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A CLEAN BREAK

THE WORLD needs more energy. Energy multiplies human labor, increasing productivity. It builds and lights schools, purifies water, powers farm machinery, drives sewing machines and robot assemblers, stores and moves information. World population is steadily increasing, having passed six billion in 1999. Yet one-third of that number—two billion people—lack access to electricity. Development depends on energy, and the alternative to development is suffering: poverty, disease, and death. Such conditions create instability and the potential for widespread violence. National security therefore requires developed nations to help increase energy production in their more populous developing counterparts. For the sake of safety as well as security, that increased energy supply should come from diverse sources.

"At a global level," the British Royal Society and Royal Academy of Engineering estimate in a 1999 report on nuclear energy and climate change, "we can expect our consumption of energy at least to double in the next 50 years and to grow by a factor of up to five in the next 100 years as the world population increases and as people seek to improve their standards of living." Even with vigorous conservation, world energy production would have to triple by 2050 to support consumption at a mere one-third of today's U.S. per capita rate. The International Energy Agency (IEA) of the Organization for Economic

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Cooperation and Development (OECD) projects 65 percent growth in world energy demand by 2020, two-thirds of that coming from developing countries. "Given the levels of consumption likely in the future," the Royal Society and Royal Academy caution, "it will be an immense challenge to meet the global demand for energy without unsustainable long-term damage to the environment." That damage includes surface and air pollution and global warming.

Most of the world's energy today comes from petroleum (39.5 percent), coal (24.2 percent), natural gas (22.1 percent), hydroelectric power (6.9 percent), and nuclear power (6.3 percent). Although oil and coal still dominate, their market fraction began declining decades ago. Meanwhile, natural gas and nuclear power have steadily increased their share and should continue to do so. Contrary to the assertions of antinuclear organizations, nuclear power is neither dead nor dying. France generates 79 percent of its electricity with nuclear power; Belgium, 60 percent; Sweden, 42 percent; Switzerland, 39 percent; Spain, 37 percent; Japan, 34 percent; the United Kingdom, 21 percent; and the United States (the largest producer of nuclear energy in the world), 20 percent. South Korea and China have announced ambitious plans to expand their nuclear-power capabilities—in the case of South Korea, by building 16 new plants, increasing capacity by more than 100 percent. With 434 operating reactors worldwide, nuclear power is meeting the annual electrical needs of more than a billion people.

In America and around the globe, nuclear safety and efficiency have improved significantly since 1990. In 1998, unit capacity factor (the fraction of a power plant's capacity that it actually generates) for operating reactors reached record levels. The average U.S. capacity factor in 1998 was 80 percent for about 100 reactors, compared to 58 percent in 1980 and 66 percent in 1990. Despite a reduction in the number of power plants, the U.S. nuclear industry generated nine percent more nuclear electricity in 1999 than in 1998. Average production costs for nuclear energy are now just 1.9 cents per kilowatt-hour (kWh), while electricity produced from gas costs 3.4 cents per kWh. Meanwhile, radiation exposure to workers and waste produced per unit of energy have hit new lows.

Because major, complex technologies take more than half a century to spread around the world, natural gas will share the lead in power

generation with nuclear power over the next hundred years. Which of the two will command the greater share remains to be determined. But both are cleaner and more secure than the fuels they have begun to replace, and their ascendance should be endorsed. Even environmentalists should welcome the transition and reconsider their infatuation with renewable energy sources.

CARBON NATIONS

AMONG SOURCES of electric-power generation, coal is the worst environmental offender. (Petroleum, today's dominant source of energy, sustains transportation, putting it in a separate category.) Recent studies by the Harvard School of Public Health indicate that pollutants from coal-burning cause about 15,000 premature deaths annually in the United States alone. Used to generate about a quarter of the world's primary energy, coal-burning releases amounts of toxic waste too immense to contain safely. Such waste is either dispersed directly into the air or is solidified and dumped. Some is even mixed into construction materials. Besides emitting noxious chemicals in the form of gases or toxic particles—sulfur and nitrogen oxides (components of acid rain and smog), arsenic, mercury, cadmium, selenium, lead, boron, chromium, copper, fluorine, molybdenum, nickel, vanadium, zinc, carbon monoxide and dioxide, and other greenhouse gases—coal-fired power plants are also the world's major source of radioactive releases into the environment. Uranium and thorium, mildly radioactive elements ubiquitous in the earth's crust, are both released when coal is burned. Radioactive radon gas, produced when uranium in the earth's crust decays and normally confined underground, is released when coal is mined. A 1,000-megawatt-electric (MWe) coal-fired power plant releases about 100 times as much radioactivity into the environment as a comparable nuclear plant. Worldwide releases of uranium and thorium from coal-burning total about 37,300 tonnes (metric tons) annually, with about 7,300 tonnes coming from the United States. Since uranium and thorium are potent nuclear fuels, burning coal also wastes more potential energy than it produces.

Nuclear proliferation is another overlooked potential consequence of coal-burning. The uranium released by a single 1,000-MWe coal

plant in a year includes about 74 pounds of uranium-235—enough for at least two atomic bombs. This uranium would have to be enriched before it could be used, which would be complicated and expensive. But plutonium could also be bred from coal-derived uranium. Moreover, "because electric utilities are not high-profile facilities," writes physicist Alex Gabbard of the Oak Ridge National Laboratory, "collection and processing of coal ash for recovery of minerals ... can proceed without attracting outside attention, concern or intervention. Any country with coal-fired plants could collect combustion byproducts and amass sufficient nuclear weapons materials to build up a very powerful arsenal." In the early 1950s, when richer ores were believed to be in short supply, the U.S. Atomic Energy Commission actually investigated using coal as a source of uranium production for nuclear weapons; burning the coal, the AEC concluded, would concentrate the mineral, which could then be extracted from the ash.

Such a scenario may seem far-fetched. But it emphasizes the political disadvantages under which nuclear power labors. Current laws force nuclear utilities, unlike coal plants, to invest in expensive systems that limit the release of radioactivity. Nuclear fuel is not efficiently recycled in the United States because of proliferation fears. These factors have warped the economics of nuclear power development and created a politically difficult waste-disposal problem. If coal utilities were forced to assume similar costs, coal electricity would no longer be cheaper than nuclear.

DECLINE AND FALL OF THE RENEWABLES

RENEWABLE SOURCES of energy—hydroelectric, solar, wind, geothermal, and biomass—have high capital-investment costs and significant, if usually unacknowledged, environmental consequences. Hydropower is not even a true renewable, since dams eventually silt in. Most renewables collect extremely diluted energy, requiring large areas of land and masses of collectors to concentrate. Manufacturing solar collectors, pouring concrete for fields of windmills, and drowning many square miles of land behind dams cause damage and pollution.

Photovoltaic cells used for solar collection are large semiconductors; their manufacture produces highly toxic waste metals and solvents