lead. In the meantime, to protect themselves, consumers should look for candles with cotton wicks. —Carol Potera



Aroma-hazard. Candles with metal wicks may emit large amounts of lead.

Safer Citrus Is Hot

A citrus processing method developed by scientists at the USDA Agricultural Research & Extension Center in Weslaco, Texas, bypasses conventional fumigation with methyl bromide—a pesticide that depletes the ozone layer—and instead uses forced hot air to kill fruit flies. Using the new method, up to eight tons of fruit at a time is processed in a hot air chamber, where the fruit centers are quickly heated to 111°F and kept at that temperature long enough to kill any fruit flies inside.

The majority of the 1.18 million tons of citrus fruit exported in 1998 by U.S. distributors required fruit fly extermination treatments. The forced hot air treatment was approved by the USDA for grapefruit, tangerines, and Valencia oranges in 1998, and for navel oranges in 1999.



Multiplying Microbials

Scientists from Wageningen University in the Netherlands and the University of Iowa have found that separating organic waste from other household waste can cause increases in microbial contaminants in house dust. Contaminants such as bacterial endotoxins, mold $\beta(1\rightarrow3)$ -glucans, and fungal extracellular polysaccharides (EPSs) of *Aspergillus* and *Penicillium*, which were determined to be markers of microbial exposure, may increase the risk for bioaerosol-related respiratory symptoms in susceptible people.

The study, published in the February 2000 issue of *Applied and Environmental Microbiology*, found that when separated organic waste was stored for over one week, concentrations of endotoxins, glucans, and EPSs were 3.2-, 4.6-, and 7.6-fold higher, respectively, than in homes where only nonorganic waste was stored indoors. Separated organic waste stored indoors for less than one week increased endotoxin concentrations 2.6-fold and EPS concentrations 2.1-fold. Indoor storage of nonseparated waste was found to have no effect on concentrations of microbial agents.

Backyard Dioxin

A report in the 1 February 2000 issue of *Environmental Science and Technology* warns that burning typical household waste in barrels may produce dioxin and furan levels higher than those emitted by municipal waste incinerators serving thousands of people. Dioxins and furans cause immune dysfunction, cancer, developmental abnormalities, and hormonal changes in laboratory animals, and are also a concern to human health.

Scientists from the U.S. EPA and the New York State Department of Health found that, under test conditions, more polychlorinated compounds were emitted from trash burned in barrels than from municipal incinerators. Burning household waste in open barrels is banned in most areas of the United States; areas in which it is permitted are mostly rural.

NOISE POLLUTION

FAA Turns Down the Volume

According to the 1998 annual report of the Air Transport Association, U.S. airlines flew 423.3 billion passenger miles in 1987, a number that grew to 619.5 billion miles in 1998. According to the Federal Aviation Administration (FAA), air traffic is expected to double nationally by the year 2017. Increased air traffic also means an increase in airplane noise. To help regulate the impact of noise on the environment, the FAA established the Airport Noise and Capacity Act in 1990, which required all civil jet aircraft over 75,000 pounds to reduce noise and lessen their environmental effects overall by 1 January 2000.

According to the FAA's 1998 progress report to Congress on the transition to quieter airplanes, aircraft have fully met these requirements. "This report demonstrates that we are moving forward in the reduction of aircraft noise in the nation's skies, and that the U.S. airline industry will continue with efforts to reduce noise and improve environmental impacts," says Secretary Rodney Slater of the Department of Transportation.

The Airport Noise and Capacity Act requires that older, so-called stage 2 aircraft meet the noise standards applied to the quieter stage 3 aircraft being built today, which incorporate the latest technology for suppressing jet-engine noise. Usually stage 3 aircraft are 10 decibels quieter than stage 2

aircraft. An increase of 3 decibels is equivalent to a doubling of the sound energy.

Despite the quieter standards, an increase in air traffic operations concerns people such as Anne Kohut, publisher of the *Airport Noise Report*, a biweekly newsletter. Kohut believes it's hard to tell exactly what effects noise pollution has on health because of the paucity of studies performed. The studies that have been performed do provide some indication, however, of the impact noise pollution may have on health.

Research published in volume 10 (1993) of *Children's Environments* by Gary Evans, a professor of design and environmental analysis at Cornell University, and Stephen J. Lepore, an associate professor of psychology at Carnegie Mellon University, suggests that living or attending school near a major noise source can lead to elevated blood pressure in children. Research published in the September 1997 issue of *Environment and Behavior* by Evans found that children chronically exposed to aircraft noise have poorer reading skills than children attending elementary school in a quieter setting.

In 1998, psychologists from Cornell conducted research with a group of German



Plane pain. Regulations to reduce noise from airplanes may soon lower noise-related health effects such as stress, particularly among children.

third and fourth graders exposed to noise from Munich International Airport. They discovered health problems such as higher blood pressure and boosted levels of stress hormones. The study, published in the January 1998 issue of *Psychological Science*, suggests that noise increases psychophysiological stress among children. "This study is probably the most definitive proof that noise causes stress and is harmful to humans," said Evans in a press release from Cornell.

In November 1998, a conference titled Noise Effects '98 was held in Sydney, Australia. Organized by the International Commission on Biological Effects of Noise, it was the seventh international conference concerning noise as a public health problem. The conference looked at noise's effects in nine areas, including its effects on sleep and its influence on performance and behavior, and evaluated the research that has been done thus far within these specific areas. Findings from the congress suggest that new standards for measuring noise's effects need to be refined so that the public can be made more aware of their relative strengths and weaknesses. —Lindsey A. Greene

RADON

Reducing Radon State by State

In August 2000, the U.S. Environmental Protection Agency (EPA) expects to finalize proposed regulations to protect people from exposure to radon through indoor air and drinking water. The regulations will provide flexibility in determining how to limit exposure to radon by allowing each state to focus its reduction efforts as it sees fit. Research suggests that 6% of U.S. homes contain more radon than the current EPA recommendation of 4 picocuries per liter (pCi/L). Radon from drinking water accounts for an estimated 2% of exposure.

The framework for this proposal was initiated in the Safe Drinking Water Act Amendments of 1996. The act directed the EPA to finalize standards for radon contamination, to be accompanied by a multimedia mitigation (MMM) program, which states may enact in one of two ways.

The first option calls for state programs requiring individual water systems to meet a less stringent proposed alternative maximum contaminant level of 4,000 pCi/L. States would also be expected to develop MMM programs to reduce radon in indoor air. At a cost of nearly \$86 million dollars per year, the EPA says this is the most cost-effective radon risk reduction approach and the one it expects most states to adopt. If a state does not choose this first option, then individual water systems must either comply with a tighter proposed maximum contaminant level of 300 pCi/L in drinking water or conform to the 4,000 pCi/L standard and

develop a state-approved MMM program plan to reduce indoor radon.

The proposed regulation does not set safety standards for airborne radon concentrations, but the EPA still recommends that households reduce indoor radon levels to a maximum of 4 pCi/L. Under the proposed regulation, water companies would be required to begin quarterly monitoring for radon within three years after the final rule is published. Companies that agree to develop MMM programs would not have to begin the required monitoring until February 2005.

In most cases, radon is released to indoor air from the soil underneath homes and buildings as a by-product of the breakdown of uranium. A naturally occurring gas, radon is a human lung carcinogen contributing to about 20,000 lung cancer deaths every year in the United States, according to a 1999 report by the National Academy of Sciences on radon in indoor air. The U.S. Surgeon General has warned that radon is the second leading cause of lung cancer. If someone living in a house with high radon concentrations smokes, there is an even greater risk for household members to develop cancer.

Although a smaller source of radon, drinking water also presents the risk of stomach cancer. The EPA estimates that drinking water containing radon causes 168 cancer deaths per year, 11% of which are due to stomach cancer. —Lindsey A. Greene





Economic Commission for Europe's Environment and Human Settlements Division

Pollution does not respect international borders anywhere, but in Europe, with its heavy industrialization and small nations, this is particularly evident. By the 1970s, it had become apparent that air pollution from other nations was contributing to the acidification of lakes in Sweden and the deterioration of statues and monuments in countries such as Germany and Austria. A 1986 industrial accident along the Rhine River in Switzerland killed thousands of fish in France and Germany, and further galvanized the European community to fight transboundary pollution.



Today, Europe is a global leader and innovator in international laws aimed at reducing the flow of pollution across borders, and many of those laws are developed and implemented under the auspices of the United Nations Economic Commission for Europe (ECE). Despite its name, the commission counts not only European nations such as Russia, France, and Greece among its 55 members, but also the United States and Canada, as well as Israel and Armenia. Thus, the ECE formulates treaties that affect almost the entire Northern Hemisphere and that are often emulated in other parts of the world. Information about the ECE's work to protect the environment is available on its Environment and Human Settlements Division Web site, located at http://www.unece.org/env_h.htm.

So far, this ECE division has drafted conventions to reduce the transboundary effects of air pollution, water pollution, and industrial accidents, as well as protocols that guide countries in assessing environmental problems and informing their neighbors about them. The division also provides guidance on housing, urban development, and land administration, and makes recommendations to member countries on human settlement policies and strategies. Information on division treaties, including their full texts and ratification status, can be found under the Environmental Policy link on the home page.

The oldest of these agreements, the 1979 Convention on Long-Range Transboundary Air Pollution, was one of the first international conventions to address environmental issues. Since then, it has been expanded through eight protocols, and it continues to be lauded as a pioneering accord. At the end of 1999, the Protocol to Abate Acidification, Eutrophication, and Ground-Level Ozone was added to the convention, marking the first time that all three of these problems were addressed together in an international agreement. The protocol is also unique in its extensive use of modeling to find the most cost-effective ways to protect ecosystems.

The division provides an extensive Internet site about the 1979 convention and its protocols at <http://www.unece.org/env/lrtap/>. Here, visitors can read the text and ratification status of the eight protocols, view brochures that explain them in plain language, and retrieve air pollutant emissions data for each of the countries that are parties to the agreement. According to data on the site, the convention has succeeded in reducing sulfur emissions by one-half in Europe (compared to 1980) and has prevented over \$9 billion worth of damage to buildings caused by air pollution.

Part of this success is due to the newly forged cooperation between eastern and western countries in Europe. The ECE has been instrumental in helping many eastern countries meet environmental goals while making the transition to a market-based economy. For example, the Environment and Human Settlements Division has sent experts to countries such as Ukraine to evaluate their environmental programs and help make improvements. Details of these efforts including full reports on some countries are also available on the division's site.

—Christopher G. Reuther

Organic Power

A demonstration project conducted by the USDA Agricultural Research Service has found that diesel vehicles such as trucks, tractors, and buses can run more cleanly if organically based biodiesel is mixed with the regular diesel fuel. "B20" fuel (which is 20% biodiesel, derived from soy or other seed oils or animal fat) requires no engine modifications in order for it to be used.

Alan Weber, a representative of the National Biodiesel Board, says that credits for biodiesel fuel use are available to federal and state agencies and public utilities in large metropolitan areas under the 1992 National Energy Policy Act. One of the goals of the USDA project, part of a federal initiative to reduce dependence on petroleum-based fuels and build new markets for U.S. crops, is to increase the federal government's use of bio-based fuel by 10% over the next five years.

Country Roads Not Always Cleaner

A new method of measuring road dust developed by researchers at Washington University's Air Quality Laboratory in St. Louis reveals that the average rural vehicle creates over six times more particulate matter (PM) than the average urban vehicle. The acidity and high volume of PM emissions, along with their heavy metal composition, may lead to such health effects as upper respiratory illnesses, cardiovascular disease, and cancer.

The new method measures the net sum of PM emissions created by a vehicle by several means over each mile it travels, focusing on particles smaller than 2.5 microns in diameter. Using this method, regulatory and government agencies can more accurately measure particulate emissions and then strategize to reduce them.



Texans Bugged in Smog

Houston, Texas, must take strong measures to reduce its air pollution—cited as the worst in the United States—in order to comply with federal ozone standards, states a 23 December 1999 article in the *Fort Worth Star-Telegram*. The article reports that 75 measures, including restricting driving on every fourth day and reducing the highway speed limit to 55 miles per hour, were proposed during a December meeting of Texas environmental officials.

To comply with federal law, Houston must reduce vehicle miles traveled by 25% and industrial nitrogen oxide emissions by 90%, but petrochemical industry emissions, along with those from automobiles and port traffic, are making this difficult. Texas commissioner Ralph Marquez said that even the measures proposed may not be enough to bring Houston in line with the Clean Air Act, which requires the city to meet federal ozone standards by 2007.