# Biological Effects of Environmental Electromagnetic Energy

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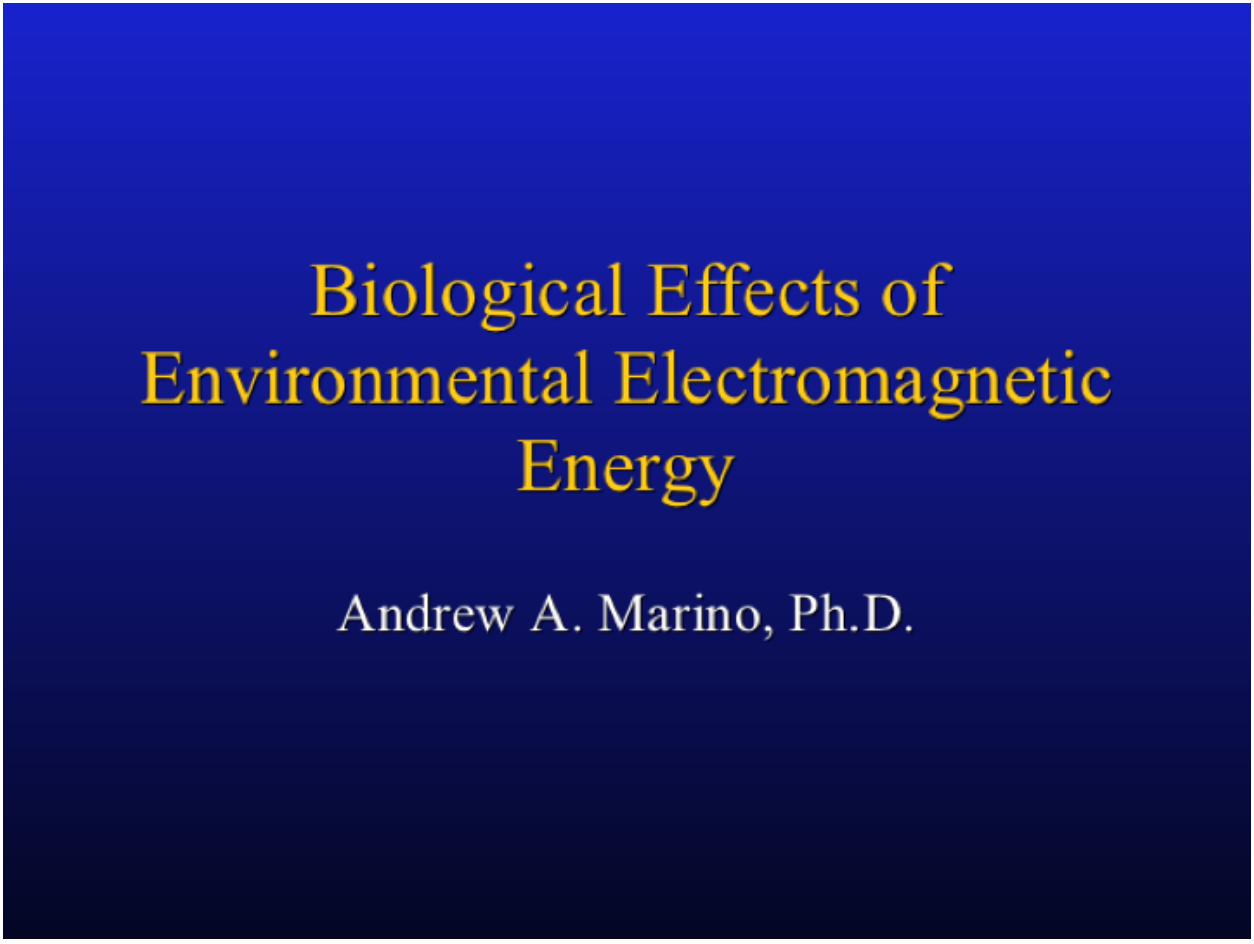
Presented at the *Annual Meeting of the American Association for the Advancement of Science, Symposium on Biological Significance of Bioelectricity*, San Francisco, CA, January 7, 1980

## Abstract

Man-made environmental electromagnetic energy (EEE) from the power and communications systems is pervasively present. Despite this, until recently there has been no serious consideration of the public-health consequences of chronic exposure to EEE. Now interest in all aspects of bioelectricity has been kindled by discovery of the importance of solid-state properties of biological tissue, and by recognition that biological growth-control systems function by means of voltages and currents comparable to those induced by EEE. In the US the emphasis has been on therapeutic application of very low levels of electromagnetic energy, and widespread clinical testing of various techniques is in progress. In a few cases proposed construction projects—a 765,000-volt transmission line in New York and a military radar in Massachusetts, for example—have involved some consideration of adverse side-effects of EEE. This evidence—and that from the USSR where the public-health consequences of EEE are under intensive study—have established that EEE is capable of causing biological changes in exposed subjects. A thorough independent review of public exposure patterns and a risk/benefit analysis are therefore required so that the true cost of specific technologies can be determined.

## Introduction

Consideration of the role of electrical forces in biological systems began with a move away from a purely chemical view of life and toward one which emphasized electron dynamics and the physical properties of biological tissue. Studies of the physiological role of the body's intrinsic electrical signals then began, and they led to experiments on the therapeutic effects of artificial electrical signals. But during this forty-year developmental period, electricity  became firmly established in society. There was a proliferation of transmitter towers, high-voltage lines, and the innumerable devices they serve, and it resulted in environmental levels of electromagnetic energy comparable to those being studied in the 1aboratory and applied clinically. I will speak about the side-effects of environmental electromagnetic energy; I will conclude that present exposure patterns are a significant public-health risk.

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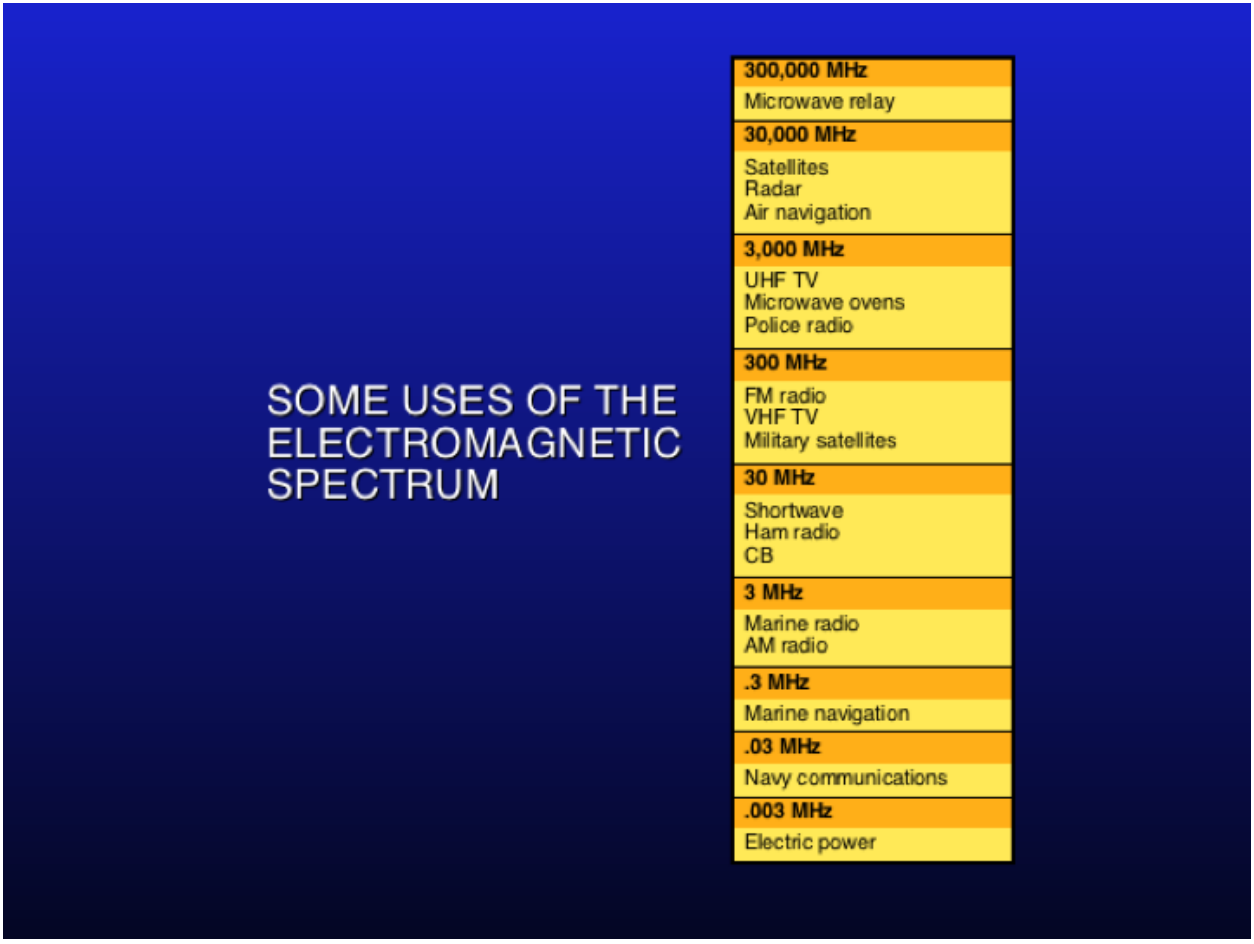
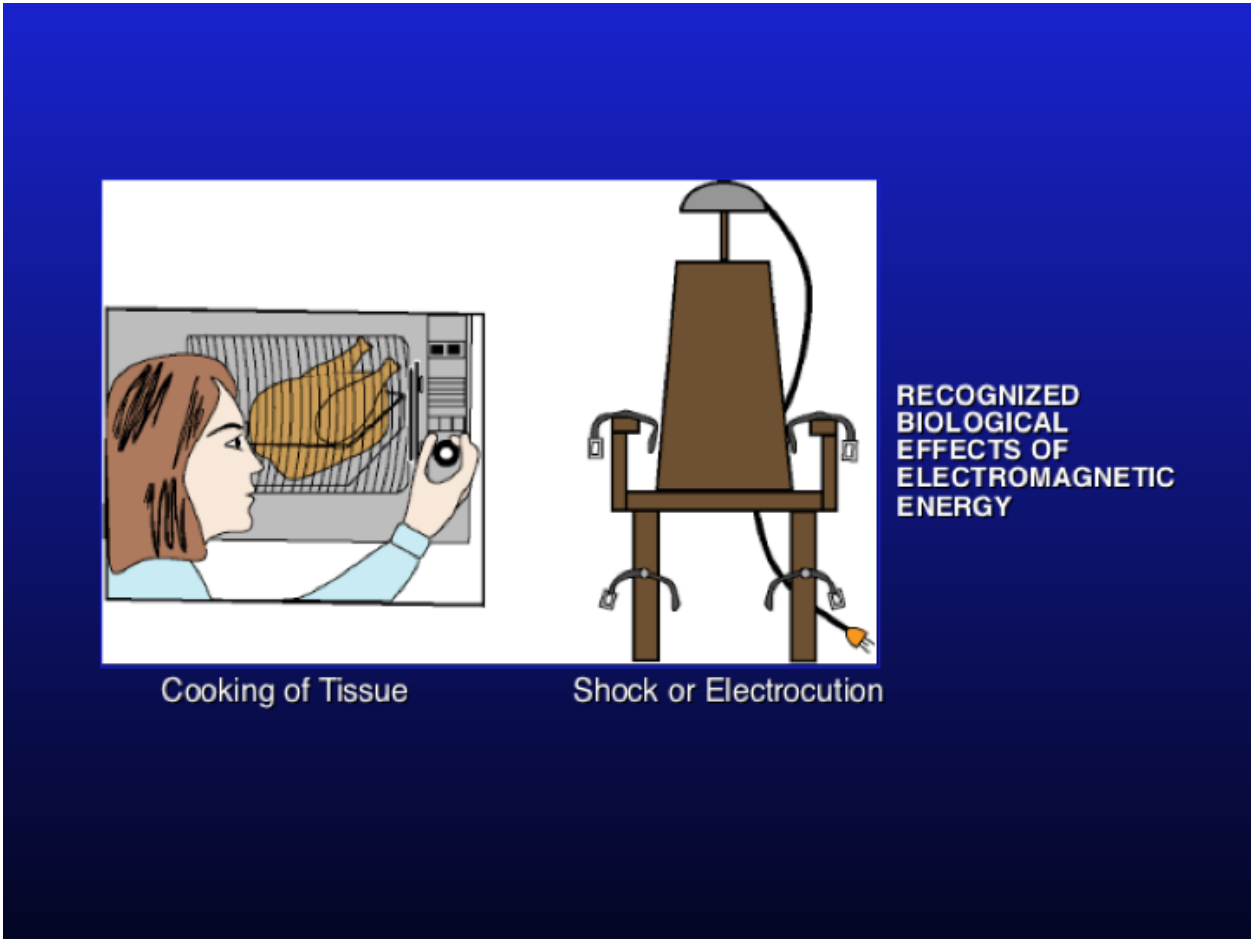
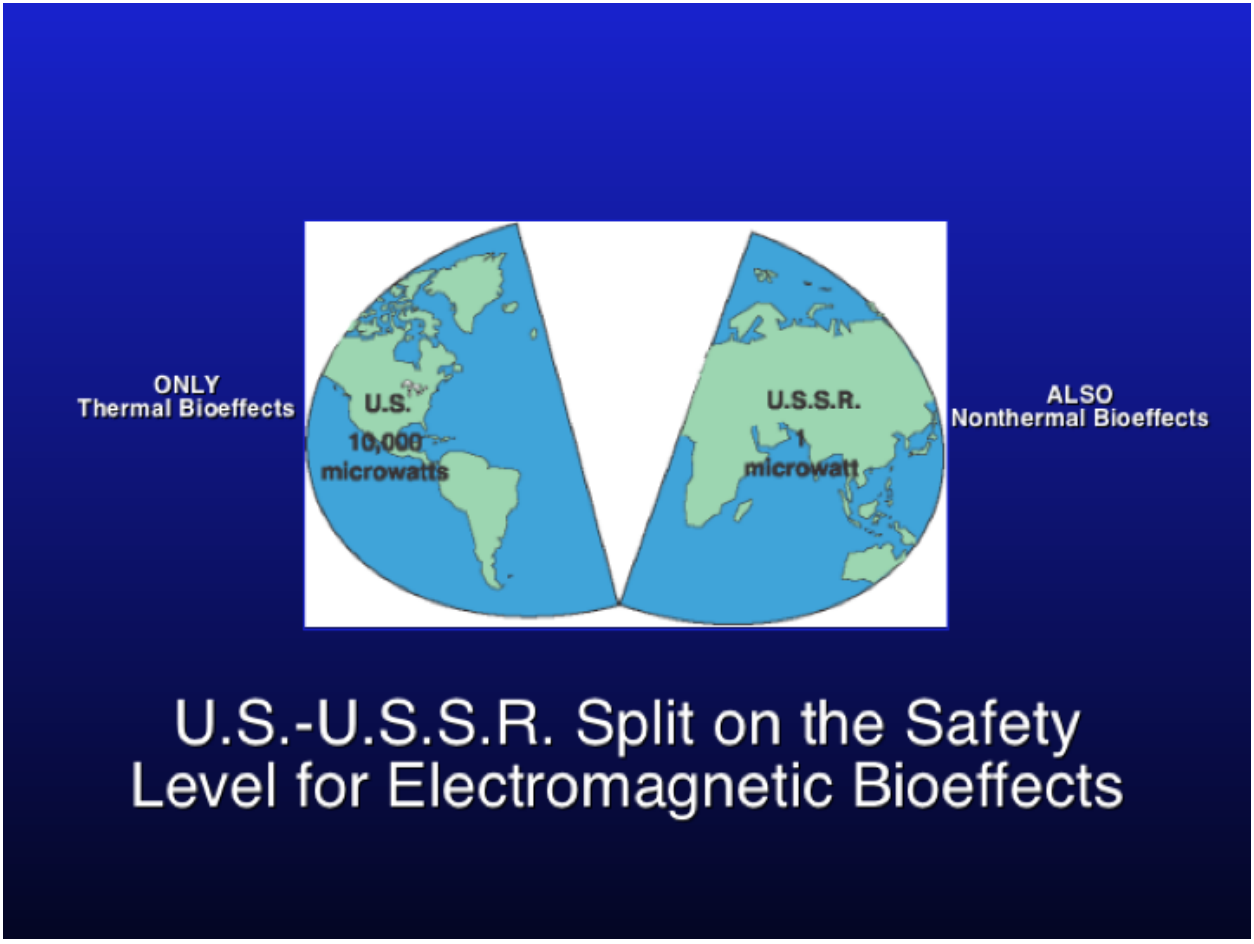



The first transmission line was built in 1882, and five years later the first transmitter-receiver system was successfully operated. From this beginning came our modern electrical power and communications systems. The existing frequencies have been divided among the various classes of users.

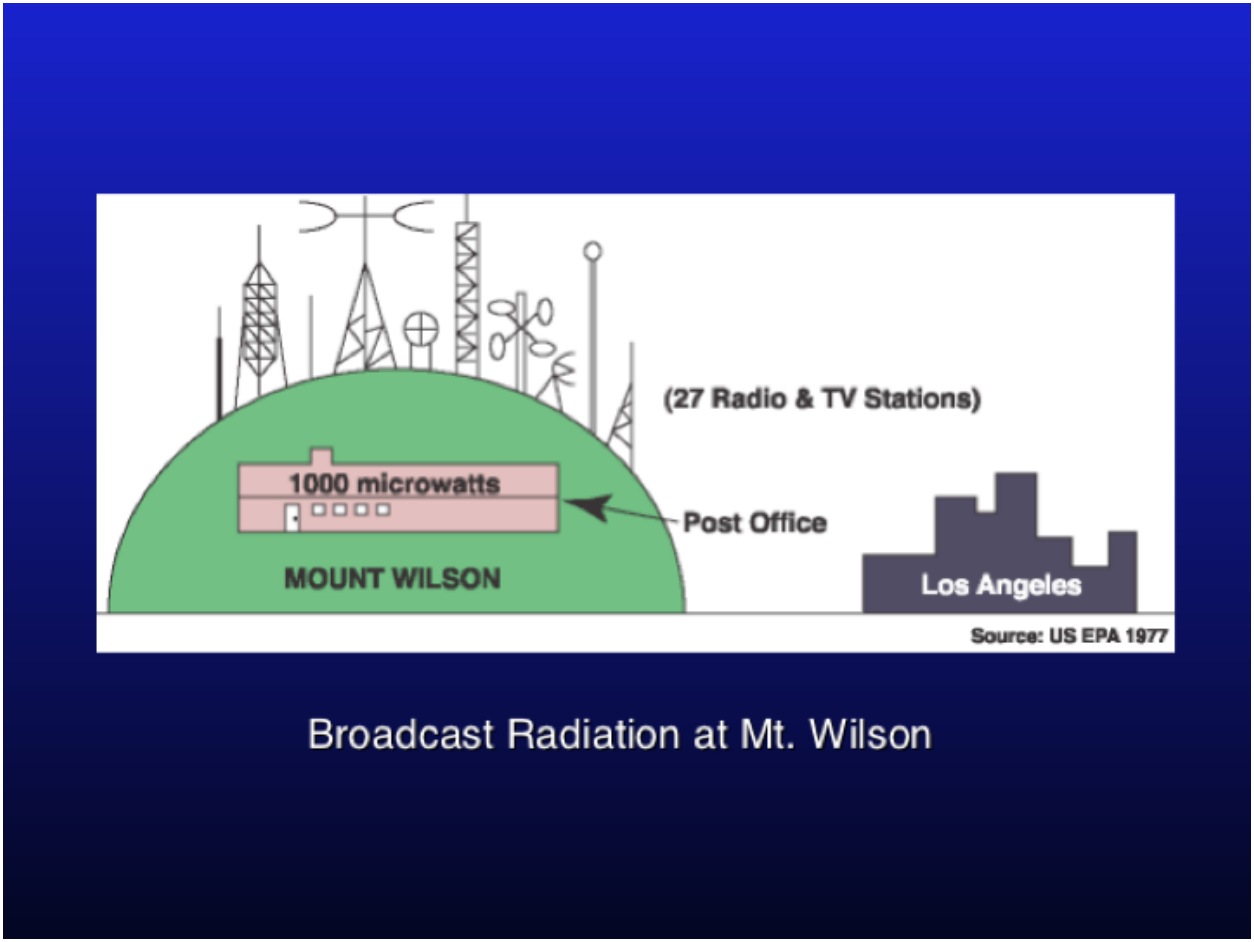



Traditional engineering concepts, at least in the United States, sanctioned only two electrical bioeffects, namely heating and shock. They became the sole design criteria with regard to possible side-effects. The rule—called the thermal-only standard because both effects occur simultaneously—developed that electromagnetic energy could be beamed through the environment or directed along high-voltage lines at any intensity level up to that which produced heating or shock.

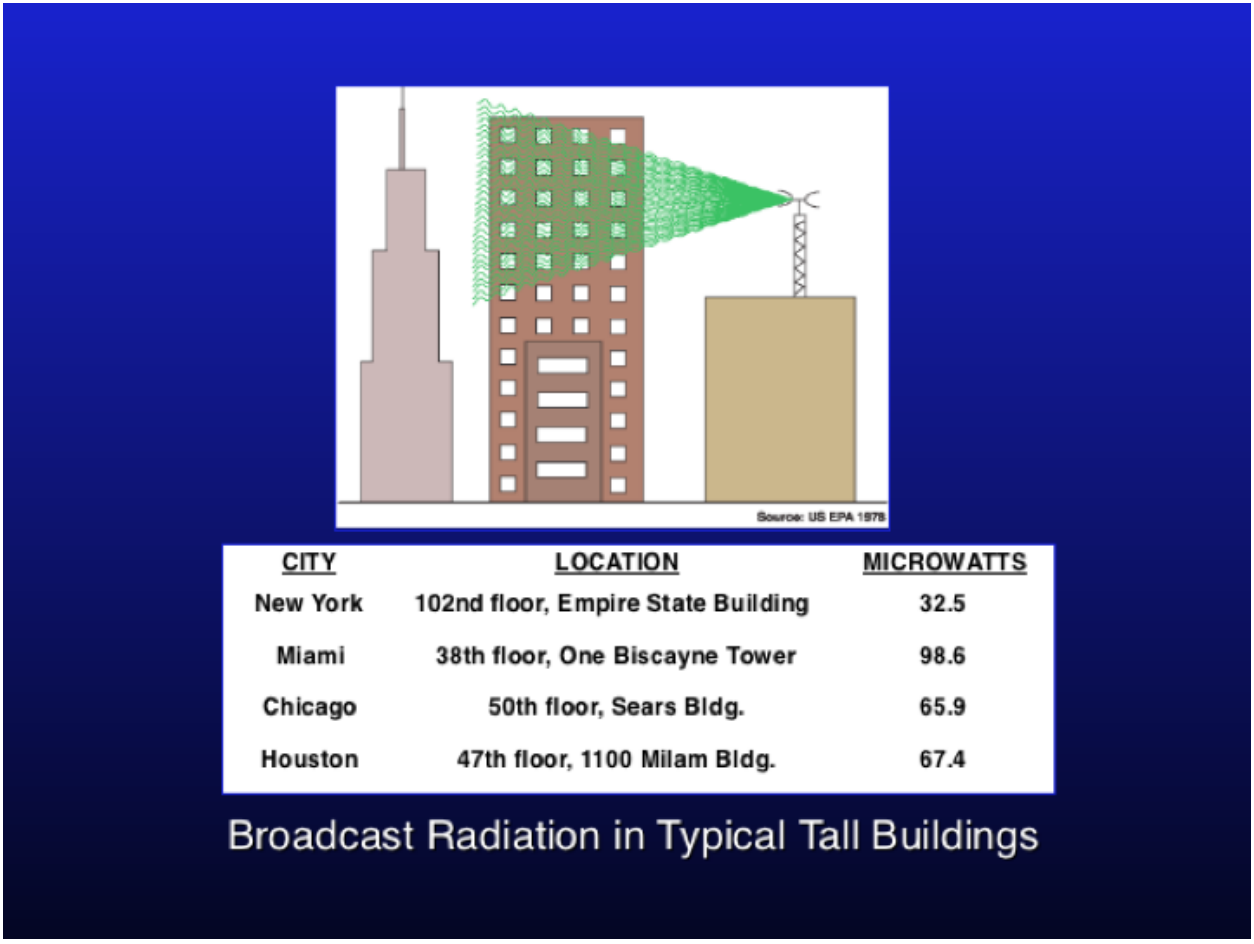

It is convenient to divide environmental electromagnetic energy into the power and broadcast regions. The power system operates at a single frequency of 60 hertz and includes all transmission lines and line-powered devices. The broadcast frequencies are characterized by wireless energy transmission and include radio, TV, radar, and microwave ovens. The traditionally-recognized electrical bioeffects can occur only above 10,000 microwatts (to be read "microwatts per square centimeter") or, at the power frequency, if one touches an energized wire. Thus, in all American jurisdictions and in the military, electrical sources are considered safe with regard to side-effects if these precautions are followed.



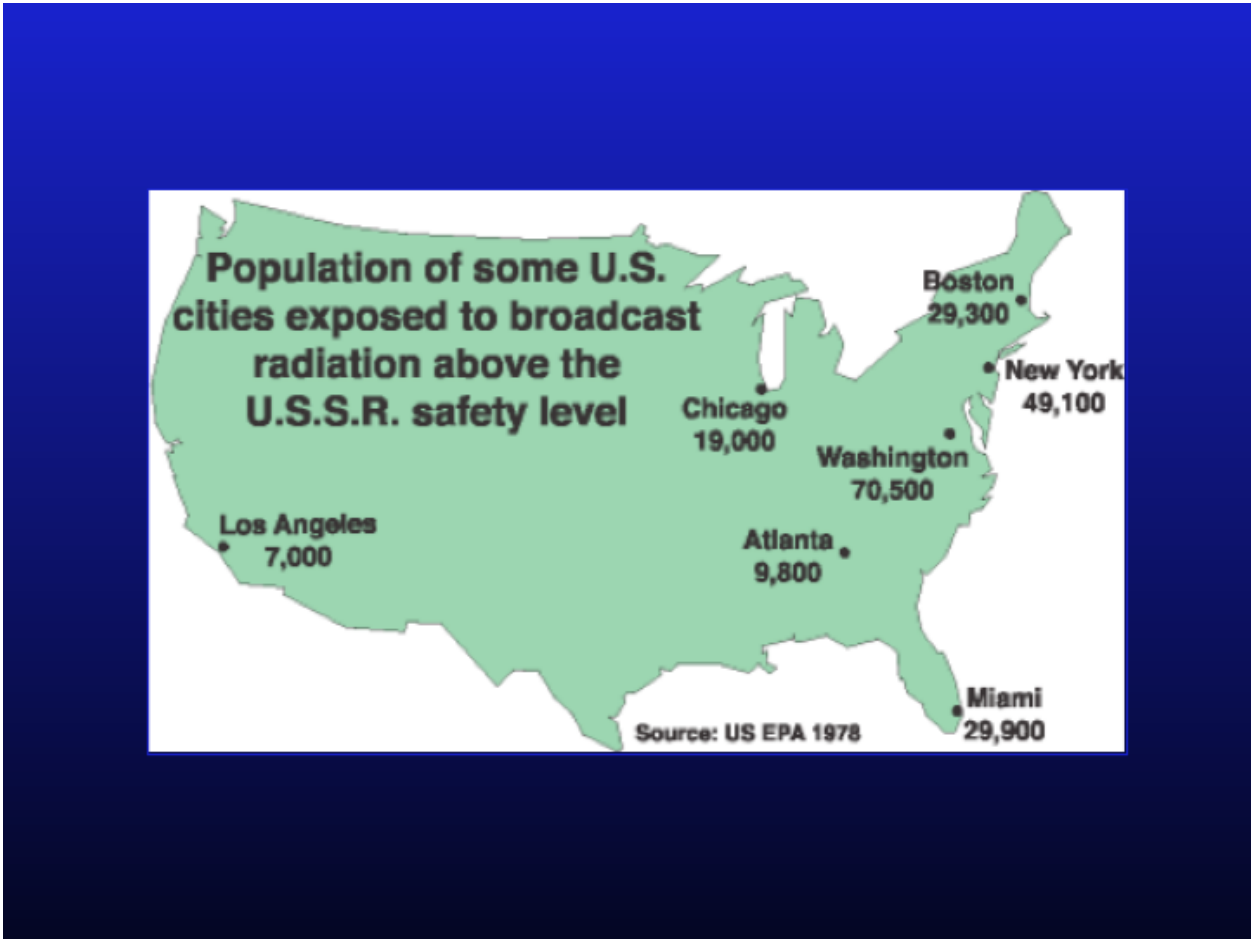

In the USSR regulation of environmental electromagnetic energy followed a much different course. Soviet scientific literature contains many reports of biological effects below 10,000 microwatts, and many reports of biological effects due to power-frequency electric and magnetic fields—effects associated with merely being in the *vicinity* of high-voltage lines. Based on these studies, national exposure standards were adopted; the standard at broadcast frequencies is 1 microwatt.



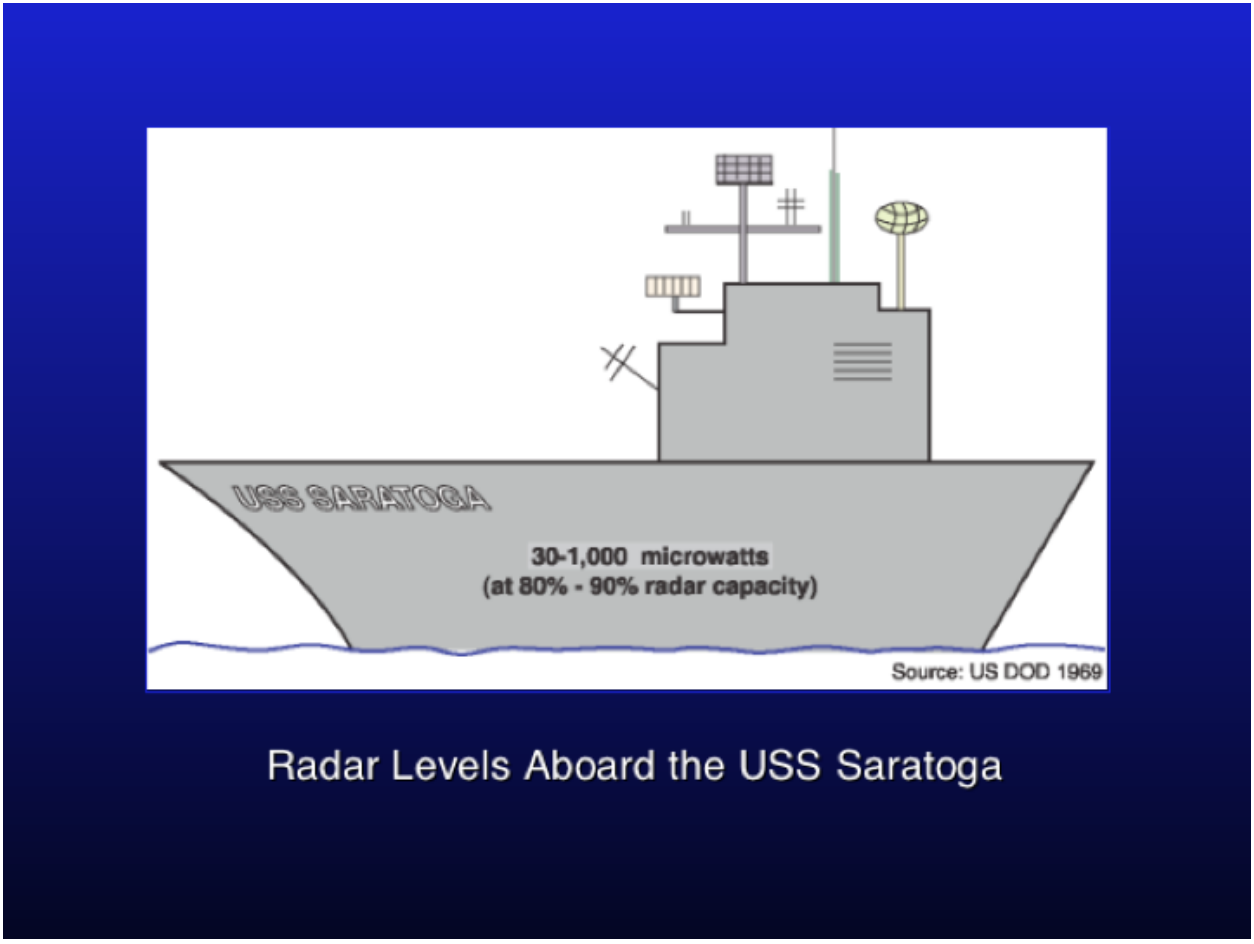

I will describe some typical levels of environmental electromagnetic energy in the United States. Mount Wilson is a high point where many commercial broadcast installations have been built to serve Los Angeles. There is a similar transmitter concentration near most other U.S. urban areas. A level of 1000 microwatts was measured in the Mount Wilson post office.



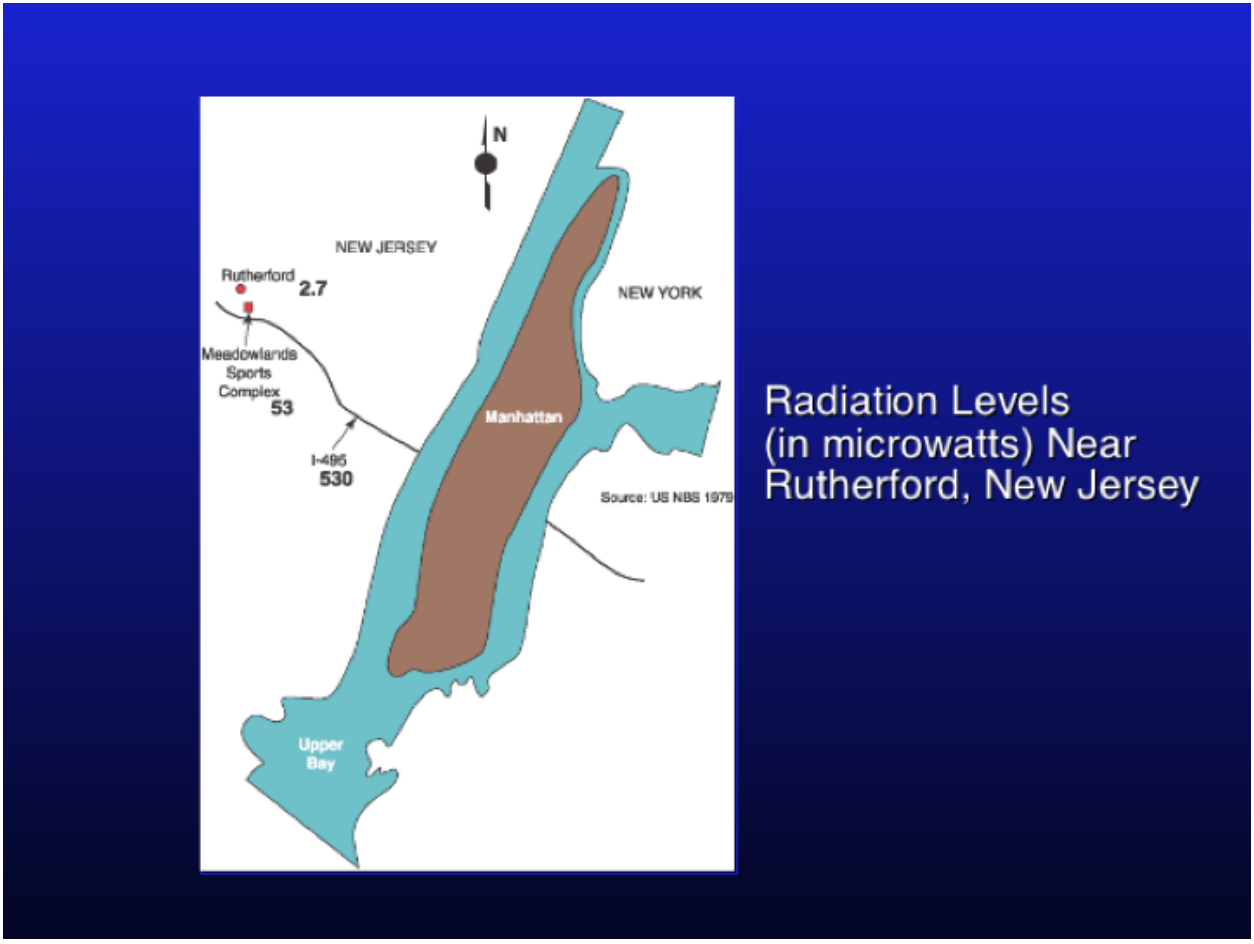

The elevation necessary for efficient energy transmission is frequently attained by mounting transmitters on tall buildings. This can produce unusually high levels in nearby buildings.



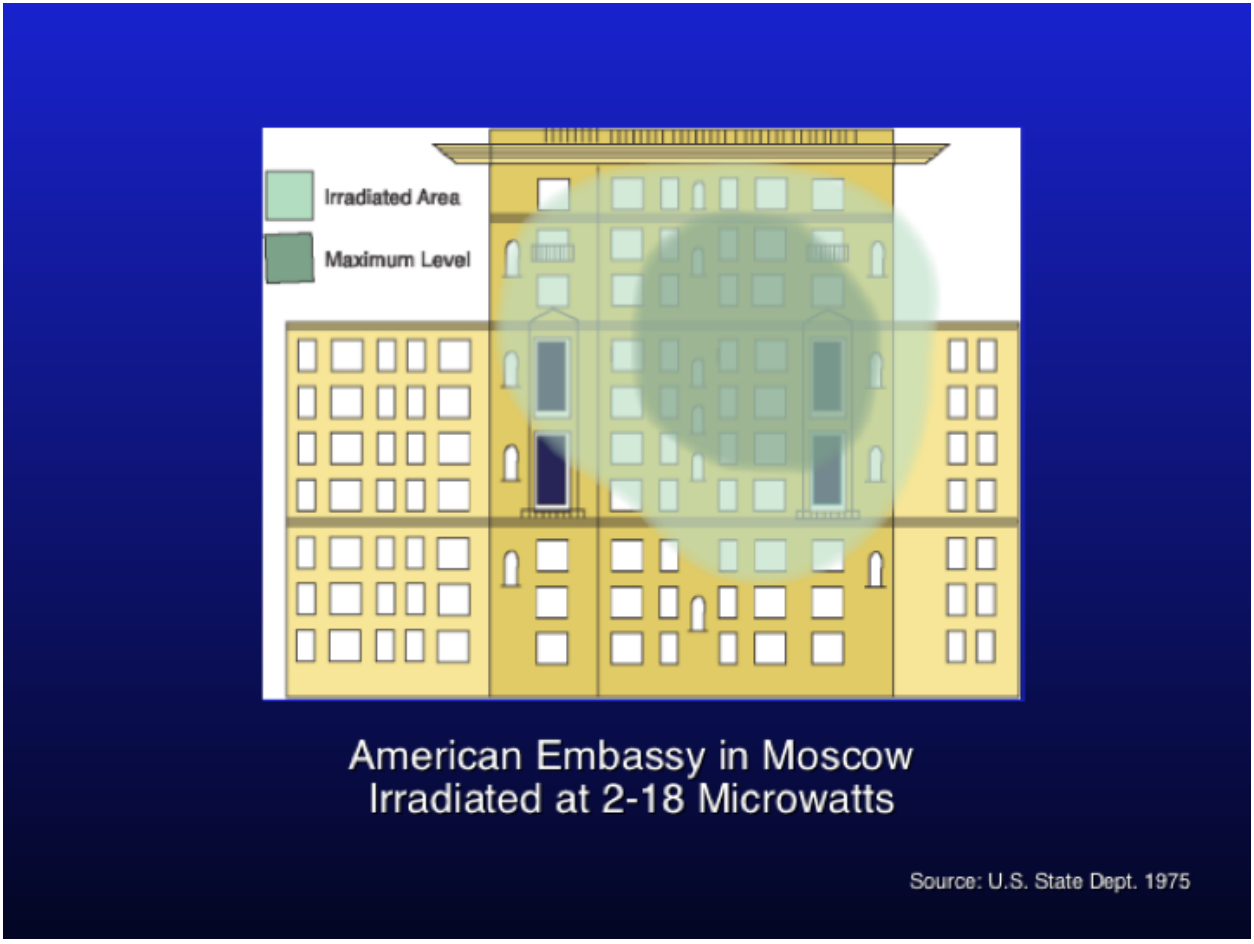

About 2 million Americans are exposed daily to environmental electromagnetic energy above the USSR safety levels.



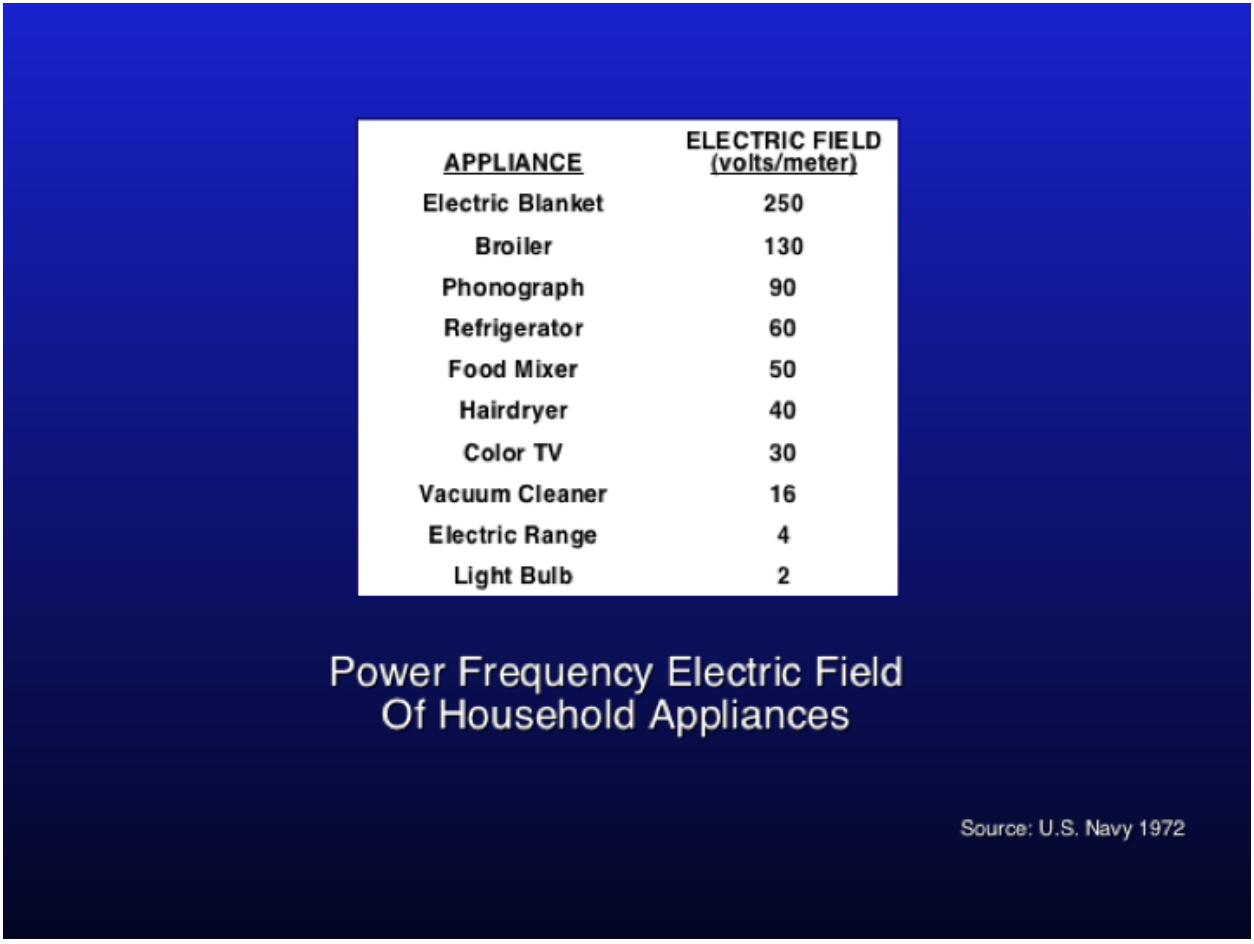

It is the military—particularly the Navy—which would be most acutely affected if the Soviet safety level were adopted in the United States.



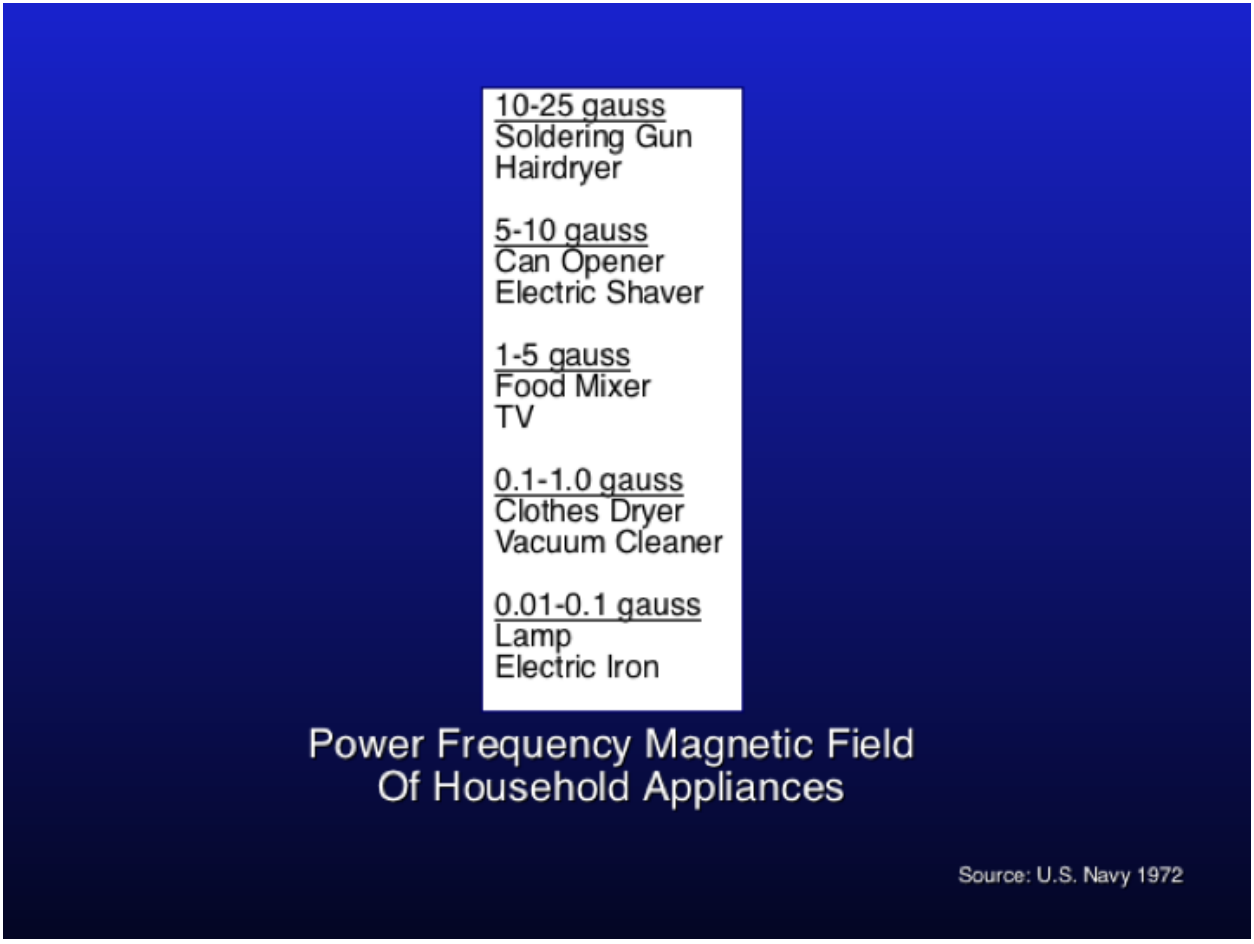

Belief within the United States in the thermal-only standard has been so strong that—with the exception of Project Pandora—essentially no laboratory studies below 10,000 microwatts have been performed. The result has been a series of disease-radiation clusters which heightened public fears about radiation hazards but for which there is no rational scientific resolution. Rutherford, New jersey is a good example. It is the site of a cluster of child cancers and the electromagnetic environment of Rutherford is highly abnormal compared to the country at large. Is there a causal connection?

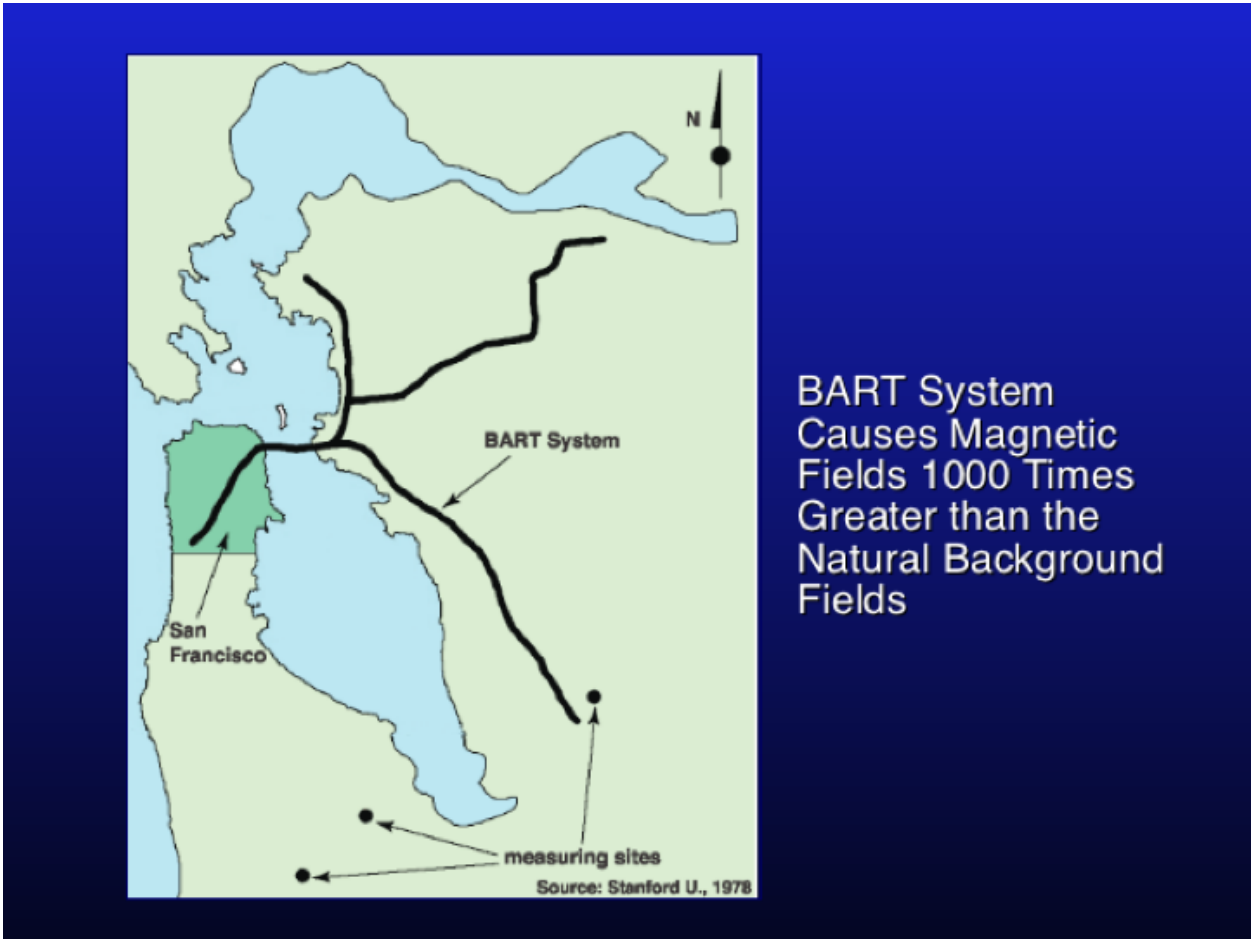



For many years the Soviet Union has intentionally bombarded the United States Embassy in Moscow with electromagnetic radiation *above* the Soviet safety level but *below* U.S. levels. There have been many reports of health problems among U.S. personnel stationed in Moscow, including the last three ambassadors at whose office the beam seems to have been aimed.

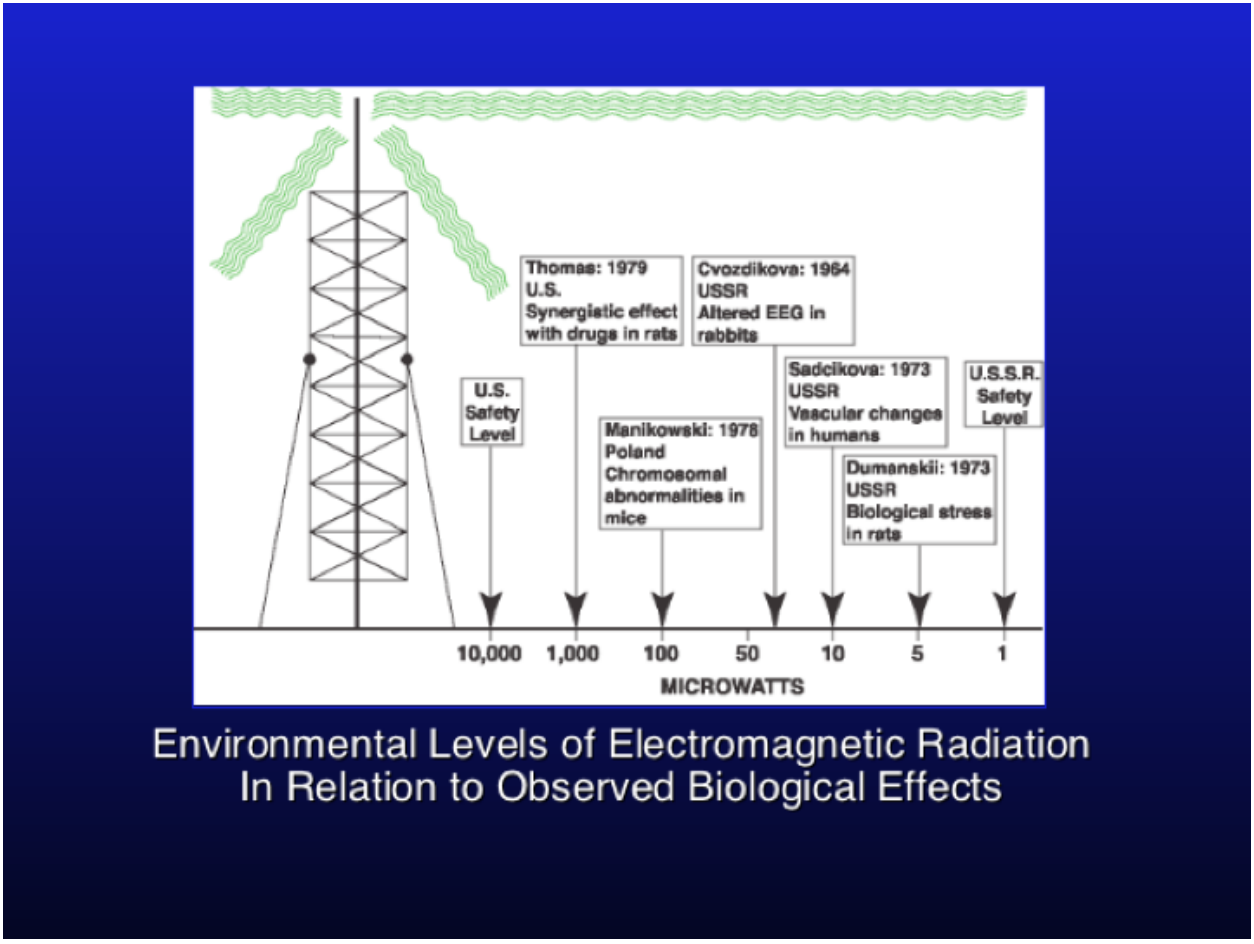



All line-operated devices and all transmission lines are the source of electric and magnetic fields. The listed values were measured in the vicinity of the appliances. The fields are safe under the thermal-only approach because a 60-hertz electric field cannot heat tissue and a 60-hertz magnetic field of more than 200 gauss would be required to do so.

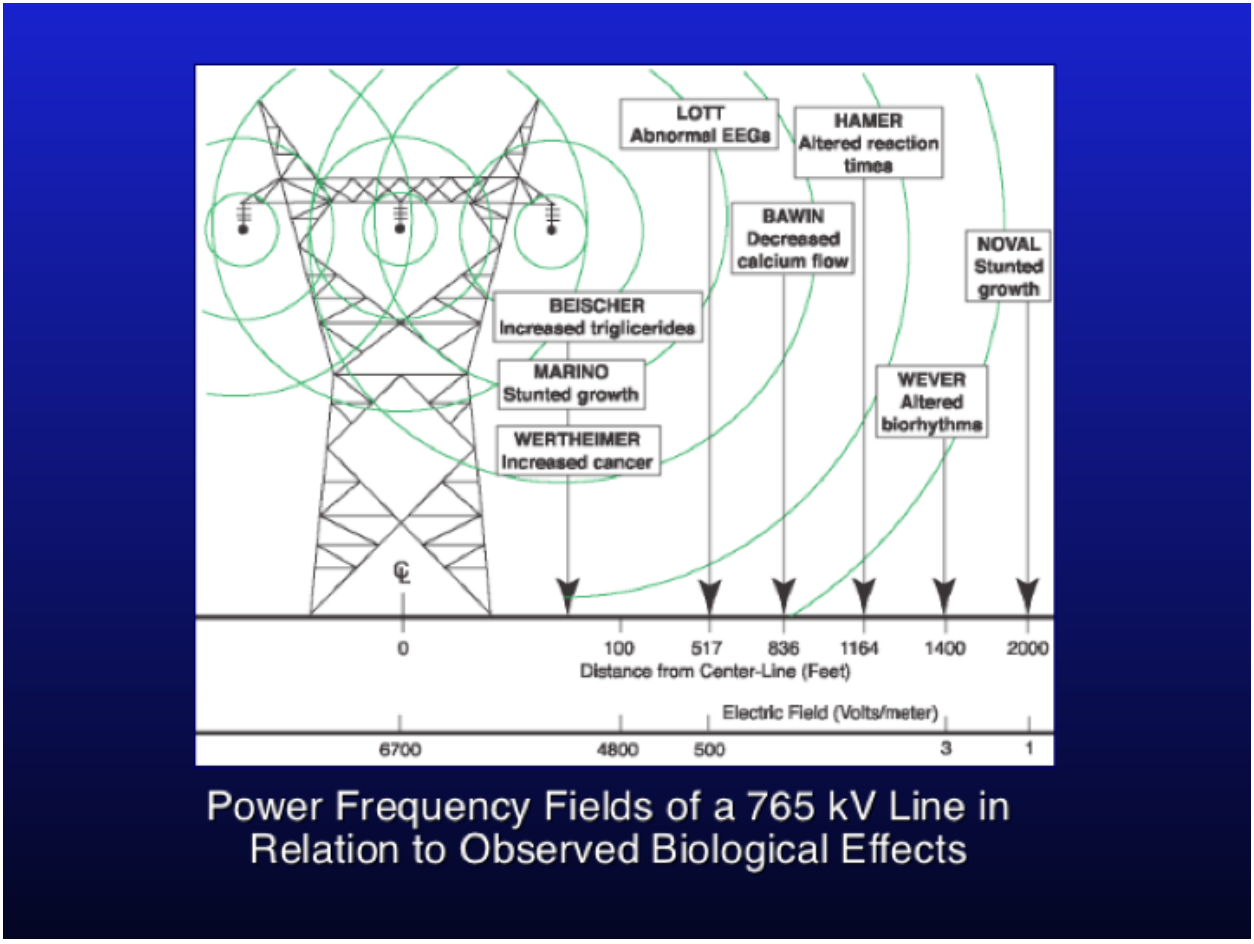

10-25 gauss
Soldering Gun
Hairdryer
5-10 gauss
Can Opener
Electric Shaver
1-5 gauss
Food Mixer
TV
0.1-1.0 gauss
Clothes Dryer
Vacuum Cleaner
0.01-0.1 gauss
Lamp
Electric Iron
Power Frequency Magnetic Field
Of Household Appliances
Source: U.S. Navy 1972



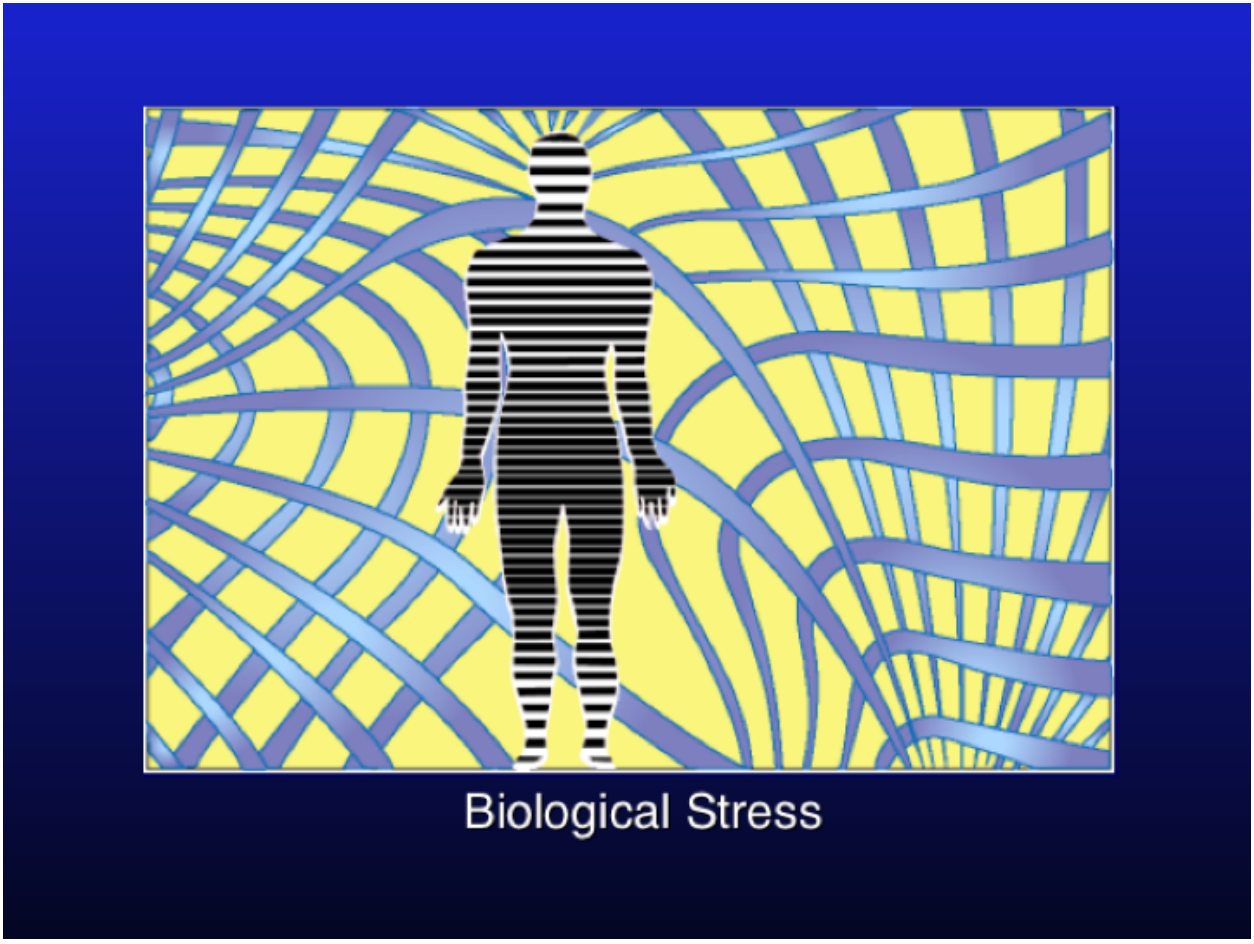

The electrical environment can also be altered by large-scale construction products—the BART system in San Francisco is a good example.



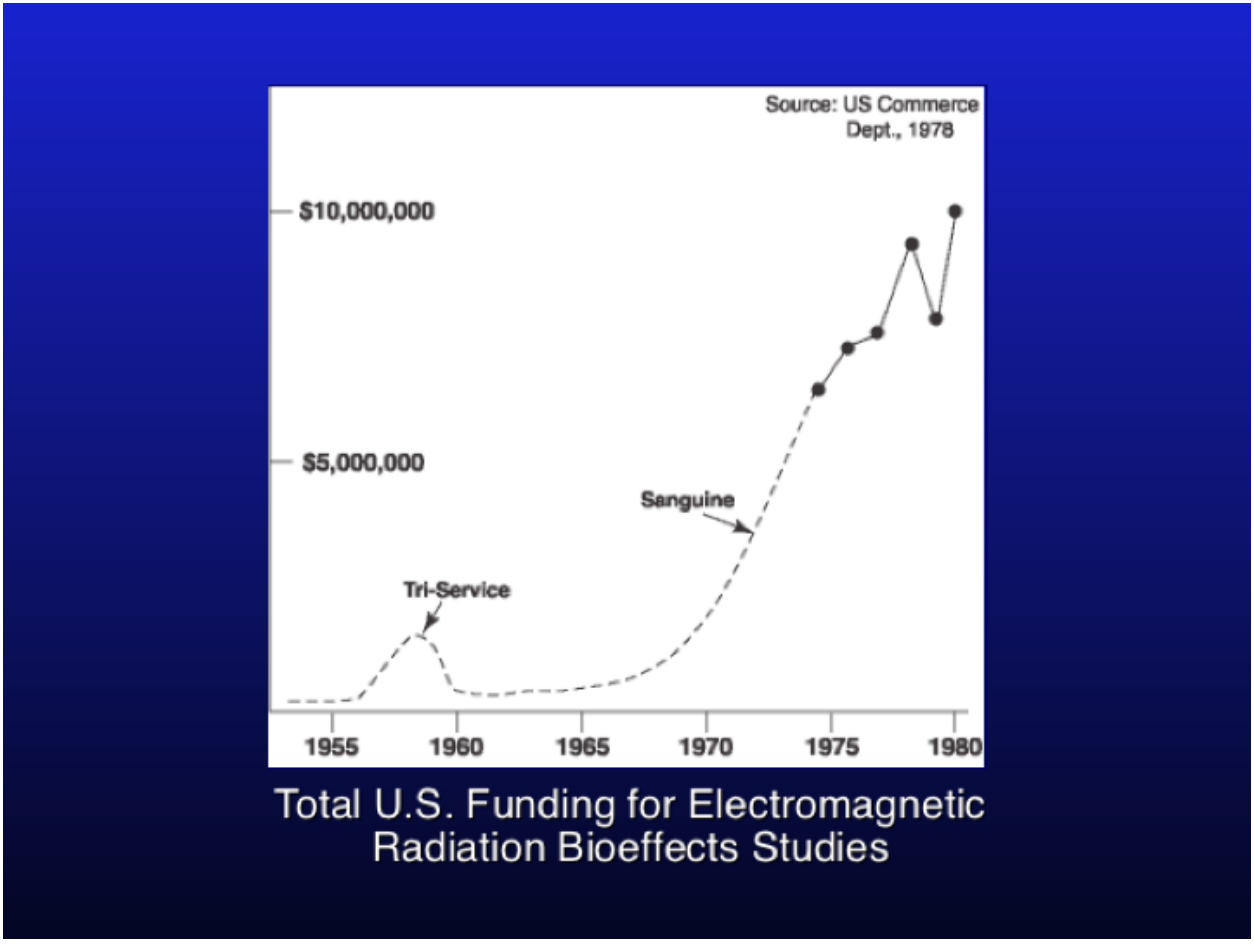

There have been many studies—mostly Soviet—describing non-thermal biological effects due to broadcast-frequency radiation.



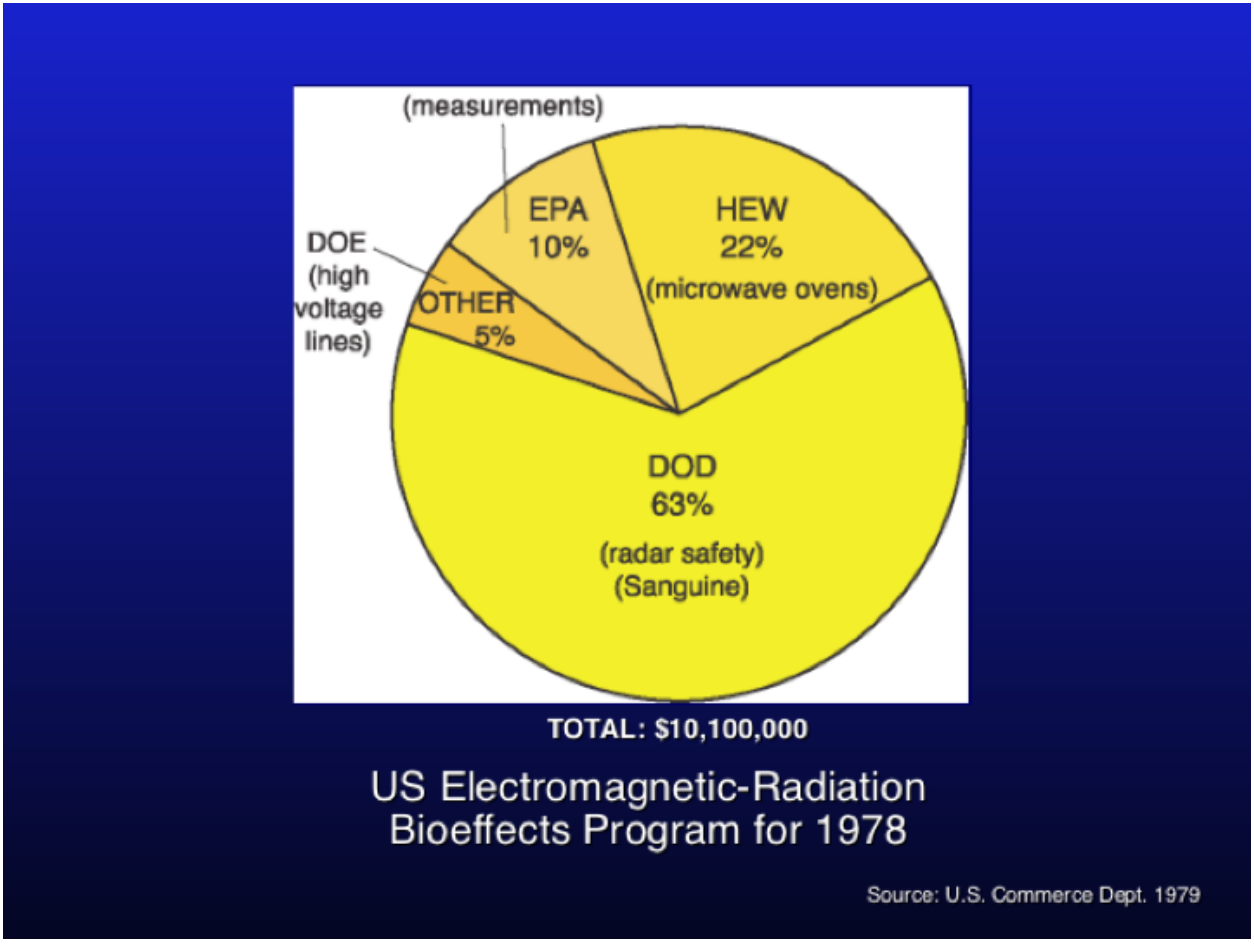

Many studies have shown the existence of biological effects from electric and magnetic fields such as arise from the electrical power system. Several such studies are shown in relation to the fields produced by a typical high-voltage line. Beischer, at the Naval Aerospace Medical Research Laboratory, found that one day's exposure to a 1-gauss magnetic field caused elevated serum triglyceride levels in humans. We found that electric fields of 3500–15,000 volts per meter altered the growth rate and mortality of mice. Wertheimer, of the Univ. of Colorado, found an association between child cancer and transmission lines. These studies used fields which exist within the first 100 feet of a high-voltage line. The remaining five studies used field intensities which exist at the indicated distances from the 765 kV line of the Power Authority of New York. Lott, of North Texas State Univ., found altered EEGs in rats after 90 minutes' exposure. Wever, of the Max Planck Institute, found that weak electric fields altered human circadian rhythms after several weeks. Noval, of Temple Univ., found that 30 days' exposure to an electric field equivalent to that at 2000 feet from the line produced stunted growth in rats.



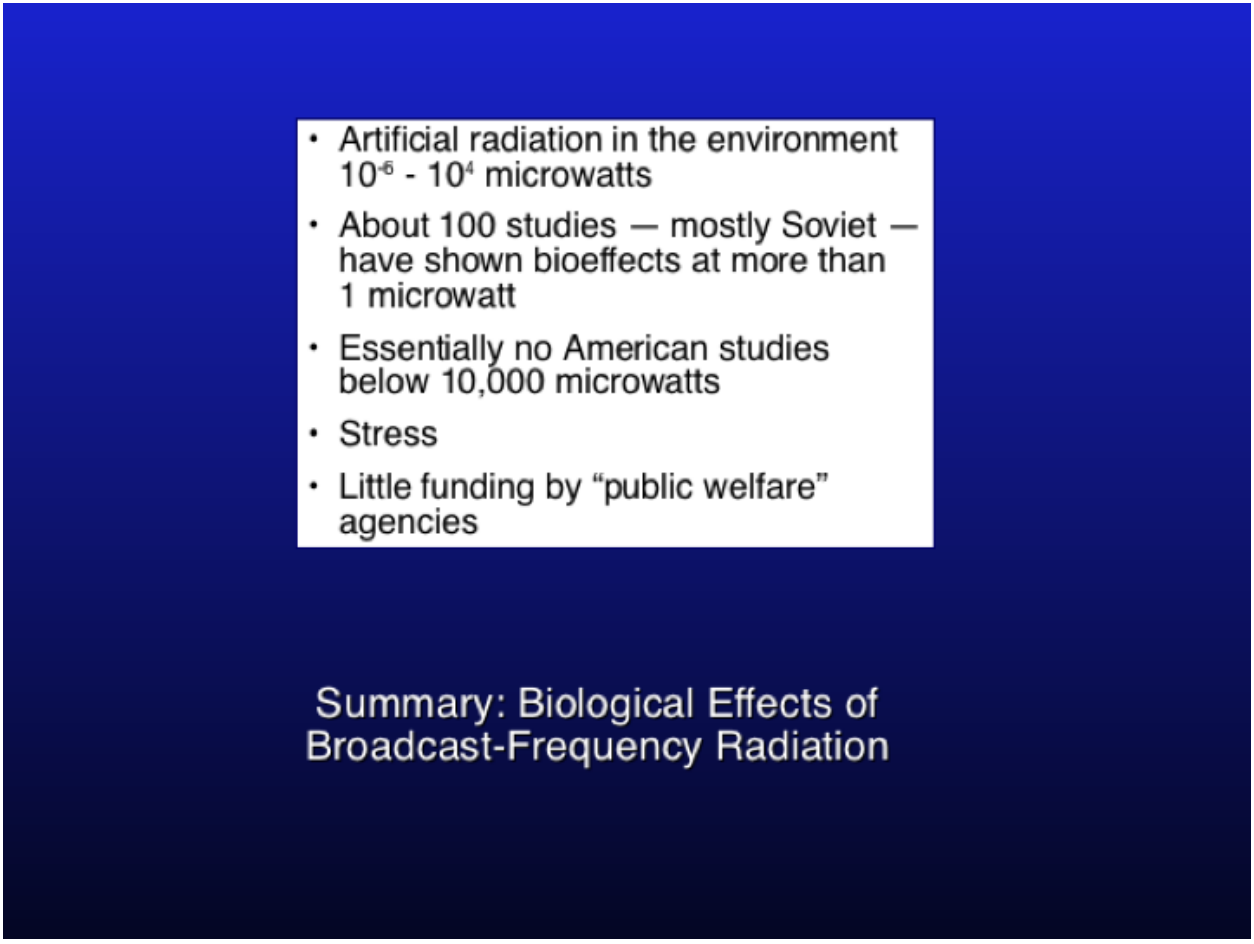

There are many other similar reports of biological effects—approximately 100 studies at broadcast frequencies and about 80 power-frequency studies. Electromagnetic energy does not act on a single target organ. There is a clear pattern in the literature indicating that electromagnetic energy is a biological stressor—it places a physiological demand on the exposed organism. When the organism's capacity to resist has been exceeded, a clinical sign—an effect—is manifested whose nature depends in part on the predisposition of the exposed subject.



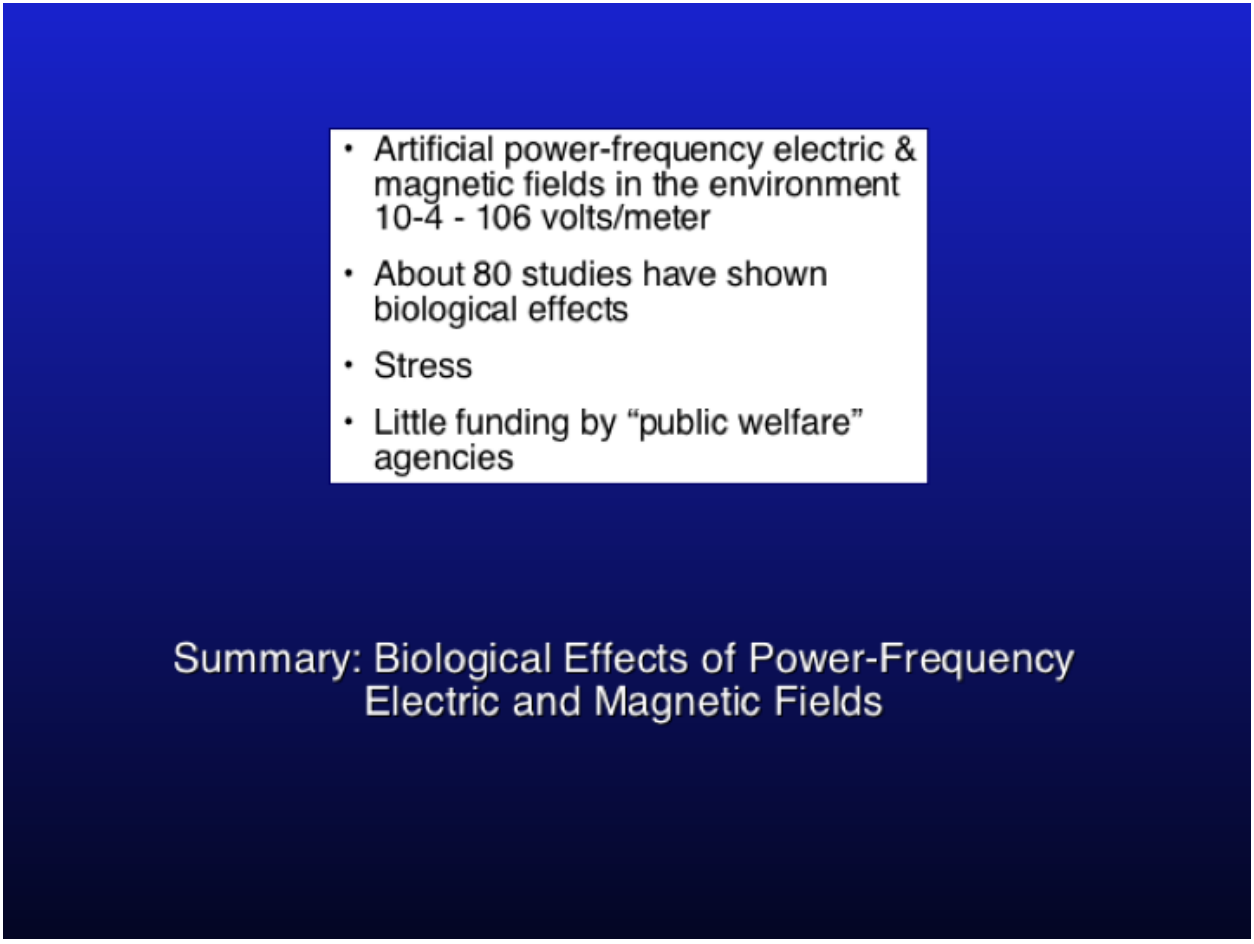

Research funding of electrical bioeffects studies is very small and wholly disproportionate to the scope of the problem.



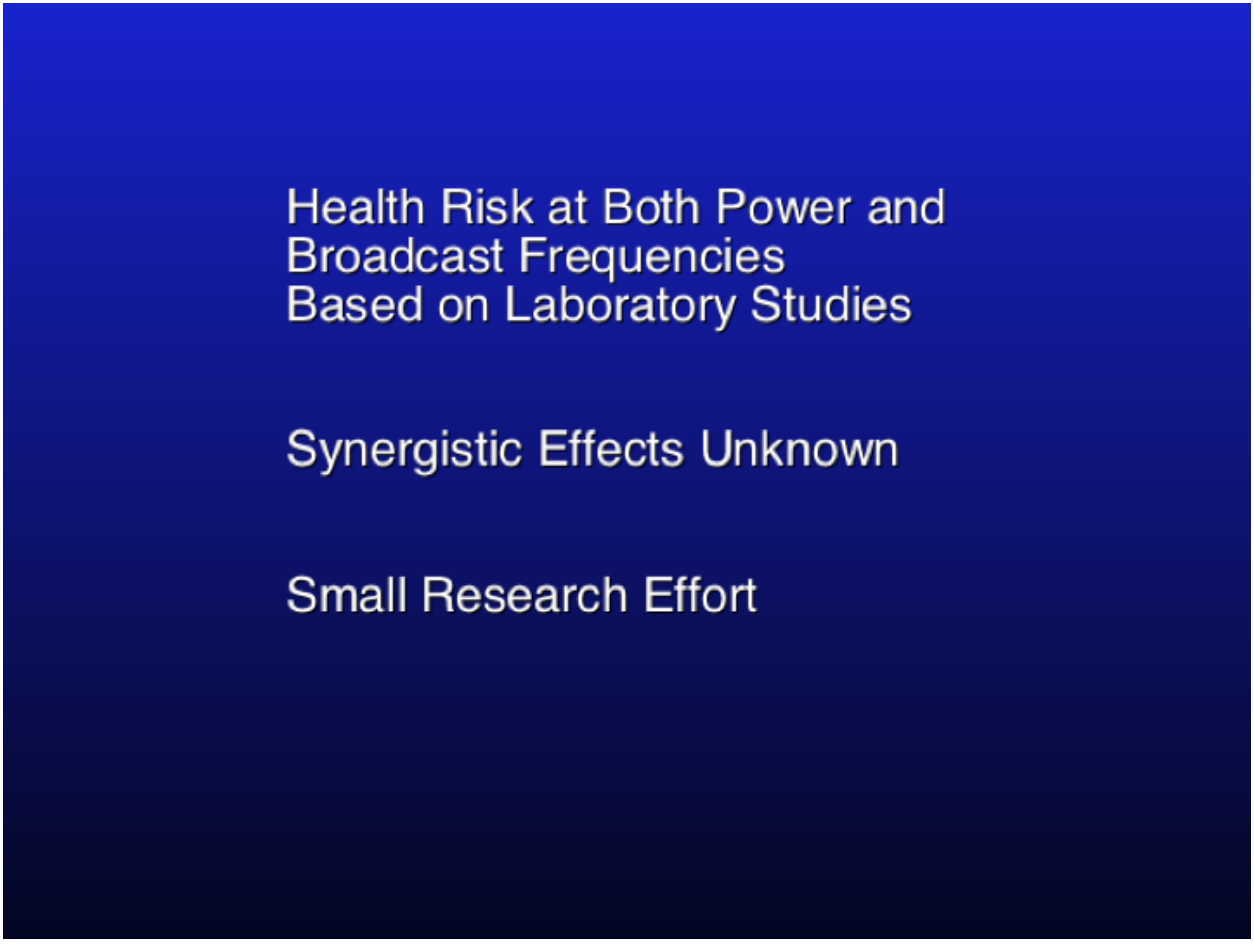

Even more seriously, there is virtually no funding in the United States of electric bioeffects studies by agencies having regulatory authority over a meaningful part of the public-exposure problem. About 63% of the research funds expended in 1978, for example, was spent by the Defense Department as part of their radar-safety and Sanguine research projects. The Department of Health, Education, and Welfare, through its Bureau of Radiological Health, is responsible for microwave-oven safety. It, therefore, also has a very limited focus with regard to the bioeffects studies it supports. The Environmental Protection Agency *has* general regulatory authority—at least at broadcast frequencies—but its efforts have been confined to measurements of the extent of environmental electromagnetic energy. All other federal agencies are even farther from the central core problem with the exception of the Department of Energy. But DOE is an unabashedly pro-utility agency and that fact is clearly reflected in its funding pattern.




Summary at broadcast frequencies.




Summary at the power frequencies.




Conclusion: Broadcast and power-frequency energy, when simulated in the laboratory, has produced biological effects in many studies. Since such energy is biologically active, it must be recognized that the exposure of substantial numbers of the population in an uncontrolled, random, and essentially involuntary manner amounts to a serious public-health and ethical problem.

It is clear that environmental energy can be a biological stressor, and thus the clinical signs it produces in specific individuals will depend on both individual predisposition and the nature of other stressors present in the environment. This generalized mode-of-action will surely complicate further analyses of the problem of environmental electromagnetic energy, but it should not be justification for refusing to address the problem.

There is a small research effort in the United States today and it is run by agencies which do not have the authority to remedy the existing problem.