Power Line EMF: A Proposed State Utility Regulatory Response

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Electromagnetic fields (EMF), generated by the flow of electric power in overhead transmission and distribution lines, recently have caused growing public concern over their potential as health hazards. Numerous studies conducted since the early 1970's have attempted to quantify the effect of EMF on humans, and to establish a link between power line EMF and certain cancers, especially leukemia. Because, the results of

1. Transmission lines are high voltage power lines (typically carrying voltages of 69 kilovolts (kV) and greater) used primarily to move electric power over long distances, such as from rural generation sites to urban load centers where the energy is consumed. Office of Technology Assessment, U.S. Congress, Electric Power Wheeling and Dealing: Technological Considerations for Increasing Competition, at 92-93 (1989) [hereinafter OTA Report]. Higher voltages are used in transmission lines so that electric power losses due to the resistive effects of the line itself are minimized. Id. At substations near the load centers, the voltage is stepped down using power transformers to a level that is safely useable by residential and commercial customers (typically below 35kV) and distributed to these customers over local grids known as distribution lines. Id.

2. See Paul Brodeur, Annals of Radiation: The Hazards of Electromagnetic Fields, New Yorker, June 12, 1989, at 51 (discussing the relationship between EMF and human disease, and military and corporate attempts to cover up the issue). But see Geoffrey Cowley, An Electromagnetic Storm, Newsweek, July 10, 1989, at 77 (questioning the irrefutable tone of Brodeur's evidence); Harold R. Piety, What We Don't Know About EMF, Pub. Util. Fort., Nov. 15, 1991, at 14 (noting that there is, as yet, no conclusive pathological link between EMF and human disease although the public may have been led to believe otherwise). See also Cynthia Hacinli, A Gauss in the House: Tips for Evicting Unwelcome Electropollution, Garbage, Jan. - Feb. 1992, at 40 (discussing what may be done around the house to reduce exposure to EMF); Citizens Networks Debate Litigation vs. Education as EMF Activism Grows, Util. Envt. Rep., May 14, 1993, at 1 (noting several citizen action groups that have grown out of the EMF controversy and the positions that they advocate on the issue).

3. Concern over the health effects caused by EMF first arose in 1972, when Soviet investigators reported that workers in high voltage railroad switch yards suffered from appetite loss, fatigue, headaches, insomnia and reduced sexual drive. OTA Report, supra note 1, at 227. The research proved to be flawed, but it did raise public concern. Id.

Since 1972 many studies have been conducted to determine if EMF is an etiologic pathogen. For an excellent summary of the studies which have been conducted recently on EMF and its possible biological effects, see Sherry Young, Regulatory and Judicial Response to the Possibility of Biological Hazards from Electromagnetic Fields Generated by Power Lines, 36 Vill. L. Rev. 129, 136-50 (1991). Young's article notes that there have been three classes of studies conducted to determine EMF's biological effect on humans: (i) in vitro studies, (ii) whole animal experiments, and (iii) epidemiological studies. Id. at 137. In vitro studies focus on determining how EMF affects individual cells, particularly DNA. Id. at 138-39. Whole animal studies subject an entire animal to EMF of different strength
such studies are inconclusive, little is actually known about power line EMF and its effects on humans.4

Despite the lack of clear scientific knowledge, there may nonetheless be a pathological link between power line EMF and certain illnesses. Given this possible causal relationship, some action should be taken to reduce human exposure to power line EMF. Currently, concern about the health effects of EMF is under discussion in several arenas. It has prompted litigation,5 federal legislation,6 and state legislation.7 It has also affected state utility regulatory agencies,8 electric utilities,9 utility liti-

and duration. Id. at 140-42. Epidemiological studies examine population and disease statistics and attempt to associate certain illnesses with a given segment of the population. Id. at 142-44.

Young concludes that while in vitro studies have shown that exposure to EMF does not initiate cancer, exposure may promote the disease. Id. at 137-38. The whole animal experiments have consistently found no adverse effects on blood and immune system chemistry. Id. at 140. However, the epidemiological studies, while inconclusive and often contradictory, have indicated that a relationship between exposure to EMF and cancer is possible. Id. at 143-44. See also, OTA Report, supra note 1 (discussing the three classes of studies and their general results).

4. OTA Report, supra note 1, at 228. The Report states:
As recently as a few years ago, scientists were making categorical statements that on the basis of all available evidence there are no health hazards from [EMF] . . . . It is still not possible to demonstrate that such effects do exist, and it is important to remember that they may not. However, the emerging evidence no longer allows one to categorically assert that there are no risks.

Id. See also Young, supra note 3, at 136-50 (discussing the results of EMF studies); Christopher B. Daley, More Study Urged on Possible Risks of Magnetic Fields, WASH. POST, Feb. 16, 1993, at A3 (noting the National Association for the Advancement of Science’s conclusion that more research is needed).

5. See infra notes 40 and 42.


7. See infra note 91 (listing state mandated maximum exposures to EMF).

8. See infra part II.

9. See, e.g., Wayne Beaty, Electric Utilities Are Doing Their Share in EMF Research, ELECTRIC LIGHT & POWER, Oct. 1990, at 36 (discussing utility funding for EMF-related research); Leonard S. Greenberger, Meadow Street Family Files EMF Suit, PUB. UTIL. FORT., Feb. 15, 1992, at 34-35 (noting that juries may decide, despite the paucity of scientific information, to “get the electric company”); Keith A. Meyer, Securing Insurance Coverage for EMF Claims, PUB. UTIL. FORT., Feb. 15, 1992, at 29 (advising utilities to evaluate their insurance coverage to ensure coverage for such claims, and recommending utility action to ensure that the utilities receive the full protection and defense due them by their insurance companies because “current EMF claims are only the tip of the iceberg and are not likely to dissipate any time soon”). But see, Business Performance a Top Concern, But Companies Ill-Prepared for Change, ELECTRIC POWER ALERT, Jan. 20, 1993, at 23 (analyz-
gators,\textsuperscript{10} and the general public.\textsuperscript{11}

Federal and state legislatures have not yet enacted comprehensive laws dealing with power line EMF.\textsuperscript{12} Thus, persons concerned about or allegedly injured by EMF exposure have turned to the courts and state utility regulatory agencies to seek relief.\textsuperscript{13} Many experts originally expected that the power line EMF issue would produce numerous claims, but the lack of certainty as to the health effects of EMF has disposed of many of these claims. This is especially true in tort litigation where plaintiffs must establish a causal relationship between power line EMF and their particular disease.\textsuperscript{14} Similarly, in land condemnation disputes, courts are uncertain how to entertain the power line EMF issue due to the inconclusive scientific evidence.\textsuperscript{15}

In choosing locations for the construction of new electric transmission and distribution facilities, state utility regulatory agencies are often more responsive to the evidence of possible health effects of power line EMF.\textsuperscript{16} While most state utility agencies still do not accept EMF-related scientific evidence outright, they often consider the possibility that a link between EMF and human disease may exist when determining the best locations and construction designs for new electric transmission and distribution facilities.\textsuperscript{17}

This Comment explores some of the legal issues related to EMF. Part I outlines how power line EMF is generated, some common sources of EMF, the potential effects EMF may have on human health, and some of the issues raised in EMF personal liability claims and land condemnation

\begin{thebibliography}{17}
\bibitem{10} See Jeffrey D. Bogart, \textit{Utility Lawyers Gear Up for the 1990s}, \textit{Electrical World}, Jan. 1991, at 27 (noting that the possibility of participating in EMF lawsuits beckons alluringly, as a major, though tenuous, source of business for aspiring attorneys); \textit{EMF Plaintiffs' Attorneys Use Sophisticated Coalition in War of Experts}, \textit{Electric Power Alert}, Dec. 9, 1992, at 23-24 (discussing an organization known as Electro and Magnetic Radiation Case Evaluation Team (EMRCET), "a quiet coalition of . . . [plaintiffs' attorneys] where information is swapped to assist attorneys in developing the best possible courtroom game plans for recovering damages from utilities . . . [in EMF related litigation]").
\bibitem{11} See supra note 2.
\bibitem{13} Id. at 966.
\bibitem{14} See infra part I.C.1.
\bibitem{15} See infra part I.C.2.
\bibitem{16} See infra part II.
\bibitem{17} Id.
\end{thebibliography}
disputes. Part II specifically discusses the response of state utility regulatory agencies to the power line EMF issue when locating new electric transmission and distribution facilities, outlining the basic approaches that regulatory agencies may take and analyzing the costs and benefits of each approach. This Comment concludes that a policy of prudent avoidance in siting new facilities is the least intrusive way to both limit the possible adverse effects of EMF and still allow construction of new facilities to meet increasing demands for electric power. This Comment also proposes regulations that state utility regulatory agencies may enact in furtherance of such a policy.

I. EMF BACKGROUND

A. EMF and Its Sources

An electric current is created when the potential (voltage) is raised at one end of a wire, for example when an electric generator raises the voltage at one end of a power transmission system.\(^\text{18}\) Currents in motion produce associated electric and magnetic fields.\(^\text{19}\) Therefore, when an electric current moves in a long straight wire, such as a transmission or distribution line, it induces electric and magnetic fields.\(^\text{20}\) The magnetic field created by current flowing in a wire consists of a field of concentric circles around the wire that weaken as the distance from the wire increases or as the current decreases.\(^\text{21}\) Magnetic fields can create electric currents in any object — including humans — entering the field.\(^\text{22}\) Although electric and magnetic fields are measured in different units,\(^\text{23}\) a

\(^{18}\) See OTA Report, supra note 1, at 228.

\(^{19}\) ROBERT T. FOLK & SHELDON H. RADIN, PHYSICS FOR SCIENTISTS AND ENGINEERS, 539 (1982).

\(^{20}\) Id. at 549-50. For a more complete summary of the interrelations between electricity and magnetism and the equations that describe the electro-magnetic phenomenon, see id. at 676-84.

\(^{21}\) Id. at 549-52. The strength of this field can be described generally by the following equation: \(B=K(2I/R)\). \(B\) represents the magnetic field strength, \(R\) is the distance from the wire, \(I\) is the current flowing in the wire, and \(K\) is a mathematical constant. Id. This simplified equation illustrates two basic concepts concerning the strength of a magnetic field created by a wire. First, the strength of the magnetic field grows as the current, \(I\), increases. Second, the strength of the field lessens as the distance from the wire, \(R\), increases. Thus, the strength and effects of the field are lessened as the current in the line, \(I\), decreases or as the distance from the line, \(R\), increases.

\(^{22}\) Young, supra note 3, at 136.

\(^{23}\) John Weiss, The Power Line Controversy: Legal Responses to Potential Electromagnetic Field Health Hazards, 15 COLUM. J. ENVTL. L. 359, 362 (1990); OTA Report, supra note 1, at 228. The electric field is measured in volts per meter (V/m) and the magnetic field is measured in ampere per meter, gauss or tesla. Id.
commercially available gaussmeter can be used for both measurements.24

Because any current moving in a wire produces associated electric and magnetic fields, anything that generates, transmits or uses electricity — computers, televisions, electric razors, hair dryers, alarm clocks, power tools, other household appliances, and even the wiring in the walls of structures — produces EMF.25 However, pulling all the fuses in your house will probably not remove all sources of EMF, as other highly potent sources include automobiles, electric powered rail systems, manufacturing tools, and cellular telephones.26 Moreover, there are natural sources of EMF, such as the earth’s magnetic field and atmospheric processes.27

Much of the EMF-related litigation is focused on EMF created by electric power lines and associated equipment because household appliances, automobiles, and trains generally have weaker magnetic fields than electric transmission lines.28 In addition, household sources are generally only operated for short periods of time, thereby limiting human exposure to their related fields.29 Power lines, on the other hand, produce continuous and stronger EMF at normal distances.30

B. Potential Health Problems Associated with EMF

In modern society, electricity for manufacturing, transportation, communication, convenience, and other needs is of such vital importance that it is difficult to imagine life without it. In the United States, electricity is generated at 60 hertz (Hz),31 alternating current (AC).32 Originally, many people assumed that at such a low frequency and correspondingly

24. Hacinli, supra note 2, at 40.
25. See generally Hacinli, supra note 2 (discussing the many items in everyday use that produce EMF).
26. Id.; see also Cindy Skrzycki, Scientists Urge More Cellular Phone Studies; No Proof of Cancer Link, Hill Panel Told, WASH. POST, Feb. 3, 1993, at A1 (describing recent public concern over the possibility that EMF from hand-held cellular telephones may cause brain cancer).
27. OTA Report, supra note 1, at 228.
28. See id. (noting that although appliances often create stronger magnetic fields than power lines, they are less extended in space than power lines and thus create magnetic fields that decrease much faster as the distance from the source increases).
30. See OTA Report, supra note 1, at 228-32 (comparing the EMF strengths of various sources).
31. Hertz (Hz) measure the number of times that electric current in an alternating current circuit reverses direction, or the number of cycles per second. OTA Report, supra note 1, at 263. One Hz is the equivalent of one cycle per second. Id.
32. Alternating current is current that reverses its direction at a given frequency. Id. at
low energy, electricity was not harmful to humans.\textsuperscript{33} However, recent studies indicate that there may be adverse effects caused by EMF associated with electricity.\textsuperscript{34}

However, most of the studies and experiments to date are inconclusive in determining whether there is a definite link between EMF and certain diseases. The results of these studies can be summarized as follows:

At best, various experiments have demonstrated that particular cells or animals have shown responses to exposure to \ldots [EMF] of particular frequencies and intensities for specific durations. \ldots It is also unknown whether the changes that have been observed are in fact harmful \ldots whether exposure to \ldots [EMF] results in numerous biological effects that in fact cancel each other out. \ldots [or] whether humans or other animals are able to adapt to exposure. \ldots Therefore, it is impossible to conclude that any given level of exposure will be harmless, no matter how precisely its frequency, intensity and duration are regulated, nor can it be established that any given level of exposure is definitely harmful.\textsuperscript{35}

While the evidence is inconclusive and there is no general consensus as to what, if anything, should be done to address the issue, the studies have "suggested the possibility of a relationship between exposure to \ldots [EMF] and cancer that cannot be ignored."\textsuperscript{36}

\begin{footnotesize}
\begin{enumerate}
\item At 60 Hz alternating current, the current oscillates back and forth 60 times per second, as do the associated electric fields. \textit{Id.}
\item At 60 Hz, electric power transmission EMF is one of the lowest frequency forms of electromagnetic radiation. Other forms of electromagnetic energy that are considered dangerous to human health are typically found at much higher frequencies on the electromagnetic spectrum, such as microwaves ($10^{10}$ Hz), x-rays ($10^{18}$ Hz), and gamma rays ($10^{24}$ Hz). \textsc{Folk \& Radin}, supra note 19, at 681.
\item The electromagnetic radiation caused by power lines is at such low frequency that it does not have enough energy to ionize an atom, and is consequently known as non-ionizing radiation. On the other hand, "[i]onizing radiation is radiation that has enough energy to turn a neutral atom or molecule into a charged particle" and is typically associated with nuclear radiation and x-rays. Weiss, \textit{supra} note 23, at 362. Ionizing radiation is extremely harmful to humans because it can break chemical bonds in human cells or cause tissue heating. \textit{OTA Report}, supra note 1, at 227. Because EMF from power lines is not strong enough to ionize atoms, power line EMF was considered safe for humans. \textit{Id.}
\item However, it must be noted that the human body contains many ion-rich fluids, such as blood and lymph, that move in response to currents induced in the body when an electromagnetic field is encountered. \textit{Id.} at 229-30. It is not clear whether these induced currents have any effect on humans or whether an unidentified pathogen is the responsible mechanism by which power line EMF may adversely affect human health.
\end{enumerate}
\end{footnotesize}
and regulatory agencies have reacted differently to this possible relationship, and, while the direction of future EMF-related litigation and policy-making is not yet clear, definite trends are developing.37

C. Power Line EMF-Related Litigation: Tort and Land Condemnation Cases

Both personal injury and land condemnation suits for damages caused by power line EMF have been the subject of extensive analysis.38 Some background on these types of litigation is helpful in understanding regulatory agency responses to the power line EMF issue in cases involving the siting of new electric transmission and distribution facilities.39

1. Tort Claims and Power Line EMF

Few personal injury claims for damages caused by EMF have been asserted.40 This is likely because the suits are very costly,41 and because establishing causation without conclusive scientific evidence of the health effects of EMF is difficult.42 Although causes of action based on several different theories are possible, each with its own benefits and drawbacks,43 there is currently no predictable trend. In one of the first EMF personal injury decisions, Zuidema v. San Diego Gas & Electric,44 the jury did not determine whether EMF could actually cause cancer, but it

37. See infra parts I.C and II.
39. See infra note 49.
41. Id. at 363-64.
42. Young, supra note 3, at 167. “The scientific information concerning the effects of exposure to . . . [EMF] fields is insufficient to support individual claims of injury from exposure.” Id.
43. For an analysis of likely directions, see Brown, supra note 38, at 333-36 (suggesting a number of potential avenues for plaintiffs pursuing personal injury claims including, cancerophobia (mental distress from fear of disease caused by EMF), negligence, and strict liability); McCune, supra note 38, at 443-58 (suggesting causes of action in tort based on the theories of battery, trespass and private nuisance).
did conclude that there was insufficient scientific evidence regarding the health effects of EMF available at the time the plaintiff allegedly was injured, and, thus, the utility was not held liable for failing to warn of the possible dangers of living near power lines.45 Although the result in Zuidema may significantly limit recovery in future power line EMF litigation,46 it has not discouraged prospective plaintiffs entirely, and further tort related EMF litigation remains possible.47

2. Land Condemnation and Power Line EMF

While personal injury litigation has not resolved the issue of whether power line EMF may cause disease and the future of such cases remains uncertain, courts have dealt more extensively with power line EMF in land condemnation cases.48 It is possible that the results of these cases will be influential in future tort litigation, as well as in facility siting decisions.49

Private land that is taken to build a transmission line corridor is compensable.50 However, an accompanying issue that often arises concerns the transmission line's effect on the market value of land bordering the corridor.51 The neighboring landowners may allege that the fear of adverse health effects caused by EMF from power lines adjoining their property causes a decrease in the value of their property for which they should be compensated.52 As with tort litigation, courts in land condem-
nation cases must deal with a lack of scientific proof of the adverse health effects of EMF. However, in land condemnation cases, the court asks whether power line EMF causes fear that can legitimately devalue property. Most courts follow one of three approaches to decide this question.

The majority view is the most liberal. This view "supports the theory that public fear of power line . . . [EMF] is admissible to show such fear might depress property values even though there is no conclusive proof of these hazards." The much stricter minority view does not allow any evidence of power line EMF fear because such evidence is based purely on speculation rather than on clear "evidence of a direct physical disturbance" from which a proper level of compensation can be determined. Finally, the intermediate approach allows evidence supporting the claim that fear might depress property value like the majority approach. The intermediate approach is stricter than the majority approach, however, because it requires that the fear be reasonable and that a decrease in market value be proven.

While these differing approaches resolve the issue of how much evidentiary weight to accord to the inconclusive EMF-related health studies, this framework is unsatisfactory for several reasons. First, none of the approaches states conclusively whether EMF actually causes adverse health effects. Second, none of the approaches attempts to control or limit the potential health problem; at best they acknowledge that power line EMF may be a health hazard and attempt to make a post hoc determination of the value of land. Finally, it is very difficult for the plaintiff to establish that fear of EMF reduced the land value and the extent of appropriate

53. See, e.g., cases cited infra notes 56-57.
54. See Young, supra note 3, at 159.
55. Weiss, supra note 23, at 366.
56. Id. at 365-67. See also San Diego Gas & Electric v. Daley, 253 Cal. Rptr. 144 (Cal. Ct. App. 1988) (allowing a property owner to collect damages for the depressed value of adjoining property caused by public fear of EMF despite the lack of any proven detrimental effects of EMF); Kaufman, supra note 38, at 720-22; Young, supra note 3, at 160.
57. Weiss, supra note 23, at 372 (quoting Central Ill. Light Co. v. Nierstheimer, 185 N.E.2d 841, 843 (Ill. 1962)). See also Central Ill. Light Co. v. Nierstheimer, 185 N.E.2d 841 (Ill. 1962) (requiring the plaintiff to show a direct disturbance caused by the power line before any damages could be calculated); Kaufman, supra note 38, at 714-17; Young, supra note 3, at 161-62;
58. Weiss, supra note 23, at 367-72. See also, Kaufman, supra note 38, at 717-20; Young, supra note 3, at 160-61.
59. Young, supra note 3, at 169.
60. See id. at 180 (noting that any compensation awarded does not redress the plaintiff's concern over EMF).
compensation. Because of these problems, land use cases addressing power line EMF have had limited success in reducing or controlling the potential health hazard caused by power line EMF.

II. STATE UTILITY COMMISSIONS AND POWER LINE EMF

Because of the difficulty of proving causation, the judicial system has proven to be rather ineffective in dealing with the power line EMF health controversy. Likewise, federal and state legislatures have done little beyond requiring additional research. However, state public utility commissions (PUCs), which hear electric facility siting cases, are not as constrained by evidentiary requirements in considering power line EMF as the courts, and thus, may be better suited to deal with the issue.

In siting cases, the PUCs balance the risks of power line EMF against the benefits of having reliable and plentiful electricity. PUCs are free to

61. See id. at 168-69 (noting some of the evidentiary difficulties a plaintiff may encounter).
62. See id. at 178-79 (noting that courts may be an inappropriate forum for dealing with EMF due to time restraints and their lack of technical and industry expertise).
63. See infra part I.C.
64. See supra note 6.
65. Depending on the state, the agency regulating the utility industry may be called a public utility commission (PUC), public service commission (PSC), department of public utilities (DPU) or other similar title. OTA Report, supra note 1, at 204. These agencies differ slightly from state to state, but generally a PUC is composed of an elected or appointed multi-member board that regulates local utilities. Id. at 56-57. This regulation includes setting prices, controlling market entry, assisting in planning and reliability determinations, and often regulating the siting of new facilities. Id. Some states have a separate board that functions like a PUC, to deal specifically with the siting issue. Id. For purposes of this Comment, PUCs and any special siting boards are considered the same.
66. The siting process involves several steps. First, the utility must determine the need for the new facility. Next, it must apply to the PUC for a “Certification of Public Convenience and Necessity” (CCN). Id. at 203. Citizen groups and others may then request to intervene, and if the PUC accepts the request(s), the siting case enters a discovery phase. Id. The parties make formal filings at the end of discovery, after which a hearing is held. Id. Most states also allow for public comment or public meetings. Id. at 205. Once the utility obtains a CCN (and any other necessary permissions), it is free to acquire the necessary land. Id.

Decisions of a PUC may be appealed in the state court system. Id. However, the scope of such review is narrow: “[t]he condemning authority enjoys broad discretion in determining the location of a proposed public improvement and a reviewing court will not interfere with that determination in the absence of abuse of discretion, arbitrariness, or other unreasonable conduct on the part of the condemnor.” Young, supra note 3, at 156.
67. See Young, supra note 3, at 169 (observing that, unlike the courts, PUCs do not require a showing by a preponderance of the evidence that EMF causes harm for the PUC to take action to mitigate potential harm).
"[weigh] the public interest in the economical delivery of electricity against the detrimental effects of the necessary transmission and distribution facilities."68 The New Jersey Board of Public Utilities described this balancing of public interest in a recent siting case as follows:

There can be no doubt that society tolerates certain degrees of risk . . . . However, in tolerating these risks, society has, based upon existing knowledge, set standards beyond which the activity will pose a clear and unacceptable risk to human health and, therefore, should be restricted. In setting such standards, the crucial determination is the point at which the identifiable risk rises to a level which imposes upon society the duty to take protective action, notwithstanding possible inconvenience and disruption to normal daily life.69

PUCs understand the utility industry, the associated body of EMF-related scientific evidence, and the societal need for and concern with electricity.70 Furthermore, addressing the power line EMF issue effectively in the siting of new facilities may eliminate, or at least limit, the need for future personal injury or other EMF litigation. Thus, in the absence of a more definite link between EMF and illness, state PUCs may be able to deal with the power line EMF issue more effectively than either the judicial system or the federal or state legislatures.71

PUCs have been forced to consider the EMF issue in many recent siting cases and as a result, have developed several approaches to address the problem. These approaches can be divided into four discrete categories, ranging from dismissing the issue to completely restructuring the electrical distribution system to limit power line EMF exposure.72 The more common and less drastic approaches are placing regulatory limitations on future facility construction and adopting a policy of prudent avoidance.

In In re Potential Health Effects of Electric and Magnetic Fields of Utility Facilities,73 the California Public Utilities Commission issued an order calling for research, information, and investigation of possible regulatory responses to power line EMF to assist the Commission in determining

68. Id.
70. See supra note 65 and accompanying text.
71. Young, supra note 3, at 184.
72. See infra part II.A-D.
what its role should be in mitigating power line EMF.\textsuperscript{74} In requesting the information, the California PUC identified four possible strategies it could adopt:

1. Conclude that there is not enough evidence to warrant any action and continue research into potential health effects of EMF.
2. Conclude that some action must be taken, even with insufficient information on beneficial regulatory action \ldots \textsuperscript{75} such as setting numerical exposure standards \ldots \textsuperscript{76} Such an action would restrict exposure increase, but would do nothing about present exposure levels or about new areas becoming exposed to field levels less than the standards defined.
3. Conclude that there is some basis for concern and use prudent avoidance. 'Prudent avoidance' is a policy of limiting \ldots EMF exposures which can be avoided with small investments of money and effort while, for the moment, foregoing other more extensive measures.
4. Conclude that we face a serious health problem and commit substantial time and money to an aggressive program of limiting \ldots EMF exposures while acknowledging that because of present scientific ambiguities, some or all of this effort may turn out to be wasted.\textsuperscript{77}

These four alternatives are considered separately below.

\textit{A. The Status Quo Approach}

Under the status quo approach, PUCs determine that there is no reliable evidence linking power line EMF to adverse health consequences and thus conclude that spending extra money or time to build safer facilities is not necessary.\textsuperscript{78} This is a narrow approach; it does not attempt to mitigate exposure to EMF, but rather simply ignores the power line EMF issue.

Missouri adopted this approach in \textit{In re Union Electric Co.}\textsuperscript{79} The Missouri Public Service Commission refused to mandate preventative measures that would limit the possible adverse health effects caused by EMF emanating from a future transmission line.\textsuperscript{80} The Commission reasoned that it would not force a utility to spend money "to combat a phenomena

\begin{itemize}
\item\textsuperscript{74} Id.
\item\textsuperscript{75} Id. at 11-12.
\item\textsuperscript{76} Id.
\item\textsuperscript{78} Id. at *1.
\end{itemize}
[sic] which, on the basis of the evidence presented may be relatively benign."

The Massachusetts Department of Public Utilities adopted a similar approach in *In re Commonwealth Edison Co.* In this case, a group of Cape Cod residents challenged the reconstruction of an existing but ill-repaired power line primarily because of a fear of the adverse health effects caused by power line EMF. The residents asserted that "the course of reason and prudence is to make installations in such a way as to lessen fields experienced by human habitation" and requested that the new cables be buried underground as a precaution. The Massachusetts Department of Public Utilities found that there was nothing on the record to support a finding that power line EMF causes illness and refused to require the utility to build and maintain the cables underground. The Massachusetts Department of Public Utilities did give some consideration to the power line EMF issue, but assigned it little weight compared to the excessive cost of underground transmission.

The Missouri and Massachusetts examples illustrate that the status quo approach is least burdensome to the utilities and clearly places the need for inexpensive, reliable electric power above any possible, albeit speculative, health risks. It does not acknowledge a link between EMF and human health and, therefore, refuses to consider any mitigation techniques. This approach is very economical in the short run, but could prove very costly should a link between EMF and human disease be established. Furthermore, some argue that "[d]oing nothing, while waiting for conclusive evidence about human health effects, is not a reasonable

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79. *Id.* at *3.
81. *Id.* at 47-48.
82. *Id.* at 50.
83. *Id.* at 48.
84. *Id.* at 51.
85. See supra notes 77-84 and accompanying text. See also *Re* Potomac Elec. Power Co., Case No. 7004, Order No. 68784 (Md. P.S.C. May 1, 1990) (WL, MD-PUR database). Refusing to modify a certificate of public convenience for the construction of a 500kV transmission line, the Maryland PSC stated:

The suggestion that construction of the ... line be delayed until scientists resolve the question at issue is likewise unrealistic. Adopting such a recommendation would require placing a similar moratorium on construction of virtually all transmission and distribution lines within the state. Clearly, such a drastic measure cannot be taken without proof that it is necessary.

*Id.* at 36.
response to the potential risks associated with EMF." 86 Therefore, something should be done now to remedy the situation.

B. The Standards Approach

The standards approach attempts to limit power line EMF exposure even though there is currently no conclusive proof of adverse health effects on humans. 87 Typically, state regulatory agencies establish a set of guidelines or standards that limit the permissible strength of EMF fields at a given distance from a transmission facility. 88 The standards are based upon existing measured field strengths. 89 In deciding that standards are needed, the PUCs conclude that avoiding the possibility that a link between power line EMF and human disease exists is preferable, even though there is no clear evidence of causation. 90 Many states have already enacted standards that limit EMF exposure along a transmission right-of-way. 91

The standards approach, however, often does not fully consider the so-

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87. The "prudent avoidance" approach, discussed in part II.C infra, also uses guidelines to limit power line EMF exposure despite the lack of an etiological link between power line EMF and human disease.
88. See OTA Report, supra note 1, at 241 (discussing Florida and Ohio standards for limiting EMF exposure).
90. See Young, supra note 3, at 183 (noting that even excessively high standards may be better than no standards).
91. See OTA Report, supra note 1, at 242. The OTA Report provides the following summary of states' limits on EMF field strengths along transmission rights-of-way (RoW):

<table>
<thead>
<tr>
<th>STATE</th>
<th>FIELD LIMIT</th>
</tr>
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<tbody>
<tr>
<td>Montana</td>
<td>1kV/m at edge of RoW in residential areas</td>
</tr>
<tr>
<td>Minnesota</td>
<td>8kV/m maximum in RoW</td>
</tr>
<tr>
<td>New Jersey</td>
<td>3kV/m at edge of RoW</td>
</tr>
<tr>
<td>New York</td>
<td>1.6kV/m at edge of RoW</td>
</tr>
<tr>
<td>North Dakota</td>
<td>9kV/m in RoW</td>
</tr>
<tr>
<td>Oregon</td>
<td>9kV/m maximum in RoW</td>
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<tr>
<td></td>
<td>10kV/m maximum for 500kV lines</td>
</tr>
<tr>
<td></td>
<td>2kV/m maximum for 500kV lines at edge of RoW</td>
</tr>
<tr>
<td></td>
<td>8kV/m maximum for 230kV and smaller lines in RoW</td>
</tr>
<tr>
<td></td>
<td>2kV/m maximum for 230kV and smaller lines at edge of RoW</td>
</tr>
<tr>
<td>Florida</td>
<td>200mG for 500kV lines at edge of RoW</td>
</tr>
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cietal need for electricity. The standards are fixed, arbitrary requirements that must be followed regardless of cost and without balancing the potential harm of power line EMF against the costs to society incurred by curtailing the use of electricity. This approach risks setting an unduly stringent limit on power line EMF that would be wasteful if it is eventually proven that EMF is not hazardous to human health. The standards approach may also have questionable utility as a risk management tool because there may not be a straightforward relationship between the degree of exposure to EMF and the level of the resulting harm.

C. The Prudent Avoidance Approach

The prudent avoidance approach is similar to the standards approach in that it calls for action rather than simply ignoring the problem until more is known about EMF and its effect on humans. Prudent avoidance has been described as “the striking of a reasonable balance between avoiding potential harm and the attendant costs and risks.” “Avoidance” requires that steps be taken to separate humans from EMF, and “prudence” requires that the steps taken are reasonable and “carry only a modest cost.” While there are many experts who oppose the prudent avoidance approach, many states have adopted this approach “as a

250mG for double circuit 500kV lines at edge of RoW
150mG for 230kV and smaller lines at edge of RoW

Id.

92. Some states, such as West Virginia, have flatly rejected the standards approach, preferring to handle the EMF issue on a case by case basis using the best information available at the time. West Virginia PSC Will Review EMF Health Effects on Individual Basis, UTIL. ENV'T. REP., May 14, 1993, at 12.

93. OTA Report, supra note 1, at 242. But see John W. Gulliver & Christine C. Vito, EMF and Transmission Line Siting: The Emerging State Regulatory Framework and Implications for Utilities, NAT. RESOURCES & ENV'T, Winter 1993, at 12, 48 (suggesting that a standards approach to EMF regulation may be beneficial because it can “clearly set a predictable compliance norm and eliminate subjectivity from the approval process,” such as the type of subjectivity encountered under the prudent avoidance approach).


95. Lori A. Burkhart, Electro-Magnetic Fields: Recent State Action, PUB. UTIL. FORT., July 1, 1992, at 32. Dr. Keith Florig, a fellow at the Center for Risk Management, Resources for the Future, defined prudence as “spending the same amount to reduce EMF risks as is spent to reduce other risks.” John Simpson, $10 Billion a Year Could End EMF Exposure, Panel Told, PUB. UTIL. FORT., May 15, 1993, at 45. Based on this definition of prudence and the assumption that EMF risks will prove to be no greater than current studies predict, Dr. Florig estimated that the cost to completely eliminate EMF exposure may be as little as $10 billion per year. Id.

96. See, e.g., Re Advance Plans for Constr. of Facilities, No. 05-EP-6, 1992 WL 486429,
common-sense solution to the unknown."

A discussion of the steps taken by some of the states that have currently adopted this approach illustrates the issues considered in implementing prudent avoidance.

In *In re Public Service Company of Colorado to have Upgrades in Douglas County*, the Colorado Utility Commission (Colorado PUC) was one of the first state PUCs to hear the power line EMF issue in a siting case and to adopt the prudent avoidance approach. The Public Service Company of Colorado wanted to upgrade an existing transmission line from 115kV to 230kV. Several residential interest groups opposed this upgrade. As in other cases where EMF was an issue, the Colorado PUC concluded that the evidence linking power line EMF to disease was inconclusive. However, the Colorado PUC decided to allow the transmission upgrade only if it was constructed so as to prudently avoid any potential EMF harm. Some of the procedures that the Colorado PUC required the utility to consider to limit power line EMF exposure included using reverse phasing of the transmission lines, using higher ground clearances, building with conductors larger than otherwise necessary, locating poles at greater distances from residential areas, and

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* at *13 (Wis. P.S.C. May 7, 1992) (Coughlin, Comm'r, concurring). Commissioner Coughlin wrote:

> I do not think that this concept of prudent avoidance . . . is either practical or appropriate. Consequently, it should not be adopted . . . . In fact the term itself, "prudent avoidance," borders on being merely clever verbiage which means different things to different people. It seems similar to the term "benign neglect" that was popular a number of years ago.

*Id.* See also Burkhart, supra note 95, at 32 (suggesting that many believe that prudent avoidance is merely a "simplistic approach to a complicated scientific question"); infra note 118 and accompanying text.

97. Burkhart, supra note 95, at 32.
99. *Id.* at 2.
100. *Id.* at 2-3.
101. *Id.* at 17.
102. *Id.* at 20. This case illustrates the cost-benefit analysis that the Colorado PUC used in applying prudent avoidance. The Colorado PUC determined that prudent avoidance did not require the utility to bury transmission lines at an added cost of $13.5 million where only 390 people were affected by the lines. *Id.* at 17-18.
103. Reverse phasing is an attempt to align the three cables used to transmit power such that the EMF field generated by each wire will cancel out or at least reduce the effect of the fields created by the other two wires. *MPS Study: EMF Reductions Possible for Lines, but Costs are Prohibitive*, Util. Env't Rep., April 2, 1993, at 11.
104. See supra note 21 (explaining how the EMF effect is diminished as the distance from the source of the EMF is increased).
105. See OTA Report, supra note 1, at 229. The OTA Report suggests that transmission lines constructed of superconducting materials instead of more traditional metallic conduc-
giving continued support to industry research and EMF-related monitoring.\textsuperscript{107} Upgrades of existing facilities were to be treated with the same prudent avoidance policy as required for new construction proposals.\textsuperscript{108}

In \textit{Re Advance Plans for the Construction of Facilities},\textsuperscript{109} the Wisconsin Public Service Commission (Wisconsin PSC) also adopted the prudent avoidance approach. In its decision, the Wisconsin PSC detailed specific requirements for prudent avoidance measures and explained how the measures were to be implemented.\textsuperscript{110} The Wisconsin PSC adopted many of the same requirements as the Colorado PUC, such as requiring technical and design improvements, locating new facilities away from urban areas, adopting uniform measurement standards, and continuing research.\textsuperscript{111} The Wisconsin PSC went further, however, by requiring each utility to file an annual compliance report and an integrated resource plan to show that power line EMF requirements were met.\textsuperscript{112} More importantly, the Wisconsin PSC stressed the role of the public in reducing its own exposure to EMF.\textsuperscript{113} The Wisconsin PSC reasoned that because individuals can directly affect the levels of EMF in their personal environments through electricity conservation, appliance selection and appliance location, it is sensible to require the public to play a larger role in EMF mitigation.\textsuperscript{114}

Furthermore, the Wisconsin PSC specified how the power line EMF

\textsuperscript{106} See supra note 21.
\textsuperscript{108} Id. at 20-21.
\textsuperscript{110} Id. at 8-13.
\textsuperscript{111} Id. at 11-13. While Colorado and Wisconsin have adopted many similar procedures in dealing with the EMF issue, they differ somewhat in the results they seek to achieve. The Colorado PUC "defines prudent avoidance in economic terms with restraints on expenditures an implicit part of . . . [their] strategy." Gulliver & Vito, \textit{supra} note 93, at 14. The Wisconsin PSC, on the other hand "creates more of a philosophical climate and a mandated dialogue . . ." for the utility to follow in siting new facilities. Id.
\textsuperscript{113} Id. at 13-14.
\textsuperscript{114} Id. (suggesting that, while it is the utilities' responsibility to promote conservation, the effectiveness of such programs depends on the cooperation between the utility and the customer). A similar argument can be made that, while it is the utilities' responsibility to educate the public on "safe" EMF levels and actions that the public can take to mitigate EMF effects, it is up to the public to carry out such actions.
measures were to be considered in a siting case. The Wisconsin PSC required a utility applying for a siting permit to submit certain information justifying a proposed transmission facility. The information required included an explanation of why the utility selected the particular route, the existing EMF level along the route, estimates of how the new facility will affect current EMF levels, proximity to schools, houses and other populated areas, and alternative routes. The Wisconsin PSC considers this information along with the utility's reasons for choosing a given location in making its siting decision.

While not making it an outright requirement, the Wisconsin PSC also stated that it was generally preferable that a utility use the design producing the least EMF. Utilities may recommend an alternative design which does not produce the least EMF when:

i. The least-EMF design is unusually costly.
ii. The least-EMF design reduces the safety of utility line workers . . .
iii. The least-EMF design does not reliably transmit power.
iv. The utility does not have proper construction or maintenance procedures for a particular least-EMF design. In this case, the utility should modify its procedures so it can use the design in the future.
v. Other valid extenuating circumstances make use of the least-EMF design unreasonable.

There have not been any Wisconsin siting cases raising the power line EMF issue since the establishment of these guidelines, and it is not yet clear how strictly they will be interpreted. However, because the guidelines are relatively specific, the results should be reasonably predictable.

Although the Colorado and Wisconsin cases lay out many of the re-
quirements of the prudent avoidance approach and explain how they operate.\(^{120}\) They do not state clearly whether the prudent avoidance policy applies only to new construction and upgrades or whether it also applies to facilities already built and operating. Applying the prudent avoidance approach to existing facilities would require time consuming, expensive retrofitting to meet the new criteria. Likewise, neither case states whether prudent avoidance is to take precedence over power line EMF standards, or whether the standards take precedence over the requirements of prudent avoidance in states that have adopted both approaches. These issues were resolved in New Jersey.

In *In re Jersey Central Power and Light Co.*,\(^{121}\) the New Jersey Board of Public Utilities (New Jersey BPU) adopted a prudent avoidance policy that was modeled after the Colorado policy.\(^{122}\) However, the New Jersey BPU declined to apply this new policy to a facility that was completed, but not yet operational.\(^{123}\) In doing so, the New Jersey BPU stated: "there appears to be a consensus that such policy should be limited to matters involving the construction of new facilities or the proposed upgrading of an existing line..."\(^{124}\) The New Jersey BPU took this position because it found that "even under the most pessimistic assumptions it is hard to justify the costs of modifying old facilities."\(^{125}\)

The New Jersey case also illustrates how to implement a prudent avoidance policy in states that already have established a power line EMF standard. The New Jersey BPU decided that both the power line EMF standard and prudent avoidance approaches should be applied if both exist, and that both must be met for a new transmission project to be approved.\(^{126}\) In *Jersey Central Power and Light*, the New Jersey BPU first found that the EMF field strength at a given distance from the transmission facility was within the limitations established for New Jersey by the Commission on Radiation Protection. Then it applied prudent

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120. See *supra* notes 103-118 and accompanying text.
122. *Id.* at 550. While this case did not specifically decide what was required under prudent avoidance in New Jersey, it initiated further hearings to consider the potential application of prudent avoidance and also determined that a future pending case would be used to clarify the contours of the New Jersey prudent avoidance policy. *Id.*
123. *Id.*
124. *Id.*
125. *Id.* (quoting DEPARTMENT OF ENGINEERING AND PUBLIC POLICY, CARNEGIE MELLON UNIVERSITY, ELECTRIC AND MAGNETIC FIELDS FROM 60 HERTZ ELECTRIC POWER: WHAT DO WE KNOW ABOUT POSSIBLE HEALTH RISKS? 27 (1989)).
avoidance.\textsuperscript{127}

The prudent avoidance approach takes into account the possibility that there may be a link between power line EMF and certain diseases, and attempts to enact feasible measures to mitigate any harmful effects before it is too late.\textsuperscript{128} At the same time, it considers society's need for reliable electric power.\textsuperscript{129} Prudent avoidance balances this need against the speculative nature of the evidence linking power line EMF to disease by limiting the level of expenditures required in carrying out the policy.\textsuperscript{130} This approach is prospective because it attempts to limit exposure before facilities are built and, thereby, reduces the need and potential for future litigation (e.g., personal injury suits and land condemnation suits). This approach is the current trend and is being reconsidered by some PUCs that originally took less active approaches in dealing with power line EMF.\textsuperscript{131}

D. The "Eliminate EMF Completely" Approach

The most extreme alternative, which has not been widely accepted, is to eliminate EMF completely.\textsuperscript{132} Under this approach, PUCs would not only put a moratorium on building new facilities and rebuilding existing ones, but would also require utilities to make significant and very costly changes to their current systems.\textsuperscript{133} The required changes would include changing from alternating current (AC) to direct current (DC) and solar

\footnotesize{\textsuperscript{127} Id.\textsuperscript{128} See In re Public Serv. Co. to have Upgrades in Douglas County, No. 89A-028E, at 17-18 (Colo. Pub. Util. Comm'n, decision No. C89-1622, Dec. 20, 1989).\textsuperscript{129} Id. at 17.\textsuperscript{130} Id.\textsuperscript{131} See, e.g., In re Potential Health Effects of Electric and Magnetic Fields of Utility Facilities, 119 Pub. Util. Rep. 4th (PUR) 1 (Cal. P.U.C. 1991) (ordering a new investigation into power line EMF to help determine the approach to take in resolving future siting disputes); Ohio Adopts Final EMF Rules, PUB. UTIL. FORT., May 1, 1993 at 8 (noting that Ohio adopted a flexible set of prudent avoidance rules similar to the rules enacted in other states).\textsuperscript{132} See Gulliver & Vito, supra note 93 at 15, 47 (noting that Rhode Island is the first state to enact such a moratorium). Some argue that a moratorium will force a utility to "devote its attention to a resolution of EMF policy issues." Id. at 47. Opponents argue that a moratorium may be an overburdensome measure given the scientific information available on EMF, that moratoria do nothing to cure the problem, and that "such measures actually increase risk rather than safeguard the public, because the current flowing in existing lines is purportedly increased to meet customer demands, thereby increasing EMF emissions." Id. at 15, 49.
power, and drastically reducing consumption of electricity.\textsuperscript{134} It has been noted that "[t]his is the kind of all-out response that would be triggered by well-supported research results demonstrating clear causal connections for serious disease."\textsuperscript{135} Because such a causal connection has not yet been proven, this alternative is plagued by the same problem as the courts in EMF personal liability and land use cases — there is no scientific justification to implement such a drastic response.

\section*{III. Conclusion}

It is clear that more research is required to determine whether EMF actually has any health effects on humans, and currently there is a great deal of research being carried out in furtherance of this objective.\textsuperscript{136} However, a conclusive finding remains remote, if at all possible. The courts are poorly suited to properly deal with the issue because of the strict standard of causation. The legislative branch has also proven to be a less than desirable forum to resolve the issue. State regulatory agencies resolving electric facility siting issues are another alternative for addressing this issue. Because of their familiarity with technical factors and their freedom from stringent evidentiary requirements, state PUCs appear to be the best place to deal with the power line EMF issue until conclusive evidence is produced.

State PUCs have advanced several approaches to deal with power line EMF. These approaches range from doing nothing to attempting an all out restructuring of the utility industry to reduce power line EMF. The former approach is inadequate because it does nothing to mitigate the possibility that there may be harmful effects from power line EMF. The latter approach fails to consider the cost to society of more expensive electricity that would accompany such an approach.

Adopting both standards to limit the strength of magnetic fields and a policy of prudent avoidance are prospective solutions because they attempt to mitigate potential power line EMF harm before it occurs. These two approaches acknowledge that little is actually known about the health effects of EMF and take this into account when considering societal costs. While a standards approach may be somewhat arbitrary, it does supply the industry with guidelines to help reduce exposure to power line EMF effects. At the same time, it does not cost society a great deal to

\textsuperscript{134} Id.
\textsuperscript{135} Id. at 5.
\textsuperscript{136} See supra note 3 (discussing some of the studies).
enforce. PUCs must be careful to ensure that such standards do not result in costly modifications that could later prove to have been unnecessary.

The prudent avoidance approach balances societal costs against potential harm. Measures such as raising transmission tower heights, improving conductor insulation, requiring stronger conductors, redesigning conductor configurations, transmitting electricity using direct current,\(^{137}\) building new facilities,\(^{138}\) attempting to locate facilities in more remote areas, continuing research, and making the public more aware of all sources of EMF and how to reduce exposure can be carried out without any undue costs or other burdens.

Further public education on the issue is also justified. The more people know about power line EMF and other EMF sources, and how to limit their exposure to EMF, the lower the likelihood that individuals will be exposed or that EMF-related issues will arise. It may also be beneficial for utilities to take the initiative in siting cases by opening the transmission siting process to the public and news media as well as siting officials.\(^{139}\) Keeping the public educated and involved in the attempt to address EMF concerns should help reduce public hostility to new electric transmission projects. It will also remind the public that despite the many available remedial actions, there is an associated cost, and therefore the entire issue must be considered, not just the health aspect.

As more states deal with the power line EMF issue, it appears that the sensible solution is to adopt a policy that limits power line EMF exposure without burdening the public. Prudent avoidance in siting new facilities appears to be the best and most logical means of dealing with the power

\(^{137}\) Direct current does not create EMF. CMS, American Power Propose DC Line as Part of Proposal for 300-MW Unit, INDEPENDENT POWER REP., May 22, 1992, at 5. Converting from alternating current (AC) to direct current (DC), while reducing EMF, is not economical given current technology unless the power is transmitted over distances greater than 400 miles. Id.

\(^{138}\) It is interesting to note that constructing new transmission facilities right next to existing ones can reduce EMF. See, e.g., In re Nantahala Power Light Co., 141 Pub. Util. Rep. 4th (PUR) 302, 309 (N.C.U.C. 1993). This is because the electric current carried by two parallel lines generates less EMF than when a single line carries the same amount of current. Id.

\(^{139}\) Salt River P.R. Campaign Delivers Support on Transmission Line Project, ELECTRIC POWER ALERT, Feb. 3, 1993, at 18-19 (discussing how one utility found that proactive public relations efforts helped it obtain public support for a proposed electric transmission project).
line EMF issue until a clear, scientific understanding of the issue is available.

Christopher A. Wilson