Health Effects of Electromagnetic Fields: The State of the Science and Government Response

With indications—but not definitive evidence—of a problem, the EMF issue presents a classic public policy challenge. Utilities' and PUCs' low- and no-cost policies of "prudent avoidance" and "passive regulatory action" make sense under these circumstances.

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Nancy Graci testified: For the past 20 years, she has lived underneath the present Minooka-Hoffman Power line. In April 1989, her son was diagnosed with Burkitt's lymphoma, which is a rare childhood disease considered to be environmentally caused, and which is sometimes linked to electromagnetic fields . . . The witness thinks that electric utility companies should use prudent avoidance in their siting procedures so as to avoid the possibility of children suffering needlessly through the agony of childhood cancer . . .

Martin Castaldi testified: His house is only 12 feet from the Walsh Street roadway. Consequently, his children will constantly be exposed to the new power line, no matter which part of the house they happen to be in . . . The witness would like PP&L to select an alternate route . . .

—from the decision of the Pennsylvania Public Utilities Commission on the application of Pennsylvania Power & Light for approval of construction of a new 138/69 kV transmission line[1]

The question of the possible health hazards of electromagnetic fields (EMFs) made its mark on the public consciousness in a dramatic manner with the 1989 publication of a series of articles by

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Paul Brodeur in *The New Yorker*, collected and expanded on in two books, *Currents of Death* and *The Great Power Line Cover-Up.* Since then, many studies have addressed the issue, and research continues. Virtually all of the studies show some link between EMF exposure and several health effects, but they convey less than definitive proof, raising more questions than they answer. Uncertainty remains as to the nature and extent of the health hazards of EMF exposure, whether power lines or household electric appliances are the more appropriate focus of possible concern, and the proper policy response.

Although numerous lawsuits have been filed against utilities alleging physical harm or property loss, no damages have been awarded for suits alleging physical harm caused by EMFs—although there have been jury awards that were later reversed on appeal, as well as court judgments and out-of-court settlements against utilities from the perception of EMFs as a health threat. In Europe and Canada, case law has also favored utilities and manufacturers.

While plaintiffs have so far not prevailed in legal actions, it is too soon to dismiss EMFs as a genuine issue of science and policy. In the face of such an uncertain picture, what actions (such as information disclosure and changes to siting practices) have regulators taken to protect the public from possible EMF health effects?

Following a quick look at the major court cases, this article surveys the current state of the science on the possible health effects of EMFs and reviews government actions taken in response to such health concerns. While the focus is on developments in the United States, a brief look is also taken at European activity. While there has been a sense recently both in the electric industry and among the general public that EMFs as a genuine cause for concern has been dispelled (in regard to power lines, at least; the media's focus on EMFs from cellular phones has increased of late), research continues, with some studies finding significant associations, particularly in the occupational arena. In the meantime, given the conflicting results of research, the low/no-cost steps required by some public utility commissions (described below) continue to make sense.

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I. Litigation

Outcomes of suits against utility companies for personal injuries from EMFs have been dismissals of claims or overturned jury awards. A New Jersey jury awarded $762,524 to John and Sandra Altoonian after they sued Atlantic City Electric Co. in 1991.[2] John Altoonian was diagnosed with chronic myelogenous leukemia (CML); their house was close to several power lines. The jury did not find a causal link between EMFs and the illness, rather awarding the money for emotional distress and lost earnings. After the company appealed, the parties settled out of court.

Leonard and Elsa Glazer sued Florida Power & Light in 1994 on the grounds that both of them developed CML as a result of exposure to EMFs from both a distribution line near their home and a water main; utility customers in the Glazers' area grounded their home electrical systems to their plumbing, which is connected with the water main.[3] The company knew or should have known of the hazards of EMFs, but withheld that information, the suit charged. The Dade County circuit court dismissed the case in 1996.

Suzanne and Melissa Bullock recently dropped their lawsuit, filed in 1991, against Northeast Utilities and its Connecticut Power & Light subsidiary, stating that insufficient scientific research had evolved to buttress their claim that EMFs had caused the brain tumor of Melissa Bullock, then nineteen years old.[4] The Bullocks lived on Meadow Street in Guilford, Connecticut, where there were several incidences of unusual cancers, discussed by Brodeur in his *New Yorker* series.

A woman who sued Georgia Power and Oglethorpe Power, alleging that her non-Hodgkins

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lymphoma was caused by EMFs from power lines near her home, lost her case in front of a jury. Although granted a new trial, she dropped the case, possibly for reasons associated with her health.[5]

At least one workers' compensation suit has been filed for alleged EMF-caused illness. The estate of a Seattle utility worker who died of cancer, allegedly caused by his work, was denied compensation by the court, which thought a causal connection unlikely.[6]

Courts in several states have ruled that property owners may claim reimbursement for EMF-caused lowered property values regardless of the actual health effects of EMFs, while courts in other states have required that a link be shown.[7] The California Supreme Court, in *Covalt v. San Diego Gas & Electric*,[8] gave the California PUC exclusive jurisdiction over property value damage claims linked to EMF exposure. The decision was seen as a victory for the utility since it was thought that the PUC would be less likely than a court to award large damages in such claims. A New York court rejected claims by sellers of a residential property near a high-voltage transmission line that the utility owner should pay for a loss of property value due to public fears about EMFs.[9] In England, National Grid has made several large compensation payments for loss of land value caused by overhead lines.[10]

II. The State of the Science

Brodeur's first *New Yorker* article reported on epidemiologist Nancy Wertheimer's research in Denver, which concluded in a 1979 study that children living within two houses of electrical transformers were twice as likely to die of childhood leukemia than other children.[11] Wertheimer followed that investigation with a 1982 study of adult cancer, in which she found that homes of cancer patients outnumbered control homes most clearly in the very-high-current configuration category, meaning that a dose relationship may exist between AC magnetic field exposures in this range, and cancer.[12]

In England, National Grid has made several large compensation payments for loss of land value caused by overhead lines.

In *Currents of Death*, Brodeur notes that the Navy first conducted studies of EMFs in the 1950s, after it was noticed that radio waves could penetrate seawater sufficiently to provide communication with deeply submerged submarines. Navy studies found that exposure to low-intensity EMFs were linked to elevated triglyceride levels—a symptom of stress—and adverse behavioral effects.[13] Brodeur also discussed studies carried out by Dr. Ross Adey at the University of California in Los Angeles in the early 1970s, showing that weak EMFs have a direct effect on the vertebrate nervous system, causing behavioral effects in monkeys and affecting the chemistry of chick brains.[14]

The New York State Power Lines Project, begun in the mid-1970s and completed in 1987, was formed as the result of a several-years-long hearing held by the New York State Public Service Commission as part of its environmental impact investigation of two proposed transmission lines. During that hearing, questions were raised by citizens groups as to possible long-term health effects of EMF exposure. The Commission stated in its order that the record did not show that the proposed lines would endanger human health or safety, but that it did contain inferences of possible risk that could not be ignored. The order led to a lawsuit and several appeals, resulting in formation of the research project, funded by New York utilities and administered by the state Department of Health.

The project's final report suggested that EMFs could have effects on human health.[15] As part of the research undertaken in the project, scientist David Savitz had replicated Wertheimer's original study. He, like Wertheimer, found that prolonged exposure to low-level EMFs increased by two the risk to children of developing cancer. For certain high exposures, the risk was more than five times that of the control population. His study also supported Wertheimer's claims that magnetic field expo-

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sures can be accurately estimated by examining the electrical distribution wiring near a given home, and that magnetic fields are determined by sources outside the house and not affected by household wiring or power use.

EMFs from household appliances have also been studied, though less than fields from power lines. For example, Nancy Wertheimer found that pregnant women who slept with electric blankets or on heated waterbeds had more miscarriages than those who did not.[16] Wertheimer found that, in general, magnetic fields given off by household appliances tend to be strong in the immediate vicinity of the appliances, then drop off sharply within a short distance. Recently, several studies have found an association between cellular phones and brain cancer; the National Cancer Institute is currently studying the link.

On the occupational front, the U.S. Public Health Service found early on—in a 1950 study—that workers who are frequently exposed to alternating current magnetic fields—power station operators, linemen, electricians, etc.—developed leukemia at a significantly higher rate than the population as a whole.[17] Samuel Milham, a doctor in Washington state, published a report in 1982 in *The New England Journal of Medicine* that found that there were more deaths from leukemia among men whose occupations required them to work in electric or magnetic fields than for the general population.[18] Milham's findings were supported by several other studies, including one in the British medical journal, *The Lancet*, in the same year.[19]

Among Scandinavian studies on EMFs, Dr. Lennart Tomenius found in a 1986 study twice as many Stockholm children whose homes were near high-voltage lines developed cancer.[20] A 1993 Swedish case-control study, which covered exposure to EMFs over a twenty-six-year period, found an elevated risk for leukemia in children from historical calculated EMFs, but no such relationship for brain tumors, lymphoma, and childhood cancers combined.[21] A 1993 Danish study found an association between childhood cancer and exposure to EMFs from high-voltage installations, but concluded that the proportion of childhood cancer caused by these fields was small.[22] A 1996 Finnish study found no increased risk for adult cancer from EMFs.[23]

The epidemiological findings cannot be completely discounted, and efforts to encourage reductions in exposure should continue.

In response to growing concern about EMFs, U.S. government agencies began to carry out their own studies. In a 1997 report, the National Academy of Sciences concluded overall that current evidence does not show that exposure to residential electric and magnetic fields produces cancer, adverse neurobehavioral effects, or reproductive and developmental effects.[24] However, it did note that an association between residential wiring configurations and childhood leukemia persists in numerous studies.[25] The report also noted some evidence from laboratory studies of biological effects, including changes in intracellular calcium concentrations from strong EMF exposures, and a suggestion of promotion of breast cancer growth and suppression of the hormone melatonin.[26]

A six-year study directed by Congress as part of the Energy Policy Act and carried out by the National Institute of Environmental Health Sciences (NIEHS) was released in mid-1999, showing a weak link between EMFs and cancer.[27] While the agency concluded that the probability that EMF exposure is truly a health hazard is currently small, EMF exposure "cannot be recognized as entirely safe." The strongest evidence of health effects found in the study was in occupationally exposed adults such as electric utility workers, machinists, and welders, although the report stated that laboratory evidence and cell studies fail to support a causal relationship. Because the epidemiological findings cannot be completely discounted, and because everyone in the United States uses electricity and is therefore routinely exposed to EMFs, the agency said, efforts to encourage reductions in exposure should continue. For example, the

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public and industry should continue to be informed as to ways to reduce EMF exposure, industry should continue efforts to alter large transmission lines to reduce their fields, and localities should enforce electrical codes to avoid wiring mistakes that can produce higher fields, the agency said.[28]

A 1999 University of Toronto/Hospital for Sick Children study found that children with higher exposures to EMFs in their homes are two to four times more likely to develop leukemia than less-exposed children. The association was stronger for children who were diagnosed at a younger age.[29]

In July 1999, news of a finding by federal investigators that a cell biologist at the Lawrence Berkeley Laboratory, Dr. Robert Liburdy, had published misleading data in two papers focusing on the biological effect of EMFs on human cells, made the front page of *The New York Times*.[30] Liburdy's findings had been considered important when published in 1992 because they linked EMFs to calcium signaling, a process governing important cellular functions. While investigators charged that he had eliminated data that did not fit his conclusions, Liburdy disputed that claim, stating that the data he used was valid and the way in which he graphed the data were a matter of interpretation. He said that he had agreed to a settlement of the case only because he lacked the money for a legal defense.

Still, research continues. At the Electric Power Research Institute (EPRI), based in Palo Alto, California, and funded by electric utilities, much of the current research focuses on occupational exposure. A study of 140,000 utility workers over thirty-eight years, carried out by David Savitz at the University of North Carolina at Chapel Hill and sponsored by EPRI, recently reported that longer duration in jobs with elevated EMF exposure was associated with a higher risk of death from heart attack and arrythmia.[31] An analysis of data on brain cancer and leukemia among electric utility workers found no association with leukemia, but a 1.5- to three-fold increase in the risk of brain cancer.[32] And many more studies are under way, including a report expected soon from the California Department of Health Services, addressing both the science and policy options, as well as further studies in Europe.

The U.S. Office of Technology Assessment enumerated a prudent avoidance strategy as one possible policy response on EMF.

III. U.S. Government Response

A. Federal Activity

The Energy Policy Act of 1992 established the EMF Research and Public Information Dissemination (RAPID) Program. Managed by the U.S. Department of Energy and NIEHS, the program aims to coordinate research on EMF, using both federal and private funds. The recent NIEHS study grew out of the program.

In May 1999, a National Academy of Sciences (NAS) panel advocated an end to federally mandated EMF research, saying that the RAPID program had not provided any evidence to contradict the NAS's 1997 conclusion that EMFs from power lines do not cause cancer.[33]

The U.S. Office of Technology Assessment (OTA), which, prior to its 1995 demise, was known for its neutrality and balanced takes on controversial subjects, discussed EMFs in its 1989 report, *Electric Power Wheeling and Dealing: Technological Considerations for Increasing Competition.* The report enumerates several possible policy responses on the EMF issue, given the limitations that it is not certain that EMFs are a health hazard, that there may be no dose–response relationship, and that there are many potential sources of exposure. These responses include

- Deferring regulatory action while continuing and expanding research,
- Establishing public information programs,
- Adopting a field-strength-limit approach to transmission line fields by setting an arbitrary acceptable level of exposure,
- Adopting a "similarity"-based approach to transmission line fields designed to make people's expo-

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sure to transmission line fields as similar as possible to the exposures from all other fields common in people's daily lives, and

• Adopting a prudent avoidance strategy by taking reasonable steps at modest costs to keep people out of fields in the siting and re-routing of transmission and distribution lines and by redesigning electrical systems to reduce fields.

B. State Activity

By the late 1980s, seven states—Montana, Minnesota, New Jersey, New York, North Dakota, Oregon, and Florida—had promulgated regulations limiting field strengths on transmission line rights-of-way.[34] Prompting these actions was public opposition to several proposed transmission line projects and, in some states, pressure from utility companies for regulations that would shield them from potential liability.

Three states notable for the comprehensive actions they have taken to protect the public from the possible health hazards of EMFs are California, Wisconsin, and New York.

California. In a 1993 decision,[35] the California Public Utilities Commission acknowledged that the scientific community had not yet isolated the impact of utility-related EMF exposures on health, but stated that in the absence of resolution of the issue, other jurisdictions and governmental bodies have concluded that the best response "is to avoid unnecessary new exposure to EMFs if such avoidance can be achieved at a cost which is reasonable in light of the risk identified." The commission put forth seven interim steps to address EMFs from electric utility facilities and power lines:

1. No-cost and low-cost steps to reduce EMF levels. The PUC found the scientific evidence too inconclusive to warrant adopting a numerical limit on EMF exposure. However, it directed that, for new and upgraded facilities, low-cost

options to reduce EMFs be implemented to the extent approved through the project certification process, and that no-cost mitigation measures be undertaken until further notice. The PUC told utilities to use 4 percent of the total cost of a budgeted project as a benchmark in developing EMF mitigation guidelines. The PUC endorsed the concept put forward by several utilities that a mitigation measure should achieve some noticeable reduction, but declined to adopt a specific number. For existing facilities, the PUC expressed interest in developing a baseline inventory of areas with higher-than-average EMF levels in order to be positioned to take actions of greater than no-cost if future scientific research so warrants.

2. Workshops to develop EMF design guidelines. The PUC asked utilities to submit guidelines incorporating such EMF mitigation options as siting new facilities in alternative locations, increasing right-of-way widths, altering line or tower geometry, using higher voltages to reduce current levels, and undergrounding. The PUC encouraged standardized design guidelines across utilities.
3. Uniform residential and workplace EMF measurement programs.
4. Stakeholder and public involvement.
5. A $1,489,000 four-year education program.
6. A $5,600,000 four-year non-experimental and administrative research program.
7. Authorization for federal experimental research conducted under the National Energy Policy Act of 1992.

Wisconsin. Wisconsin has also taken numerous steps to address EMFs. In 1997, the Wisconsin Public Service Commission ordered two utilities building a new transmission line to use low-EMF structures on portions of the line within 100 feet of a residence, hospital, nursing home, daycare center, school, or workplace.[36] (The PSC found that designs using single-pole, V-string, and horizontal line post insulators generally had lower EMFs than designs with two-pole, H-frame structures or single-pole structures with

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I-string insulators.) The PSC stated that research indicated that EMFs are probably not a serious health threat. "However, in the absence of a clear scientific consensus, the commission continues to make balanced choices where EMF reduction is only one factor," it said in its order.[37]

Following hearings on EMF and human health effects, the PSC in 1998 ordered Wisconsin utilities to:

- Contribute to the national EMF research effort;
- Provide information to the public on EMF, perform EMF measurements for customers on request, and develop a uniform EMF measurement protocol;
- Evaluate how magnetic fields differ for alternative power line configurations in construction applications—utilities must provide the PSC with estimates showing the difference in EMF between types of poles, show how magnetic fields decrease with distance from the line, and calculate EMFs for a variety of possible current flows;
- Create a database on magnetic fields around representative distribution and transmission facilities;
- Consider the number of people exposed to EMF, and the intensity and duration of exposure, along proposed transmission line routes;
- Submit a list of homes, workplaces, hospitals, nursing homes, daycare centers, and schools near proposed and alternate transmission line routes; and
- Credit energy conservation programs that reduce current flow throughout the electrical system for their ability to minimize exposure to EMF.[38]

In making a decision on a proposed line, the Wisconsin PSC checks the utility's EMF calculations and analyzes each route for potential EMF exposures. It also provides this information to the public. In choosing transmission line routes, the PSC balances "environmental and social impacts with need, performance, and cost."[39]

New York. Following the conclusion of the Power Lines Project,

the New York Public Service Commission in 1990 issued an interim policy requiring that new high-voltage transmission lines in New York be designed so that the maximum magnetic fields at the edge of power line rights-of-way would not exceed those of the typical 345 kV lines in operation in New York at that time.[40] An interim electric field standard limits new high-voltage transmission lines to 1.6 kV per meter at the edge of the right-of-way.

The policy was established on an interim basis in order to "ensure that future lines do not produce unnecessarily high electric or magnetic fields," given that "there is no technical or scientific way to determine what levels . . . may be safe or unsafe."[41] The state follows the OTA's approach of "prudent avoidance," which "suggests a degree of caution in dealing with magnetic fields until further research permits a more conclusive determination."[42]

The utilities themselves, since EMFs became a concern, have focused on education—through disseminating brochures and taking measurements upon request—and research, through EPRI and RAPID. Most utilities, in siting and installing new lines, have taken EMFs into account through design options, if the options will add little or no cost. In making these decisions, they have balanced cost and efficiency, as well as aimed to avoid controversy at sites where people may feel they are close enough to the project to be at risk for health effects.

IV. Canadian and European Government Response

No government action has been taken on EMFs in Canada, on either a provincial or national level. Government officials feel that evidence of health effects is insufficient to warrant action, although research continues.

In Europe, the Scandinavian countries, not surprisingly, have been particularly activist in addressing EMFs. The Environmental Report 1997 of Eltra, the independent transmission system operator for the western part of Denmark, notes that in 1995

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the organization launched an action plan in conjunction with Denmark's county councils and the network owners, with the aim of reducing the length of the overhead line network[43] As part of the plan, two 150 kV overhead lines through residential areas were reconstructed, and several 150 kV overhead lines were expected to be removed. Norwegian policy is, if possible, to increase the distance between power lines and buildings.

The Swedish agency for occupational safety and health recommends a precautionary principle: If measures generally reducing exposure can be taken at reasonable expense and with reasonable consequences in all other respects, an effort should be made to reduce fields radically deviating from what could be deemed normal in the environment concerned (i.e., in areas where people can be expected to be repeatedly present for a considerable length of time, such as schools, houses, and workplaces). Where new electrical installations and buildings are concerned, efforts should be made at the planning stage to design and position them in such a way that exposure is limited.[44]

The European Union (EU) requires that employers take steps to ensure that video display equipment and other components of workstations meet certain minimum radiation levels.[45] Employers also must assess activities—including those involving exposure to non-ionizing radiation—that could be risky to pregnant workers, and take appropriate measures.[46] In June 1999, the EU's Council of Health Ministers approved a recommendation to limit the public's exposure to EMFs, which basically adopts current standards. Italy, which has a more restrictive approach, opposed the paper.[47]

V. Conclusion

Overall, studies on EMFs, while inconclusive, show some association between residential EMF exposure and childhood leukemia and other biological effects, and between occupational EMF exposure and certain types of cancer and, possibly, heart function.

As a health-conscious consumer, I put EMFs pretty far down on my list of health concerns—certainly below pesticides and other chemical contaminants in my food, air, and water. However, I would not use an electric blanket or microwave oven, or put an electric clock close to my bed. And if I were buying a house, I would check the location of the nearest electricity transformer and, if it were very close to a room in which I expected to spend a lot of time, would take that into account in my purchasing decision.

The EMF issue—in which there are indications, but not definitive evidence, of a problem—presents a classic public policy challenge. If regulators do not take steps now, the lack of proactive action may increase harm to the public. If regulators do mandate measures to protect the public from EMFs, and EMFs turn out not to be a genuine hazard, then expensive efforts will have been wasted. This conundrum applies not just to the electricity industry, but to many of the technologies we rely on in modern society, from cell phones to genetic engineering to complicated medical interventions. We assess the possible health hazards, based on the best available evidence, and we consider the benefits of the technology. Weighing the two, we decide whether the risk is worth taking.

In the face of the current evidence indicating that EMFs pose some risk, but probably a small one, the low- and no-cost policies of "prudent avoidance" and "passive regulatory action" advocated by some PUCs and utilities make sense. Perhaps in the future, we will have more definitive evidence on EMFs, and will then be able to adjust public policy accordingly. ■

Endnotes:

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