logies in the United States is far less than $1 billion annually. Compare that to the $30 billion-plus damage from this quake, and the $4.5 billion damage from the 1989 San Francisco Bay quake.

One idea is to develop "active" quake-resistant technologies, which are different from the "passive" systems in use since 1971. The Japanese are leading the way in this. The idea of active rather than passive systems has two main aspects. First is the development of "smart materials," which have special properties. One "smart material" is a fluid mixture of mineral oil and aluminum oxide. When electricity passes through the fluid, it becomes more viscous. The higher the applied electrical voltage, the greater the viscosity of the mixture. Earthquake vibrations automatically transmit current to, and thus activate, the smart material. A structure in an earthquake zone would be built into the smart material. During an earthquake, the change in viscosity of the smart material, would allow the structure to yield to the quake, but also transmit back to the quake some of the quake's own energy. The structure is no longer a passive sitting duck.

Dr. Saiid Saiidi, professor and researcher of Civil Engineering at the University of Nevada at Reno, told the Jan. 20 *Wall Street Journal* that smart materials applied to bridges "can absorb a great deal of energy." He said that such materials can allow bridges to sway without collapsing.

Another "active" approach, being studied by Tsu Soong, professor of civil engineering at the State University of New York at Buffalo, uses hydraulic systems and/or steel tension wires to produce repelling forces which counterbalance and right a structure against the jolts of an earthquake.

The exciting feature of this earthquake research, is that it does not accept the condition of soil or of the earth's substrate as given.

This research is run on a shoe-string budget in the United States. No force in government or outside it has actively demanded it be developed and funded appropriately. Most of these American research projects are years away from the development phase.

This is not the case in Japan, however, which leads in these technologies, and has already the technologies in several areas. The Japanese have also experimented with constructing buildings on rubber pads, something that has belatedly been picked up in the United States, and is now being tested in 10 U.S. structures. Japan has a population of 130 million, living in an area one-third the size of California (population 30 million); thus its urban structures are closely packed. Japan is a nation living directly over some earthquake faults. Unlike the United States, Japan takes that situation, and human life, very seriously, and the Japanese have an "Earthquake Day" every year. Everybody learns what to do during an earthquake. In some parks, there are earthquake simulator rooms, which shake strongly. A family enters the rooms and learns what to do.

Japan also leads the United States in the building and use of "shake tables," which shake violently and are used to test the seismic features of scale-model replicas of structures to be built. Shake tables are to earthquake structural engineering what wind-tunnels for testing airplanes are to aerodynamic engineering. Yet, while the United States has only one table, which is 20 feet long, Japan has 20 such tables, with one table on the island of Sinkoku, which was used to test scale models of nuclear plants, being 50 feet long. Larger tables allow larger models to be employed in the tests, and thus more accurate knowledge to be obtained.

One final note. The earthquake did open up the question of having Los Angeles build a mass transit system. Up through the 1950s, the Los Angeles area was served by an excellent mass transit system called the Red Car. It was essentially an over-sized trolley car, sometimes more than one car linked together, which travel on railroad-type tracks around the county. The Red Car system was simply bought out by a cartel which was formed for this purpose, consisting of, among others, companies associated with automobile and bus interests. This cartel immediately shut the system down and scrapped it. The same thing was done in Baltimore and other cities. Now is the time to push ahead on a modern, fast, and comprehensive Los Angeles mass transit system.

An electricity grid 'doomsday' scenario

by Richard Freeman

The January cold snap forcefully raised the question of just how close the eastern two-thirds of the United States' power grid may have come to a power blackout lasting several days, had the policy of "rolling brownouts" not worked.

First, we settle the question: Just how cold was January, really? The National Climatic Data Center attempts to quantify the cold by a measure called "heating degree-days." A heating degree-day indicates how many degrees the day's mean temperature fell below 65°F. So, if Day X had a mean temperature of 0°F, then Day X had a "65 degree-day." Then the sum of the heating degree-days for a month is stated as a cumulative total. With the temperature for some of the last days of January 1994 estimated, the National Weather Service projected that January 1994 would produce a 1,017 degree-day month. If that projection holds true, then this January will not be as cold as January 1985 or January 1988. January 1982 was a 1,130 degree-day month, a full 10%

colder than this January. Although January 1994 may have produced more *extreme* low temperatures, placing peak energy demands greater than those of other recent Januarys, the unusual weather merely exposed the overall fragility of the system.

The brink of collapse

Nonetheless, this January pushed much of the nation's power grid to its outer limits, using a procedure by which the whole system could have failed. The partial failures of the current power grid system were not due to the record cold, but the inadequacy of the system, an inadequacy that would not have existed 25 or even 15 years ago. We will use the case of Virginia Power, the major electricity supplier to Virginia and to a part of North Carolina, to illustrate the point.

As early as 1990, the Virginia State Corporation Commission (SCC), the agency that regulates the state's utilities, wrote a scathing report on Virginia Power, blasting the company's decision to buy, by the year 2000, up to 31% of its electricity output from generating plants it did not own. The SCC also criticized Virginia Power for overestimating the capacity it had, while underestimating the peak demand of electricity use it would have to supply. Clearly, Virginia Power was trying to produce as little power as it could, and to get by with as little power as it could. The State Corporation Commission's staff report concluded, in very strong language, that "the most disturbing aspect of this case is not the problems identified by the parties. . . . It is the *company's refusal to admit, at least publicly, that its capacity-planning and acquisition process is experiencing problems that need to be corrected*" (emphasis added).

Apparently, Virginia Power never corrected the problems identified by the SCC. Spurred by pro-financier, pro-environmentalist regulators, Virginia Power, like almost every utility in the nation, devised various schemes to reduce demand. In fact, utilities have a category called "interruptible demand," which counts as an addition to the utility's capacity, *which is the utility's ability to shut off electricity to customers during peak load periods*. Sometimes the utility pays for this privilege of shutting off customer's electricity, and sometimes it doesn't. For example, Pepco, the utility that supplies electricity to metropolitan Washington, D.C., effectively pays customers to allow it to turn off their electricity. Pepco permits residential customers to save $7 to $9 per month during the summer. Pepco installs a radio-activated device that allows it to turn off the customer's air-conditioner compressors for 13 minutes out of each half-hour on up to 15 summer afternoons.

During the cold snap of January 1994, Virginia Power and other utilities were turning off customers' power—without asking the customers—as a way of keeping its electricity grid from becoming unglued. Not just Virginia Power's grid was affected, because wheeling (trading) electricity among utilities is so common these days, and because almost all the utilities are in the same fundamentally tenuous condition as Virginia Power. It was the entire East Coast electricity grid that was at risk of becoming unglued.

On Jan. 19, Virginia Power began implementing a policy of "rolling blackouts"—temporary, but repeated, shutdowns of power to its customers. By 6:00 a.m. on the morning of Jan. 19, Virginia Power knew that demand had risen above the level it had predicted the previous night. So Virginia Power cut voltage by up to 5% throughout its system. That wasn't enough. So at 8:23 a.m., Virginia Power ordered rolling blackouts, eliminating 400 watts of its load. Still not enough. Twenty minutes later, Virginia Power lopped off 800 megawatts of power supply from the system. This meant large numbers of customers were losing power. The utility's procedures required the blackouts to be carried out through a checklist of priorities that was to preserve power to hospitals, police, fire and rescue operations, and public services such as water and sewage.

Some priority customers weren't protected at all, however. The sewage treatment plant in the state capital of Richmond, for instance, was blacked out without warning. At a Suffolk peanut-processing plant, a company spokesman explained, "We shut down for [four shifts] because we could never get an answer about whether we'd seen the end of the blackouts." This plant lost a huge batch of peanuts, which it was about to hoist from a boiling bath when the power went out.

Virginia Power was committed—in fact, locked in, as a matter of iron-clad policy—to instituting deeper and deeper power cuts to get out of the crisis that it was in on Jan. 19. The reason, a company spokesman explained, is that if demand kept outstripping supply, this would have forced an automatic, computer-driven dumping of power users across the whole nation. Virginia Power would not have had to do anything.

In this doomsday scenario, a computer would have, at a certain point, triggered the whole process, without Virginia Power's being able to stop it. In Virginia, this would have meant that almost 5,000 megawatts of Virginia Power's electricity would have been dumped, more than six times the amount of power that the company had eliminated in rotating blocks. Then there would have been a total blackout lasting several days, during the cold winter weather. An official of a Virginia Power subsidiary, Gus Kappatos, told the Jan. 23 *Richmond Times* that if the strategy of rolling blackouts "hadn't worked out, everyone would have been out of [power] for days." Does America really want to live this close to the edge? The only thing that pulled Virginia Power out of this scenario, is that the weather warmed up. What if a real cold wave, colder than any of the winters of the last 15 years, were to strike? The nation would face a catastrophe worse than any it has yet seen.