

OPINION
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STATE OF NEW YORK
PUBLIC SERVICE COMMISSION

OPINION NO. 78-13

CASE 26529 - POWER AUTHORITY OF THE STATE OF NEW YORK -
Moses-Massena 230 kV Transmission Line,
Massena-Moses 765 kV Transmission Line, and
Massena-Quebec 765 kV Transmission Line.

CASES 26529 and 26559 - Common Record Hearings on Health and
Safety of Extra-High Voltage
Transmission Lines.

OPINION AND ORDER DETERMINING HEALTH AND
SAFETY ISSUES, IMPOSING OPERATING CONDITIONS,
AND AUTHORIZING, IN CASE 26529, OPERATION
PURSUANT TO THOSE CONDITIONS

Issued: June 19, 1978

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Transmission Lines.

EDWARD P. LARKIN, Commissioner, concurring:

I concur with the decision of the majority in all respects except insofar as it presumes to order the applicants to purchase real property. I cannot concur in what I believe to be an exercise of authority which this Commission does not possess. The problem which this part of the majority's order seeks to correct may be solved in other forums which do have jurisdiction. Even if this Commission had such authority, it could not properly promulgate a naked sanction such as this which is totally devoid of standards or criteria on which to base the implementation of such a directive.

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STATE OF NEW YORK
PUBLIC SERVICE COMMISSION

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CASES 26529 and 26559

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STATE OF NEW YORK
PUBLIC SERVICE COMMISSION

COMMISSIONERS:

Charles A. Zielinski, Chairman
Edward P. Larkin, concurring
Carmel Carrington Marr
Harold A. Jerry, Jr., dissenting
Anne F. Mead
Karen S. Burstein

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(Issued June 19, 1978)

BY THE COMMISSION:

In 1973, the Power Authority of the State of New York applied for a certificate of environmental compatibility and public need, under Article VII of the Public Service Law, for a proposed 765 kV transmission line from the Canadian border, near Massena, to Marcy, a distance of about 155 miles. Early in 1974, Rochester Gas and Electric Corporation and Niagara Mohawk Power Corporation applied for a certificate for a 765 kV line from the Pannell Road Substation in Monroe County to Volney, a distance of about 66 miles.^{1/} The hearings

^{1/}PASNY, RG&E, and Niagara Mohawk are collectively referred to as applicants.

in each of those cases disclosed the existence of questions about the health and safety aspects of 765 kV lines generally, and, on a motion made by staff, the Administrative Law Judges in the two cases jointly ordered common record hearings on those issues. Routing and other remaining issues in each case continued to be treated separately; the RG&E case (26559), which involves a line not planned to be in service before 1983, has been dormant since the common record hearings began, but the PASNY case (26529) has proceeded to its conclusion in all respects save health and safety. Pursuant to Opinions 76-2, 76-12 and several subsequent orders, certification of the route is now complete, construction is authorized and under way, but operation is precluded pending completion of the health and safety inquiry.^{1/} The premise for authorizing construction was our determination, in Opinion No. 76-12, that even the worst case health and safety findings would not preclude operation of a transmission line at a nominal voltage in the 765 kV range; we felt that any adverse health and safety effects could be adequately treated through various operating conditions or protective measures.

The Common record hearings have now been completed and have produced a record of more than 14,000 pages of testimony by 31 expert witnesses and close to 150 exhibits.^{2/} Administrative Law Judges Matias and Colbeth issued their

1/Case 26529, Opinion No. 76-2, issued February 6, 1976; Order Amending and Clarifying Opinion No. 76-2, issued April 1, 1976; Opinion No. 76-12, issued June 30, 1976; Order Granting Further Partial Certificate of Environmental Compatibility and Public Need, issued December 29, 1976; Order Granting Partial Certificate of Environmental Compatibility and Public Need for Certain Route Segments and Denying Motion for Certification of Other Route Segments, issued June 21, 1977; and Order Granting Certificate of Environmental Compatibility and Public Need for Remaining Route Segments, issued January 12, 1978.

2/After having been first closed during the summer of 1977, the hearings were reopened to permit the admission of testimony by farmers who work and live near the 765 kV lines in Ohio. This testimony was the sole exception to the practice of hearing only expert, as opposed to anecdotal, testimony. A list of the expert witnesses who appeared is set forth as Appendix A to the Administrative Law Judges' Recommended Decision.

recommended decision on January 20, 1978 and numerous parties have filed briefs and reply briefs on exceptions.^{1/}

Early in the common record hearings, the issues to which the parties were to address themselves were identified. They are: ozone production; effect on cardiac pacemakers; induced electric shock; audible noise, and biological effects of magnetic and electrical fields. In the rebuttal stage, staff witness Marino introduced the additional issue of transmission line radiation and the theoretical possibility that it might affect the atmosphere in a way that could alter global weather patterns or increase the incidence of skin cancer in humans; we shall consider this issue under biological effects. Phase I of the proceeding was devoted to examining the operating characteristics of the transmission lines while Phase II was intended to consider the health and safety implications of the information adduced in Phase I. The conclusions and recommendations of the Administrative Law Judges are set forth at pages 155 to 157 of their recommended decision. While they are reasonably sanguine in their conclusions, they recommend, in effect, that the right-of-way be approximately 350 feet, instead of the 250 feet proposed by the applicants; and that information concerning the possible effects of the lines on users of cardiac pacemakers be

^{1/}Briefs have been filed by staff, the Power Authority, Rochester Gas and Electric Corporation, Niagara Mohawk Power Corporation, Long Island Lighting Company, the Department of Environmental Conservation, the St. Lawrence County Planning Board, Andrew A. Marino, the Tri-County Power Line Association, UPSET, Inc., the Town of Livingston Environmental Management Council, the Powerline Committee for Environmental Protection, and Patrick McGuire. Reply briefs on exceptions have been filed by staff, the Power Authority, RG&E, Niagara Mohawk, the Department of Environmental Conservation, and UPSET, Inc. A number of briefs have been the subject of various motions to strike on grounds of untimeliness or deficient service; but no party has been substantially prejudiced by any such brief, and we shall deny all those motions.

distributed to cardiologists in the State.^{1/} They also recommend that we not encourage the use of the right-of-way for recreational purposes, and that complaints concerning shock and audible noise be reported to and monitored by us. They found no need for any of the other various protective measures proposed by the parties and also saw no need to take any action with respect to transmission lines operating at voltages lower than 765 kV.

This proceeding has been, to our knowledge, the most comprehensive study ever conducted of the health and safety of extra-high voltage (EHV) transmission lines. It has been widely publicized and has stimulated a large amount of comment, most of it adverse to the lines. Some of the adverse comment was directed to the innovatively high voltage of the proposed lines, but other critics challenged the propriety of building lines through the north country and would, we can assume, be just as opposed to lines of lower voltages.^{2/} We believe it desirable to address ourselves to some of these criticisms in general terms before turning to the particular issues in the case.

To begin, we note that the Legislature has vested in the Power Authority, and not in this Commission, the authority to decide whether a line proposed by it is necessary.^{3/} We were, accordingly, bound by PASNY's determination that a particular amount of power was required to be

^{1/}Whether the information should be distributed to all cardiologists or only to their professional organizations is a question raised on exceptions by several parties.

^{2/}The brief submitted by Patrick McGuire is a sociological study that attempts to describe in detail the antipathy to the PASNY line of the people through whose lands it passes and the resulting social changes, including a loss of confidence in government and a propensity to possibly violent resistance.

^{3/}This observation, of course, is germane only to the line proposed in Case 26529. Case 26559 involves an application for certification by two private utilities and the need for that line will be an issue to be resolved in the case.

transmitted. While we were at liberty to decide that the needed capacity should be made available by means of a larger number of lower voltage lines--it appears that four or five 345 kV lines would be needed to provide the same capacity as a single 765 kV line--the larger number of lines required would, itself, entail considerable environmental degradation as well as added costs.^{1/} And 765 kV lines are, except with respect to audible noise, qualitatively no different from the large number of 345 kV lines now in place throughout the State and nation. Society has accepted the use of 345 kV lines as among the prices to be paid for the benefits of abundant, reliable electric power at rates lower than otherwise would be the case;^{2/} the use of 765 kilovolt transmission, subject to the necessary operating conditions and protective steps, represents no new incremental risk or burden to society.

These considerations, of course, do not make the prospect of the line, whatever its voltage, any more attractive for those people whose lands it traverses. Many opponents of the PASNY line question the fairness of subjecting north country residents to the line in order to reduce the price and enhance the reliability of the power supply to downstate cities. But society does not lend itself so easily to compartmentalization: New York's rural residents expect, and are entitled to, electric power as reliable and abundant as that of their urban fellows, and they receive it at much lower prices, largely because of the availability to them of cheap PASNY power. Meanwhile, the 2.7 million customers who buy their electricity from Con Edison, representing more

^{1/}DEC, in point of fact, supports the use of a properly operated 765 kV line in place of the larger number of 345 kV lines that would be needed in its stead in part because of the greater land use impact of the larger number of 345 kV lines.

^{2/}We discuss this premise in greater detail below, at p. 41.

than half the population of the State, pay the highest electric rates in the country. A Con Edison residential ratepayer using 500 kilowatt-hours a month pays \$43.84 for that power; a similar ratepayer in Niagara Mohawk's territory, through which the PASNY line will go, pays \$21.12 for the same electricity.^{1/} There are hundreds of thousands of people in the Con Edison area whose income is below the poverty level; what they pay for electricity affects the amounts they may expend for food and medical care. And the cost of power is among the factors cited by businesses leaving New York City, thus weakening even further its economic base. The PASNY line is projected to provide \$45 million in annual fuel savings that will be flowed through directly, automatically and completely to these customers and those of other downstate utilities through the operation of the fuel adjustment clause. Considerations such as these, of course, would not warrant clearly endangering the health of people living near the line. Among our tasks in this case has been to evaluate the risks and costs that have been asserted to exist and to weigh them against the benefits reasonably anticipated, as well as the risks to public health and safety of burning the oil that will not have to be burned when the Quebec hydroelectric power is available; the environmental risks of having to bring in that oil in oceangoing tankers; and the national security risks of possibly being unable to obtain foreign oil.

With the need to strike this balance in mind, we turn to the particular issues in this case. We begin with

^{1/}These figures are computed at the rates in effect on April 1, 1978. 500 kWh a month is the average residential use in Niagara Mohawk's service territory and in the Westchester County portion of Con Edison's area. In New York City, average residential use is 250 kWh a month, which costs \$23.55.

the biological effects of electric and magnetic fields, by far the most complex and difficult issue presented.^{1/}

BIOLOGICAL EFFECTS OF ELECTRIC AND MAGNETIC FIELDS^{2/}

The passage of an electric current through any unshielded conductor produces both electric and magnetic fields in the surrounding medium. Higher voltages produce more intense fields that cover wider areas. For an overhead AC transmission line, the three separate phases create an interference pattern so that the strongest field exists in the area below the outer phases, approximately 20 to 60 feet from the centerline of the facility. The field drops off moderately as one moves closer to the centerline, and falls off rapidly as one moves further away from the facility. A 765 kV facility with minimum ground-to-conductor clearance of 48 feet produces a peak electric field of between 9 and 10 kV per meter at a point approximately 60 feet from its centerline. The magnetic field produced by a high voltage transmission line has similar characteristics.^{3/}

Based upon a maximum operating current of 4,000 amps and a minimum conductor-to-ground clearance of 50 feet, the maximum ground level magnetic field expected to be produced by the

^{1/}The Administrative Law Judges found that the effects of ozone need not be further considered in this case, and no party has presented any arguments excepting to that finding. We shall adopt it. Applicants' witnesses Cohen and Barnes testified on Hydro-Quebec's and American Electric Power Corporation's generally satisfactory operating experience with extra-high voltage transmission lines in the 700 to 800 kV range. Their testimony and its limited significance was adequately considered in Opinion No. 76-12 at mimeo pp. 11-13 and need not be taken up again here. UPSET witness Ruggles, a farmer living near one of AEP's lines in Ohio, testified to his difficulties with electric shock caused by the line and to its asserted adverse effect on cattle breeding; we shall discuss his testimony in our consideration of induced electric shock.

^{2/}The issue considered in the case was the biological effects of these fields on humans. Although much of the scientific work cited dealt with their effects on animals, the possible effects of the fields on natural ecosystems were not considered.

^{3/}Opinion No. 76-12, at mimeo p. 13.

765 kV lines is approximately 0.49 gauss. Under more normal operating conditions (current of 2,000 amps), the field is calculated to be less than 0.25 gauss. The electric and magnetic fields will both have a frequency of 60 hertz (Hz); this is within the range of frequencies termed extremely low (ELF).^{1/}

These electric and magnetic fields are not unique to 765 kV transmission lines and are produced by all power lines as well as by a wide variety of electrical devices. The earth itself creates a DC electric field of some .12 to .15 kV/m; its magnetic field is approximately 0.5 gauss. In contrast to the risk of shock--where the potential harm is readily defined and the issue is the adequacy of the measures to be taken to protect against it--the subtle effects, if any, of the electric and magnetic fields are unknown,^{2/} as is the likelihood that they will be harmful. Moreover, research concerning the effects of ELF fields is relatively recent, and conclusive results are hard to come by.

The Administrative Law Judges'
Recommendations and an Overview
of the Positions of the Parties

After discussing the evidence, the Administrative Law Judges concluded that occasional exposure to the lines' electric fields did not present a hazard to human health;

^{1/}To avoid confusion, we point out now that microwave fields, occasionally referred to in the case and now the subject of considerable public discussion, are of much higher frequency, and extrapolations from one range of frequencies to another cannot be made.

^{2/}AEP's and Hydro-Quebec's operating experience suggests the absence of gross biological effects, but is of little help in identifying possible long-run subtle effects.

that it was possible, but not established, that continuous long-term repeated exposure to electric fields exceeding 2.5 kV per meter might result in some biological effects that might be harmful; that exposure to the magnetic fields of the lines would not be hazardous; and that the applicants should therefore "arrange that no person lives or works regularly in areas where the electric field exceeds 1.0 kV/m at 1 meter above ground, a figure chosen to allow a factor of safety below 2.5 kV/m. This recommendation would require a right-of-way width of perhaps 350 feet, depending upon the specific design of the line."^{1/} The Administrative Law Judges also recommended that the Commission not encourage recreational use of the right-of-way; that the New York State utilities not be directed to fund extensive studies of the issue; that warning signs not be posted on the right-of-way but that the utilities be required to report to the Commission all complaints about field effects; and that a safety factor greater than that used by the Administrative Law Judges not be imposed. All active parties have excepted to the recommended decision.

Positions of the Applicants

The applicants, under the leadership of RG&E, except to the Administrative Law Judges' recommendation that the line should be built so that no one is chronically exposed to an electric field greater than 1.0 kV/m; as already observed, this recommendation entails a right-of-way of approximately 350 feet, compared with the 250 feet proposed by the applicants. They also object to the predicate of the recommendation, namely, the Administrative Law Judges' acknowledgment that there were weak indications that the

^{1/}R.D., at mimeo p. 156.

power line fields could cause effects and that "the available evidence does not provide reliable, applicable data for humans concerning the risks of chronic exposure to the lines."^{1/} The last 25 pages of RG&E's brief on exceptions contain proposed findings and conclusions that it would substitute for the Administrative Law Judges'.

RG&E asserts that to conclude that exposure to the fields "poses a sufficiently unreasonable risk to human health to require regulation by the Commission (nothing is entirely without risk)," we must ignore decades of operating experience, the opinions of eminent scientists, the opinions of a National Academy of Sciences (NAS) committee that looked into the matter,^{2/} "well accepted, time tested principles of the biological and physical sciences," the assertedly limited scientific caliber and lack of confirmation of the studies cited in support of the contrary conclusion,

1/Appendix A to RG&E's Brief on Exceptions is a 4-page list of extracts from the recommended decision to which the company explicitly excepts.

2/NAS Committee on Biosphere Effects of Extremely Low Frequency Radiation, "Biological Effects of Electric and Magnetic Fields Associated with Project Seafarer" (1977). Project Seafarer (previously known as Project Sanguine) is the Navy's proposal to install a vast network of underground wires, probably in northern Wisconsin or Michigan, as part of a system for communicating with submarines. The wires would produce electric fields at about 76 Hz, in the ELF range, but considerably weaker than those produced by the power lines. Much of the research discussed in the case was conducted in connection with Project Sanguine and three of applicants' witnesses were members of the NAS committee that produced the 1977 report. The report came into evidence, over staff's objection, as Exhibit T-6; the Judges admitted it, however, only for the purpose of showing that the scientists on the committee disagreed with staff witness Marino's opinions here. R.D., Appendix G.

and the result of medical evaluations of linemen and residents along the transmission line. The company goes on to claim that staff witness Marino is the only person to have independently claimed that biological effects would probably occur in humans, and that to accept his testimony we must ignore his failure to provide scientific evidence linking the studies on which he relied with human exposure to transmission line fields, the asserted inaccuracies and distortions in his testimony, the conclusions of the Administrative Law Judges, the Canadian National Energy Board, and the Minnesota Department of Health that Dr. Marino's testimony was speculative, and the asserted meaninglessness, after cross-examination, of his hypothesis.^{1/} Presumably because they are satisfied with the Administrative Law Judges' treatment of Dr. Marino's credibility, applicants do not raise the issue again on exceptions; but it formed an important part of their arguments in their initial briefs.

1/RG&E describes Dr. Marino's position thus:

"There is a somewhat greater than a mere possibility, perhaps one chance in 10,000,000,000, that an exposure of unknown duration to the transmission line electric fields of undetermined strength, possibly in conjunction with other unspecified agents, might under unknown, almost indeterminable circumstances, cause by some unknown mechanism or combination of unknown mechanisms one or more or a combination of unspecified biological effects in some organisms, which might include humans although any extrapolation between specific laboratory experiments and possible effects when people are exposed to the transmission line fields cannot be made. Further, if such effects exist, they may or may not be hazardous." Initial Brief to the Administrative Law Judges, at p. 143.

The description, of course not a disinterested one, points out, through overstatement, the tentative nature of Dr. Marino's conclusions.

Staff's Position

Staff bases its conclusion that overhead transmission lines will probably cause biological effects in humans on one of Dr. Marino's two studies and on some 20 other experiments in the literature. It also cites approvingly the Judges' statement that observed effects not known to be benign must be considered potentially hazardous unless they are temporary or reversible.^{1/} Staff concludes that any safety factor between 10 and 100--compared with the Judges' factor of 2.5^{2/}--would be reasonable and opts for a safety factor of 25; applying the factor to the electric field in the Marino study staff relies on produces a maximum permissible exposure of .4 kV/m. Staff does not call for an absolute widening of the right-of-way to achieve this level but, rather, suggests that residents within 275 feet of the centerline be given an option to have their houses purchased or relocated if the field strength outside the house is greater than .4 kV/m. This measure of flexibility recognizes that the strength of the field at any given distance from the centerline may vary with other environmental factors, and that people may not wish to move, given the uncertainty of the risk.

Staff also takes the position that its witness Marino's credibility cannot be used as the basis for deciding the issue and that the applicants' vigorous efforts to discredit him were more suitable to a slander trial than a fact-finding, scientific investigation. It observes that even if Dr. Marino's public statements, which form the basis for much of the applicants' effort to impeach him, were misleading, they were, nonetheless, made after he had conducted

^{1/}R.D., at p. 77.

^{2/}Staff is not quite right when it says that the Judges used a safety factor of 2.5. If Dr. Marino's experimental field strength is used as a starting point--as was done by staff--the application of a safety factor of 10 produces a 1 kV/m standard equal to that chosen by the Judges.

the studies that formed the basis for staff's position and that there is no reason to assume that the statements could have biased his research and experimentation.

Staff does not limit its exceptions to proposing a more rigorous safety factor than the Administrative Law Judges'. It would also recognize the uncertain state of our knowledge about these effects by requiring the utilities to fund a broad scale research program, to be developed and supervised by staff with the assistance, if necessary, of outside experts. Finally, staff would require the utilities to inform each resident living adjacent to the right-of-way that the Commission has determined that there is a risk of danger from exposure to the overhead lines and that a research program is underway to determine whether or not adverse biological effects will occur in exposed individuals.

Dr. Marino's Position

In a rather unorthodox procedure, staff witness Marino has submitted his own briefs amicus curiae.^{1/} Dr. Marino's principal difference with staff is in recommending, in his testimony, a safety factor of 100 and a consequent maximum exposure level of .1 kV/m, equivalent to a right-of-way of 600 to 900 feet. In his brief, however, Dr. Marino goes further and urges applying that standard only to existing lines; the standard he recommends for new lines, such as the ones here under consideration, is a considerably more rigorous

^{1/}RG&E asks that we strike Dr. Marino's Brief on Exceptions on the grounds that it deals mainly with extra-record matters, which we must ignore, and that its few assertions based on the record are unavoidably tainted by its extra-record disquisitions. While we must, of course, be bound by the record, a greater measure of flexibility is warranted here than in court proceedings, and RG&E's motion, whatever the merits of Dr. Marino's brief, will not be granted.

0.01 kV/m; he describes that field as the average ambient electric field in New York State. To permit more intense fields, according to Dr. Marino, would be tantamount to subjecting the people exposed to them to involuntary human experimentation in violation of the Public Health Law and fundamental ethical principles. He also suggests that doing so could expose power companies to liability for the tort of battery or for the taking of a constructive easement over lands beyond the right-of-way.^{1/}

Dr. Marino also contends that the transmission lines pose a risk of increasing human cancer and altering global weather patterns through the magnetic duct mechanism discussed below.^{2/} Staff considered this concern to be speculative, but Dr. Marino suggests that the hazard may be found, upon further inquiry, to be great enough to require undergrounding this and similar lines. He urges further hearings on the matter.

Finally, Dr. Marino urges that the Commission establish an administrative research council to oversee basic and applied research on the health and safety effects of the manufacture and transport of electrical power and to fund research in this area by independent investigators.

DEC and Other Parties

The biological effects issue was disputed in the main by staff and the applicants. Other parties, however, also expressed views on the subject. DEC simply urges, in its Brief on Exceptions, that a safety factor greater than the Administrative Law Judges' 2.5 be applied in determining the standard for the maximum electric field to which people

^{1/}The lines' deliverable electric power, according to Dr. Marino, is transmitted in a wide space surrounding, rather than actually in the conductors.

^{2/}See below, at p. 36.

should be regularly exposed. In its Reply Brief on Exceptions, DEC proposes applying a safety factor of 10 to a threshold level for field effects of 10 kV/m. The resulting design standard is 1 kV/m--which equates to a 350 foot right-of-way, the same as that called for by Judges--to be compared with staff's proposed .4 kV/m standard and 550 foot protective zone. DEC would apply this criterion to all future overhead transmission lines, regardless of voltage; but it would exempt, pending further research, all currently operating lines. Although it acknowledges that additional research on the matter is needed, it counsels against our directing a program; it proposes, instead, that we monitor, over the long run, published research in the area and modify our rules as may be shown necessary.

UPSET argues that, in view of Dr. Marino's testimony, operation of a 765 kV transmission line is tantamount to human experimentation and that we should restrict operations to 345 kV.

The St. Lawrence County Planning Board recommends a protective zone 1800 feet wide within which owners of homes, commercial dairy barns and other facilities involving extensive human use would be given an option to sell the building or have it relocated. The Board bases its recommendation on Dr. Marino's views,^{1/} and points out that its recommendation would impose relatively small costs on PASNY insofar as its line traverses mainly rural territory.

Other intervenors, such as the Town of Livingston Environmental Management Council, the Tri-County Power Line Association, and the Power Line Committee for Environmental

^{1/}SLCPB attributes to Dr. Marino a recommendation that the protective zone extend 900 feet on each side of the centerline. In fact, Dr. Marino's testimony called for a zone 900 feet wide in all, or 450 feet on each side of the centerline.

Protection, endorse, in general terms, Dr. Marino's various claims and oppose operation of the lines at 765 kV in the absence of proof that such operation is safe.

Burden of Persuasion

Much of the parties' efforts was devoted to minute examination of the details of a large variety of scientific experiments. Underlying their disagreement, however, was a crucial difference of opinion on how an investigation such as this must proceed. This disagreement raises issues of scientific method and legal procedure and deserves discussion in general terms before the particulars are taken up.

It might be tempting for a tribunal assessing the safety of an innovation to put its proponent in the impossible position of having to prove a negative: that the innovation will cause no harm. But to impose such a burden on the applicants would be to rule against them in advance, and applicants do not, because they know they cannot, assert 100% certainty that the lines will produce no ill effects.^{1/} Their position boils down to asserting that no ill effects have been shown, that scientific theory and the weight of experimentation suggest that no ill effects are likely, and that a reasonable weighing of risks and benefits requires that the lines be authorized on the 250-foot right-of-way

^{1/}"At the outset it must be understood that a responsible scientist would never claim with absolute certainty that subtle effects cannot occur. The possibility always looms that some new concept, instrument or technique as yet undeveloped, will provide insight into the matter." RG&E Initial Brief, at p. 69 (citations omitted).

they proposed. Their witness Michaelson conceded on cross-examination, however, that his position was neither "what we don't know can hurt us" nor "what we don't know can't hurt us"; it was, rather, that "what we don't know might hurt us."

To relieve the applicants of the burden of proving a negative, of course, is not to impose on advocates of more rigorous protective measures the task of demonstrating beyond any doubt that the lines as proposed would be hazardous. Here, too, the parties acknowledge the uncertainty: Dr. Marino does not predict the occurrence of particular effects; he claims only that effects can occur and that some unspecified ones probably will occur. In deciding the case, we will be choosing not between absolutes but between widely separate positions on a spectrum ranging from asserting that ill effects are probable to asserting that they are extremely unlikely.^{1/}

In these circumstances, we believe it is only fair to proceed by considering the successful operating experience as imposing the burden of going forward and suggesting potential hazards on those parties who claim they exist; once that burden of going forward has been satisfied, however, prudence suggests imposing on the applicants the burden of

^{1/}The popular impression of the case ascribes a greater degree of certainty to both sides than is actually the case. Some of Dr. Marino's extracurricular comments may have encouraged this tendency, but his unfortunate willingness to speak loosely when off the witness stand does not really undermine his testimony.

refuting the inferences of harm, or showing that its likelihood is so small that any reasonable analysis requires authorizing operation as they propose. The stronger the unrefuted inferences of harm, the more rigorous the protective measures we must adopt.^{1/}

One difference of scientific opinion that permeates the case is between advocates of what are termed the "biological" and "biophysical" methods of analysis. The applicants' witnesses generally adhered to the biophysical method, which proceeds by applying the principles of physics to biological material, determining how, in theory, electromagnetic fields can affect biological material, and then calculating whether the electromagnetic fields produced by the power lines under consideration are theoretically capable of producing those effects. Experimental results showing subtle effects must be questioned, according to this method, if the effects cannot be explained by biophysical principles, and applicants' witness Schwan insisted that it was necessary to understand the reasons for a particular effect before extrapolating it from the experiment in which it is found to other situations. A helpful, if not impartial, discussion of the differences between the biological and biophysical approaches is set forth in the direct testimony of applicants' witness

^{1/}Imposing this burden on applicants is not at odds with the requirement, in Public Service Law Section 126(1)(b), that we determine the nature of the line's "probable environmental impact" (emphasis supplied). Reading Section 126 in its entirety, we are free to decide that a particular impact is not probable but is, nevertheless, possible and deserving of being protected against.

Carstensen; it is reproduced in the margin.^{1/} On cross-examination, Dr. Carstensen contended that if an experiment claimed a biological effect contradicted by physical principles he would disbelieve it at first, but he conceded that if the experiment were reliable and clearly established the effect, he would accept the result and would study the phenomenon further until the biophysical model incorporated it.

1/ "In the case of the biological approach, a biological specimen is chosen, exposed to fields of interest and observed for possible changes. This is a little like prospecting. On the one hand, negative results may simply mean the investigator was not looking in the right place for the right things. Negative results frequently are not reported. On the other hand, a positive result in such experiments, confirmed and shown by several independent investigators to be reproducible under carefully defined conditions, is substantial proof of the biological effect. Subsequent research would then be directed to an investigation of the mechanisms of the effect. Once the effect is understood, this knowledge may permit extrapolation to other biological specimens and other conditions.

"The biophysical approach combines our current information on the physical properties of biological materials with information on the magnitudes of the electric and magnetic fields to assess potential for biological effects. In this way we can predict the likelihood of interference by these fields with the natural electrical phenomena of the biological material. This approach is quantitative and permits us to draw rather broad general conclusions concerning the potential for biological effects caused by the proposed lines.

"The results may provide hypotheses to guide both biological and biophysical investigation. Because the development must be based on simplifying assumptions, the biophysical approach cannot be used as the sole proof that there are no important biological effects. However, it provides a sound basis upon which to assess the results of analyses of the biological approach and, taken together with those results, allows us to have confidence in our overall conclusions. Through analyses of geometrically simple model systems, my testimony will illustrate the basic biophysical processes which are involved. This approach yields results which are directly applicable to the questions of possible biological hazards associated with the fields of the proposed lines." S.M. 3396-98.

Staff witnesses Marino and Frey vigorously take issue with relying on applicants' biophysical model. Mr. Frey holds that the nervous system is simply too complex to permit relying on mathematical models for predictions that electromagnetic fields can or cannot affect its working. Dr. Marino believes mathematical models and theoretical analyses and predictions useful in the absence of experimental research and helpful in guiding scientists in choosing experiments. They cannot, however, themselves be evidence on the likelihood of biological effects, and must yield to contrary experimental results even if those results are not fully understood. Biophysical theories, according to Dr. Marino, cannot explain complex life processes, and knowing what can happen is often more important than knowing how or why it happens.^{1/}

The parties' differences over scientific method are of more than academic interest. We cannot ignore scientific theory, and our decision must weigh the claims of responsible theoreticians who use widely acceptable scientific theories in their attempt to demonstrate the extreme unlikelihood-- not the impossibility^{2/}--that the lines would produce adverse

^{1/}On cross-examination, Dr. Marino described the views of a "new generation" of researchers who adhere to the philosophy that "a scientist does not need a formal theory within which to conduct an experiment if it is justifiable for a number of reasons other than a formal theory." S.M. 13019. When pressed, he could not provide information on the proportion of researchers in the field who adhere to that new philosophy. He also did not place himself in the "new generation" for all purposes: he joined the "biophysical" camp to concur in the applicants' witnesses' conclusion that theoretical calculations sufficed to eliminate any concern over tissue heating, one of the two physical effects that applicants postulated could occur as a result of sufficiently strong electromagnetic fields. If Dr. Marino's statements in the press diminish his credibility as a witness, his concession here that his opponents are correct about an issue enhances his status as a reasonable, responsible investigator.

^{2/}Dr. Schwan conceded on cross-examination that there were no biological principles that precluded the observations made in the experiments adduced by Dr. Marino.

effects. But though the theoretical approach portrayed on this record is certainly a valid method for conducting scientific inquiry, it provides, in the short run, an inadequate basis for determining public policy. We reject RG&E's extreme view that Dr. Marino and Mr. Frey advocate returning to the Dark Ages when they question the helpfulness of mathematical models and calculations in the enterprise at hand. The recent history of science is just too burdened by surprising discoveries of adverse effects for a government agency to make its decision principally in reliance on this sort of evidence. For this reason, the Administrative Law Judges were correct in directing most of their attention, as RG&E points out in its Brief on Exceptions, to staff's direct case and the applicants' efforts to refute it.

A final point must be made before we conclude this general introduction. In examining the record, it is necessary for us to bear in mind the distinction between a biological effect and a biological hazard. The Administrative Law Judges held that "the weight of scientific evidence in the case dictates that observed effects not known to be benign must be considered potentially hazardous unless they are temporary or reversible."^{1/} RG&E asserts, on exceptions, that its witnesses uniformly rejected the assertion that an effect must be presumed hazardous; it also contends that staff witness Frey endorsed this rejection as well. Staff, in reply, argues that the evidence and common sense support the Administrative Law Judges' conclusion, particularly when the mechanisms responsible for the observed effects are not understood. Staff witness Frey did, indeed, testify unequivocally

^{1/}R.D., at p. 77.

on cross-examination that all effects were not necessarily hazardous, but, as staff points out in its brief, this does not undermine his view that an evaluation of risks and benefits may have to proceed on the assumption that an effect is hazardous even if there is no scientific basis for concluding so.

Dr. Marino's comments on this subject are useful. He acknowledged the distinction between an "effect" and a "hazard," but contended that even the unproven potential hazard of a probable effect sufficed to warrant regulation. Only if the applicants produced evidence that particular biological effects are not hazardous can the presumption of hazard be vitiated; to adhere to a less rigorous standard, he said, is to experiment on humans. Here, again, we must recognize that our concerns differ from those of even disinterested scientists seeking to discover truth. A scientist who discovers a biological effect need not presume it hazardous; that issue becomes relevant academically only if he is trying to decide whether to conduct experimentation that might produce the effect in humans. The Commission, however, is charged with protecting the public and has no alternative but to presume that a biological effect is hazardous until it is proven otherwise. Doubts about the hazardous nature of the effect can be taken into account in determining the degree of caution that is proper, but we cannot simply ignore a possible effect on the grounds that no one has proven it a menace.

Dr. Marino's Experiments

Staff's case relied heavily, though not exclusively, on the experimental results of its witness Marino as interpreted by its witness Becker. Dr. Marino conducted two studies, one of mice and the other of rats;

applicants sought to discredit both efforts and staff, in its Initial Brief, conceded that the results of the rat study were inconclusive and showed nothing more--or less--than that something "may be happening." In view of the recommended decision's extensive discussion of the rat study we shall confine our comments here to the mouse experiments, accorded less extensive consideration in the recommended decision.^{1/} Staff excepts to the recommended decision's limited discussion of the mouse study.^{2/}

The mouse experiments exposed three generations of mice to 60 Hz electric fields of 10 or 15 kV/m (these fields are slightly greater than the maximum field predicted to be produced by the lines at 60 feet from the centerline, the point of greatest concentration). Mice exposed to the electric fields showed diminished body weight and increased mortality rates compared with the controls. The Administrative Law Judges discounted the significance of the mouse experiments on the grounds that their results were inconsistent across the generations, suggesting that uncontrolled variables, including micro-shocks from the drinking straws, were involved; that Dr. Marino had failed to trim the litters to equal size to insure equal nutrition during nursing; and that he had failed to determine the causes of mortality.^{3/} Staff excepts,

1/A summary of the rat study: rats were exposed to a 60 Hz electric field of 15 kV/m for one month. They exhibited depressed body weights, altered concentrations of serum corticoids and albumin, decreased water and food consumption, and enlarged pituitary and adrenal glands.

2/Dr. Marino, of course, continues to stand by his rat study.

3/The Administrative Law Judges' criticisms, of course, were based in part on the applicants'; since three of the applicants' witnesses were on the NAS committee that prepared the Project Seafarer report, it is not surprising that that report contained similar criticisms of the studies.

arguing that movies made by applicants' witness Miller proved that the mice were not receiving micro-shocks;^{1/} that inconsistency of results across the generations is not surprising since there is no way to control biological variability of animals; and that Dr. Marino's failure to trim the litters provided him with broader populations and hence made the statistical significance of his results more impressive. Staff concedes that Dr. Marino should have determined the causes of mouse mortality but denies that the experiment is seriously flawed by reason of his failure to do so.

In its Brief Opposing Exceptions, RG&E stresses Dr. Marino's own conclusion in his study that further work is needed to establish a cause and effect relationship between the electric field and the observed results. It also cites his acknowledgments that the study had generated contradictory evidence and that the observed effects might be attributable to micro-currents. The company contends, further, that staff's photograph purporting to show that the typical exposed mouse was about one-third the size of a control was misleading--the differences between the groups were not nearly so great--and, finally, points out that the

1/The micro-current issue, which arose as well in connection with the rat study, involved the possibility that the animals experienced very small shocks when they drank from the drinking tubes in their cages. Dr. Marino himself raised the possibility that the weight depressions and increased mortality in some of his experimental mice might be related to micro-currents. Applicants' witness Miller made movies of rats in cages constructed to replicate Marino's apparatus and claimed that he could observe the rats recoiling when they drank while the field was on; staff reviewed the movies and contends that they "demonstrate unequivocally that there is no difference in the behavior of rats drinking in either the 'field off' or 'field on' condition." (Staff's Initial Brief, at p. 18, citing Dr. Marino's testimony.)

full title of the mouse study was "The Effect of Continuous Exposure to Low Frequency Electric Fields on Three Generations of Mice: A Pilot Study" (emphasis added by applicants). This last criticism, of course, gets to the crux of the matter: the results of experiments claiming to show biological effects are, indeed, far from conclusive, but they do suggest further work is needed.^{1/}

Marino's Review of the Literature

In addition to testifying about his own experiments, Dr. Marino provided a wide ranging review of the literature on ELF fields and contended that a very large number of studies supported his conclusion.^{2/} On cross-examination and rebuttal, applicants sought to discredit these studies. Staff contends that nine of the reports cited by its witness provide "a solid body of evidence that electric fields from the transmission line will probably cause biological effects in humans" and that ten other studies also support that conclusion to a lesser degree; it excepts to the Administrative Law Judges' omission of any detailed consideration of this body of work. Staff also contends that the nine studies on which it principally relies have been published in refereed scientific journals and hence are considered to be of acceptable scientific quality.

Applicants respond by questioning the importance of peer review in refereed journals and denying, in any event, that all of the studies have appeared in those journals. They also cite the Project Seafarer committee's dismissal of several of the reports involved and argue that none of this

^{1/}Applicants witness Schwan described Marino's work as "suggestive" but not "convincing." S.M. 6591.

^{2/}Dr. Marino testified his search of the literature established that ELF fields could affect biological systems and that his testimony would have come to the same conclusions even if his and Dr. Becker's work did not exist.

work has been independently confirmed or shown to be subject to extrapolation to humans. Applicants' witness Michaelson testified extensively on the criteria for a proper literature search and denied that Dr. Marino's effort satisfied them; Dr. Marino's conclusions, he contended, were "based simply upon the existence of a number of studies reporting diverse and inconsistent results." S.M. 11634-37.

The studies staff principally relies upon and RG&E's critique of them are summarized in Appendix A. None of the studies by itself proves anything about the lines' fields; taken together they suggest a need for further inquiry.^{1/}

Staff also points to ten additional studies that it relied on to a lesser degree. Applicants criticize these studies in detail and also raise a number of general objections. They contend that four of the studies are irrelevant because they were conducted at extremely high field strengths; in fields such as these, field enhancement caused by the presence of animals can result in local fields near the subject ten to twenty times greater than the undisturbed field. This, in turn, will produce localized corona and a situation qualitatively different from that prevailing under the transmission lines; staff, in response, aptly points out that if the presence in an experimental field of an animal can enhance the field around it, the presence of an animal

^{1/}Staff witness Frey: ". . . a biological investigator will often look at an area which is in its infancy and many studies which are not very well done or have faults or they are preliminary in nature and such and looking at them in toto, he will make an assessment that there may be something happening because of the pattern of results that he has seen, although any particular study in and of itself, one would discount." S.M. 10261.

in the field produced by the lines can do the same. Applicants also point to the absence of independent confirmation of any of these studies and contend that some have actually been contradicted; they also point to staff witness Frey's questioning of four of the studies. Finally, applicants point to a finding that subjects maintain their biorhythms closer to normal in an environment with a natural or simulated natural field than in one having no field and suggest that this finding, if confirmed, shows that the fields have a beneficial effect. This criticism, of course, misses the point that any such benefit may be outweighed by other, harmful, effects.

Magnetic Fields; Synergism

Dr. Marino's own work, and most of the reports he cited, dealt with electric fields. The magnetic fields produced by the line--about 0.5 gauss at ground level--are also of concern. Staff cites the observations of Beischer, et al.,^{1/} who found that exposing human beings to 45 Hz magnetic fields of 1 gauss for up to 22-1/2 hours produced elevated levels of serum triglycerides; Beischer's observations, according to staff, were confirmed at the Project Sanguine/Seafarer Wisconsin Test Facility. According to staff, elevated triglyceride levels are believed to produce an increased risk of arteriosclerotic disease. Applicants criticized various aspects of Beischer's experimental protocol; they also observed that later laboratory experiments, including one by Beischer himself, showed no effect of magnetic fields on

1/D. Beischer, J. Grissett, and R. Mitchell, Exposure of Man to Magnetic Fields Alternating at Extremely Low Frequency, Naval Aerospace Medical Research Laboratory, NAMRL-1180, AD 770140 (1973).

triglyceride levels. Staff witness Becker agreed that laboratory studies had greater significance than clinical studies such as the Beischer work on which staff relies. There is, however, no suggestion that Beischer has renounced the results of his earlier work--he told Dr. Marino that his only reservations concerning the validity of the experiment were related to the relatively small number of subjects involved--and a committee of experts appointed by the Navy reviewed Beischer's work and found it to be competent and to warrant further study. And that, of course, is all that staff is saying: not that the lines are dangerous, but that further study is needed before it can be concluded that they are not.

In his rebuttal testimony, Dr. Marino suggested that the biological response to the concurrent application of electric and magnetic fields might be greater than the sum of the independent effects of the two fields; this effect is termed "potentiation." He also expressed the fear that synergistic effects could occur between electromagnetic fields and other agents such as radar, air pollution, drugs and the like. Staff disavows its witness' position on this point, observing that there is no evidence on the record to support any inference of potentiation or synergism, but does suggest that the matter be studied by a research program. Applicants deny the existence of any scientific basis to support the existence of synergistic effects.

RG&E's efforts to dispute the existence of synergistic effects on the basis of theory are no more persuasive than its efforts to dispute, on the basis of theory, the possibility of biological effects of electric fields alone. But Dr. Marino here has not borne his burden of going forward with evidence showing the possibility of harm, and his inferences are based on mere speculation. In these circumstances, we have no reason to conclude that synergistic effects are cause for concern.

Dr. Becker's Testimony

Dr. Marino provided the premises for staff's case; its witness Becker, the only physician to testify on this subject, drew the conclusions. Dr. Becker testified that the literature on ELF fields constituted "a solid body of data" indicating that living organisms were influenced by ELF fields and were likely to be affected by them with respect to growth, both cellular and of the total organism, and to the functioning of the central nervous and cardiovascular systems. He further said that "the condition of [Marino's experimental] rats at the end of 30-days exposure was consistent with chronic exposure to an environmental stresser," and that "systemic stress denotes a condition in which, due to function or damage, extensive regions of the body deviate from their normal resting state." S.M. 8992-8993. He portrayed the stress adaptation syndrome, first described by Dr. Hans Selye, and pointed out that Selye had been able to correlate chronic stress with certain disease states including hypertension and gastric ulcers. Human beings, Dr. Becker felt, could sustain the same effects as Marino's rats, and different individuals would be likely to react differently to the same degree of exposure. According to Dr. Becker, the weight of the evidence suggests that biological effects would occur in human beings subjected to long-term exposure to the lines; the effects would be within the framework of the stress adaptation syndrome "and may be evidenced in a variety of fashions, from such functional changes as increased irritability and fatigue, to such actual pathological states of hypertension and stomach ulcers"; a medical doctor could diagnose the electric field from 765 kV lines as the causative agent for stress related illnesses. S.M. 8999-9000. Dr. Becker concludes that chronic exposure of human beings

to the fields produced by the lines should be viewed as human experimentation and subjected to the rules applicable to human experimentation in laboratories, the key element of which is informed consent. He therefore recommends against construction of the line as proposed by applicants until the complete spectrum of biological effects produced by exposure to 60 Hz fields is determined and firm levels of permitted exposure are established.

Applicants' attack on Dr. Becker was directed largely to his views on stress, their witness Michaelson testifying that stress was not necessarily harmful and citing Dr. Selye himself for the view that stress is not something to be avoided and is, in fact, necessary. Dr. Becker, however, did not dispute this view, and only after describing the kinds of situations in which stress is good for an organism did he go on to observe that the continuation of stress will necessarily result in exhaustion. Applicants take exception to the Administrative Law Judges' unwillingness to resolve the Becker-Michaelson dispute over the beneficial effects of stress. But as staff points out in reply, Selye's recognition that stress is a part of everyday living hardly amounts to a conclusion that stress from a newly imposed source, at unknown intensities and of long-term duration, is harmless.

Dr. Becker's presentation, of course, suffers from the same ultimate infirmity as Dr. Marino's: it deals in possibilities and probabilities, not certitudes. Becker's extrapolations are based on Marino's and other experiments, none of which are conclusive; and he himself testified on cross-examination that it would take extensive epidemiological

studies, none of which have yet been conducted, to show the effects, which he thinks likely, of existing transmission lines on human health.^{1/}

Mr. Frey's Views

Staff witness Frey testified on potential effects of the lines' fields on the nervous system and behavior. While there is little directly relevant research, eastern European reports as well as American work--including Frey's own--suggest that there may be behavioral or neural effects of consequence at 60 Hz and that "whether such possible effects are hazardous or not is unknown at this point in time." S.M. 9990. Mr. Frey stresses, however (and his testimony is weakened because of) the need for caution in applying the results of these reports, most of which were obtained at frequencies much higher than 60 Hz. An important aspect of Mr. Frey's testimony is his rejection of the use of mathematical models and calculations to predict whether or not electromagnetic fields can influence nervous systems and behavior. He believes that it can as well be argued from calculations that there will be effects as that there will not; the reason is that any set of calculations involves a large number of hypotheses, none of which are universally accepted as truth, concerning the extremely intricate functioning of the nervous system. Moreover, the simplifying assumptions required by calculations misrepresent the very complex nature of the nervous system. Mr. Frey concludes

^{1/}Dr. Becker pointed explicitly to the increased incidence during recent decades of hypertension, arteriosclerotic heart disease, and gastric duodenal ulcers. His conclusion: "it is true that no one has had their hair turned green and their eyeballs fall out when they stand underneath a transmission line, but whether or not the disease complex that we see in medicine today is or is not related thereto, I am not about to say at this time." S.M. 9105.

"we have a situation in which there are weak indications that the 60 Hz power line fields could cause neural and behavioral effects. There is insufficient data to establish whether these possible effects are hazardous or not. Further, there is no way, through calculations and modeling, to determine if there are or are not hazardous effects." S.M. 9993-94. In this situation, in which further experimental investigation is needed to determine whether or not the lines present a hazard, Mr. Frey recommends that we permit the construction of 765 kV transmission lines but on a right-of-way of such width that the field strengths to which the general public could be exposed on a short- or long-term basis are no higher than those to which it is now exposed as a result of operating transmission lines.

The Administrative Law Judges endorsed Mr. Frey's agnosticism concerning the existence and hazardousness of the effects of the 60 Hz fields. Applicants conclude that the Judges, having totally discredited and discounted Drs. Marino and Becker, must have relied solely on Mr. Frey's testimony in refusing to give the lines a perfectly clean bill of health, and except. They stress Mr. Frey's Achilles' heel--his background in microwave, rather than ELF, research--and disparage his credentials compared with those of their witnesses Schwan and Carstensen. Staff responds that the Administrative Law Judges did not rely on Mr. Frey, but simply used his statement as a summary of their view of the entire body of evidence; more significantly, staff points out that Frey himself acknowledged the dangers of extrapolating from microwave research and that the more important aspect of his testimony is his warning, on the basis of his expertise in studying nervous systems and behavior, against using mathematical calculations to predict the absence of biological effects.

Applicants' Affirmative Case and
Staff's Response to It

Applicants contend that an accepted body of scientific principles, together with the absence of biological effects demonstrated by experimental evidence or operating experience, are "consistent with the proposition that the proposed transmission lines' electric and magnetic fields pose no detriment to the welfare of plants, animals or humans. Risks to human health and safety from the proposed lines' fields appear to be nearly zero."^{1/} Their witnesses Schwan and Carstensen argued that electric fields can, in theory, interact with biological materials by inducing currents in the materials; those currents can, to our existing knowledge (the only basis for judgment) manifest themselves only in two ways: by heating and by exciting nerves. The field inside the cell is what matters for these purposes, and, at 60 Hz, will always be less than the external field.^{2/} Applicants' theoretical calculations showed that fields produced by the lines would not produce internal fields capable of producing either possible biological effect; hence safety can be presumed.

Applicants also say that experimental studies bear out the theoretical inference that the lines are safe. Most of the studies purporting to find effects are, according to applicants, irrelevant--because they deal with different frequencies or different field intensities--incompetent, or inconclusive. Applicants also stress that the process by which articles are selected for publication works against negative findings, for they frequently have little value outside of the specific laboratory setting in which they are

^{1/}RG&E Brief on Exceptions, at p. 84 (citations omitted).

^{2/}At microwave frequencies, internal and external fields will be similar; this is one reason the microwave research is inapposite.

produced. In the research that grew out of Project Sanguine/Seafarer, however, much of the selectivity in favor of positive results had been eliminated and, according to applicants, the vast majority of reports were negative. Moreover, of the six positive reports that applicants believe valid, all used electrodes placed in a highly conductive medium and would require impossibly high fields in air in order to reproduce the fields experienced in the water medium.

Staff considers applicants' model to be simplistic: its prediction of a safe current density, according to staff, is based on a model of a nerve that does not realistically simulate the extremely complex nerve function in a living body and on questionable calculations of internal current densities.^{1/} Through its witness Frey, moreover, staff disputed Dr. Schwan's assumption that a nerve can be affected only by a field sufficient to trigger it; it is entirely possible, according to Mr. Frey (and according to DEC witness Henshaw), that current densities substantially lower than those required by Dr. Schwan's model could provoke a neural response. The matters are simply too complex, and too much is still unknown, for the model to have predictive value.^{2/} Staff also deprecated the importance of the negative literature applicants cited, arguing that these reports merely established the existence of certain conditions for which effects are not observed but made it no less likely that other conditions would yield results. Staff further attacked applicants' reports on grounds similar to

^{1/}Dr. Marino reasoned that if Dr. Schwan's "safe" internal level of current density were translated, by Dr. Schwan's own methods, into the corresponding external level, the conclusion would be that danger existed only in fields stronger than 20,000 kV/m.

^{2/}Though he, too, defended the Schwan-Carstensen biophysical approach, applicants' witness Michaelson conceded, on cross-examination, that it suffered from the weakness of requiring the use of simplified models.

those used by applicants in attacking staff's reports: defective experimental protocols and inconclusive results.

Soviet Research and Standards

A considerable amount of effort in this case was spent on a discussion of various ELF field exposure standards applied in the Soviet Union. Dr. Marino testified that Soviet electrical workers are limited in the time they can spend in fields exceeding 5 kV/m and that Russian 750 kV lines are not permitted to be located closer than 300 to 500 meters from the borders of future population sites, 100 meters (roughly 330 feet) from inhabited dwellings, and 40 to 60 meters from old noninhabited dwellings. In addition, the zone where the field is higher than 2 kV/m is defined by signs and farmers using the right-of-way within that zone must have metallic shields over the seats of their farm vehicles. Recreational activity, in addition, is not permitted there. Magnetic fields are of concern only to occupationally exposed individuals.

Applicants' response to these standards was to argue that Soviet regulations, by the admission of Russian experts with whom applicants' witnesses have spoken, are not designed to be enforced. A more significant problem is the limited availability of the studies that must have formed the basis for the Russian standards and the weakness, conceded by Dr. Marino, of the four Russian studies he was able to obtain. Applicants cite an American study by Kouwenhoven^{1/} that purports to show that linemen are not affected by exposure to electromagnetic fields; but staff contends that this study is flawed. Applicants' witness Schwan, finally,

^{1/}W. Kouwenhoven, O. Langworthy, M. Singewald and G. Knickerbocker, Medical Evaluation of Man Working in AC Electric Fields, 86 IEEE, PAS 506 (1967).

testified that the Russians considered field gradients up to 12 kV/m as satisfactory for the design of high voltage lines and applied the following standards: 20 kV/m for difficult terrain; 15-20 kV/m for non-populated regions; 10-12 kV/m for road crossings.

The Soviet experience, accordingly, is inconclusive and of limited decisional consequence. What is of interest is that it appears that the Soviets have not ignored the possible risks of extra-high voltage transmission lines. Staff witness Frey warned against wholly discounting the Russian experience on the grounds of flawed research, and pointed to the microwave area where Soviet reports, initially disregarded because of their poor quality, had later been borne out by American researchers.

Transmission Line Radiation - The
"Helliwell Phenomenon"

In his rebuttal testimony, Dr. Marino raised the specter of a risk not previously considered. He testified that Robert Helliwell of the Stanford University Radio-science Laboratory had found that electromagnetic radiation from the Canadian power system was being injected into one of the earth's magnetic ducts. These waves pass into the magnetosphere where their interaction with trapped electrons results in the production of X-rays which, in turn, give rise to secondary interactions producing ultraviolet light. Thus far Helliwell; Dr. Marino reasons further and warns that the ultraviolet light can increase the incidence of skin cancer and result in global climate changes. He suggests that the scope of these hazards, now unclear, might be so great as to necessitate undergrounding the proposed line and recommends that a subsequent hearing explore the matter in greater detail.

Applicants' witness Savedoff sought to rebut Dr. Marino's contentions on this matter and testified that any increase in ultraviolet radiation or potential for change in weather resulting from power line radiation was negligible. Staff, without relying on Dr. Savedoff's testimony, disavows its witness' position on this issue. It considers it to be speculation based on a large number of unknowns, and feels that Dr. Marino has not established a sufficient case to warrant our concern. Dr. Helliwell himself, in a letter to Dr. Marino, wrote that "we would not expect that a new transmission line would produce a noticeable change in the electron precipitation from the magnetosphere."^{1/} Similarly, in a letter to Niagara Mohawk, Dr. Helliwell made the following comment on Dr. Marino's testimony: "Although his description of my experiments is generally correct, his conclusions regarding the biological effects of transmission radiation are, in my opinion, not supported by data."^{2/}

In his Reply Brief, Dr. Marino agrees that the possible effects of the Helliwell phenomenon on global weather and skin cancer are unproven but contends that we must nonetheless determine its biological consequences and that our "responsibility ends only when [we] determine on the basis of independent scientific opinion, that no credible health hazard is presented." But in view of the apparently speculative nature of the risks Dr. Marino posits, we are satisfied that this risk is one we need not now take into account.^{3/}

^{1/}Letter of 20 January 1976 from R. A. Helliwell to Andrew A. Marino (not admitted in evidence).

^{2/}Letter of 1 March 1977 from R. A. Helliwell to Henry J. Nowak, Niagara Mohawk Power Corp. (admitted in evidence as Exhibit R-5).

^{3/}Our conclusion here does not rule out further exploration of the matter in the program of studies discussed below.

Analysis of Risks and Benefits; Conclusions

At the heart of the case is the question of how we should balance the possible risks associated with a 765 kV line against its clear benefits: using a 765 kV line is both cheaper, and less environmentally insulting, than constructing and operating a greater number of lines of lower voltage.^{1/} The economic benefit of 765 kV transmission, of course, is diminished as the right-of-way to be required is expanded; this point is the central argument relating to costs raised by applicants in their briefs on exceptions.

RG&E contends that requiring a wider right-of-way for its Pannell Road to Volney line would incur an estimated cost of \$2,531 an acre for fee title; the additional cost attributable to the Administrative Law Judges' proposed 350 foot right-of-way, therefore, would exceed \$2.5 million, exclusive of the cost of additional residences or buildings which might have to be acquired or severance costs where applicable. There are no data in the record on the additional cost to PASNY of the 350 foot right-of-way for its proposed line; but its witness Fullerton said that an 870 foot right-of-way (wider than that proposed by staff) would incur additional land costs, at \$250 an acre, of \$1.8 million. RG&E also argues that a wider right-of-way would impose added social costs insofar as it would fan the public's fears and lead them to avoid any activities on transmission line rights-of-way. Our declaring the lines safe would, according to RG&E, alleviate the fears the public now feels and lead them to accept the "imperceptibly small and purely hypothetical risks" associated with the lines just as they accept the known risks associated with normal activities

^{1/}We have already observed that DEC accepts the operation of a 765 kV line in place of the four or five 345 kV lines that would be needed for equivalent transmission capacity in part because of the greater land use impact of the larger number of 345 kV lines.

such as crossing streets and driving cars. Finally, RG&E suggests that even if the now speculative effects postulated by Dr. Marino do in fact occur, in almost all cases their upper limit is within the population's normal range of biological variability and they would not impose a significant risk to human health or safety.

Staff, in reply, believes that the cost of adopting its recommendations--more rigorous than the Administrative Law Judges'--will not be significant when compared with the biological risks. It contends that land acquisition costs cannot accurately be predicted--because local conditions will vary the intensity of the fields at any given distance from the centerline, thus making additional acquisitions unnecessary in some areas--but that the costs, in any event, are likely to be small compared with the total cost of constructing the line. Perhaps more significantly, staff observes that incurring additional costs now could avoid future costs related to health, to modification of the facilities, and to the removal or abandonment of buildings subsequently built near the lines.

Although the record before us is, in many ways, reassuring--it does not show that the electric and magnetic fields of the lines as proposed will produce effects endangering human health and safety--it contains unrefuted inferences of possible risks that we cannot responsibly ignore. Fields similar to, though much stronger than, those here at issue seem to have produced effects in laboratory animals and these effects cannot be presumed harmless. Some of these experiments may have been flawed in various ways, but we are far from persuaded that their flaws warrant disregarding their results.^{1/} Operating experience in other

^{1/}Applicants could have aided the record by attempting to replicate Dr. Marino's experiments in a manner free of the defects they perceived in them. For reasons best known to them, they did not do so.

jurisdictions seems to have been good, but the epidemiological studies that might have disclosed subtle biological effects have not been conducted. And applicants' theoretical analysis may provide an added basis for questioning the significance of the reported effects, but is not, itself, conclusive.

We believe it important that the unresolved questions raised in this case be clearly answered so that New Yorkers can enjoy the benefits of 765 kV transmission free of fears that they are doing so at some unknown cost to their well-being. A properly designed program of studies should be able to provide some of these answers within a few years. The program should be funded by the utilities^{1/} but must, to assure its general acceptance, be conducted by independent researchers under our supervision. We are prepared to enlist the help of prominent, disinterested experts to assist us in planning and contracting out the studies and in evaluating their results. We shall direct staff to prepare a plan for proceeding with this sort of program; we shall issue it for comment before we adopt it.^{2/}

Until we have the more definitive information the research program can provide, we conclude that the best course of action, in principle, is the one proposed by staff witness Frey: make the right-of-way for a 765 kV line wide enough so that the field strength at its edge is no

^{1/}We are, of course, not now in a position to determine the full cost of the program. We shall set PASNY's contribution, on which today's certification is conditioned, at an amount not to exceed 2% of the cost of the line. This contribution will be in lieu of the 2% that would otherwise be required to be applied to the development of recreational facilities along the right-of-way. PASNY's maximum financial exposure on account of this program, therefore, will be no greater than what it should have expected because of our existing policy on recreational facilities. See Case 26845, Consolidated Edison Co. of N. Y., Inc., 12 NY PSC 267, 309 (1972).

^{2/}Staff will also be directed to inform the United States Occupational Safety and Health Administration of our conclusions today. Utility workers are often exposed to much higher fields than the general public, and the research program we are requiring may be of interest to OSHA in promulgating standards for occupational exposure.

greater than that produced by the many existing 345 kV lines at the edge of their rights-of-way. In this way, we assure that the risks, if any, of long-term exposure to 765 kV transmission in the areas traversed by PASNY's line and any future 765 kV lines will be no greater than those, now widely accepted, of long-term exposure to the 345 kV lines operating throughout the State.^{1/} We declare, in effect, a moratorium on higher fields until the results of the research are in.

A standard 345 kV right-of-way is 150 feet wide, though some are narrower because of particular circumstances. At the edge of a standard 345 kV right-of-way, the calculated electric field strength (assuming a single-circuit line) is approximately 1.6 kV/m. A single-circuit 765 kV line will produce a field of approximately that strength at the edge of a 300 foot wide right-of-way and that width, accordingly, is the minimum consistent with the mode of analysis we have adopted. The actual field strength, however, will often differ from the one predicted, for it will be affected by such factors as land contours and line height. At 150 feet from the centerline, a higher conductor will produce a stronger field at ground level, and, the line will, in most circumstances, be higher than the design standard.^{2/} In light of these factors, we believe that a right-of-way somewhat wider than the 300 foot minimum is justified. Moreover, the record shows that at 150 feet from the centerline the field drops off sharply as one moves further out. Thus, with a

^{1/}We do not imply that society has, in any way, explicitly decided that 345 kV lines are worth whatever risks they may entail. But the lines are in place and are not widely opposed; staff witness Becker testified that he would not recommend turning off existing lines, even where they produce fields that cause him concern, because of the benefits, not the least of which are medical, of the electrical service they provide.

^{2/}This matter is discussed in connection with the issue of induced shock. See below, p. 46.

relatively small increase in the width of the right-of-way one can achieve a relatively large diminution in the calculated electric field strength at its edge for what appears to us to be a reasonable cost. We shall, therefore, adopt the 350 foot right-of-way recommended, in effect, by the Administrative Law Judges and DEC.^{1/} It is entirely possible that the research program we are requiring will show us to have been unnecessarily conservative. But we believe this is the proper course to follow on the record before us.

We turn next to the regime to be enforced within the right-of-way. Our decision to require a 350 foot right-of-way rejects staff's proposal that persons whose houses are within a given field contour be offered an option to have the house purchased or moved. An option is not suitable here because the risk, if any, is so uncertain that a person who chooses to remain cannot be said to have knowledgeably assumed it. And we agree with RG&E that defining the right-of-way or protective zone with reference to actually measured field strengths, rather than as a uniform distance from the centerline, would impose unreasonable administrative burdens. We shall therefore require the exclusion of all residences within the 350 foot right-of-way. Farming and other activities are not now precluded on existing 345 kV rights-of-way and we shall not do so here either; but we recognize that there may be circumstances in which the purchase or removal of a farmhouse may make continued operation of the farm impractical. In those cases, the matter should be reflected in the negotiated purchase price or in the damages ultimately awarded by the courts: this, too, is analogous to the procedure followed with respect to 345 kV lines and differs only in the width of the zone involved.

^{1/}The discussion here is limited to field effects. DEC recommends a wider right-of-way on account of audible noise. While we do not follow DEC's recommendation, we recognize, through other means, the possibility of having to satisfy noise complaints beyond the right-of-way. See below, p. 65.

While existing residences are our primary concern, we must also consider future development. We see no need now to force the utilities to acquire the permanent right to preclude future residential development within the 350 foot right-of-way,^{1/} for the research program may find that zone too wide. Permanent rights to bar development need only be obtained within a 250 foot wide zone; within the remainder of the 350 foot right-of-way, future residential development need now be precluded only for seven years. At the conclusion of the research program, we shall decide on the permanent size of the zone from which housing must be barred.

It remains to apply the foregoing principles to existing 345 kV lines on rights-of-way narrower than 150 feet. LILCO, whose main interest in the case was the applicability of its results to its existing 345 kV lines,^{2/} excepts to the Administrative Law Judges' failure to recommend standards for existing lines. It urges us, if we adopt a standard for 765 kV lines, to make it clear that the standard is being established out of an abundance of caution and not because any health hazard has been established. And it requests that the standard be made less stringent for lower voltage lines that now exist, are already certified, or for which certification has already been sought. DEC, in its Reply Brief on Exceptions, makes a similar argument, but would limit the exemption to currently operating lines in order to avoid the need to make large expenditures to acquire wider rights-of-way for these existing lines.

The arguments of LILCO and DEC make sense. Our decision here is, in fact, no more than a precaution. We shall, therefore, exempt operating 345 kV lines from the interim standard we adopt today. New 345 kV lines will be required to be on rights-of-way no narrower than 150 feet.

^{1/}We are dealing here, of course, with a situation in which the utility chooses to acquire the right-of-way by easement, rather than in fee.

^{2/}Some of LILCO's 345 kV lines produce an electric field of 2.2 kV/m at the edge of the right-of-way.

ELECTRIC SHOCK

We discussed the issue of induced current shocks extensively in Opinion No. 76-12,^{1/} and the only evidence received on the subject since then is the testimony of UPSET's witness Ruggles, an Ohio farmer living near an AEP transmission line. We shall, therefore, proceed directly to the Administrative Law Judges' present recommendations and the exceptions to them.

Conclusions of the Administrative
Law Judges and Exceptions to Them

The Administrative Law Judges concluded that staff's proposed design criteria, which will be more than met by the PASNY line, sufficed to provide adequate protection against shock.^{2/} They recommended only that the applicants be ordered to correct annoying shock conditions as they are complained of by persons living or working near the right-of-way. They counseled us not to require an information program of the sort advocated by staff and DEC on the grounds that a program of this sort would be tantamount to a scare campaign.

Staff and DEC except to the Administrative Law Judges' failure to recommend directing the utilities to adopt grounding and bonding programs in advance of receiving complaints; they also continue to urge that we require a public education program. DEC, in addition, recommends that the design criteria be changed to include a minimum clearance of 50 feet over all terrain and would particularly include warnings against gasoline refueling under the lines as part

^{1/}Our majority's discussion, and Commissioner Jerry's dissent from it, are reproduced in Appendix B to this Opinion.

^{2/}Staff's criteria include clearance of 61 feet over public roads, 46 feet over private roads, and 44 feet elsewhere. RG&E proposed a 50 foot minimum height except that it would use a 70 foot minimum over public roads; PASNY proposes a 48 foot minimum height.

of the educational program. UPSET, contending that grounding can only reduce but not eliminate shock hazards, nevertheless agrees with staff and DEC that grounding should be required.

The St. Lawrence County Planning Board contends that the grounding of vehicles will not alleviate farmers' problems adequately and that the only means for eliminating or reducing the magnitude of the shock problem is through altered routing, higher ground clearances, or lower voltages, all procedures which, it says, have been ruled out for the PASNY line by our past decisions.

RG&E excepts to the Administrative Law Judges' failure to take administrative notice of the 5.0 mA standard adopted by the National Electric Safety Code as the safe level of current permitted to be induced in objects by overhead transmission lines, and requests that this standard be adopted by us.^{1/} Staff and DEC express no objection to our taking official notice of that standard but continue to recommend that the standard used by the Commission be 4.5 mA.

Discussion and Conclusions

Mr. Ruggles' comments cast doubt on the effectiveness of grounding in alleviating shock problems. It must be borne in mind, however, that his testimony is anecdotal, and is at odds with the other anecdotal testimony--received through applicants' witnesses--of satisfactory operating experience. More significantly, it appears that the line near which Mr. Ruggles lives is designed to meet criteria considerably less conservative than those proposed by applicants in these cases, including a right-of-way of only 200 feet and a minimum ground clearance of only 40 feet. We find no need, therefore, to modify our disposition of this

1/The standard is also used by Hydro-Quebec and AEP.

issue in Opinion No. 76-12: any risk of shock posed by these lines, as proposed, can be taken care of through proper operating conditions.

The operating conditions we shall impose are more stringent than those recommended by the Administrative Law Judges. It is clear from the evidence that grounding of fixed objects and movable objects regularly used along the right-of-way can reduce the incidence and severity of shocks. Although the applicants appear willing to undertake a grounding program voluntarily, we agree with staff, DEC, and UPSET that their doing so should be a condition of certification. We shall also require applicants to establish an educational program designed to acquaint persons likely to enter the right-of-way with the precautions that can be taken to reduce shock annoyance. The particulars of the grounding and education programs will be subject to our approval, and should be set forth in the EM&CP. Finally, we shall direct each applicant to report to us promptly each shock-related complaint it receives and its resolution.

We shall reject DEC's proposal that a minimum 50 foot clearance be maintained throughout the line. The clearances, as pointed out in the discussion in Opinion No. 76-12, are computed with reference to worst case conditions, including an ambient temperature of 104°F and maximum loading; in more normal circumstances, the minimum clearance will probably exceed 50 feet even under existing design criteria. We also reject RG&E's suggestion that we set a 5.0 mA standard for maximum induced current for other than fixed objects. Despite the use of the 5.0 mA standard by other agencies, this record discloses that the 4.5 mA standard provides a better safety margin and the lines, as now designed, will more than meet that standard in all but the most

extraordinary cases.^{1/} We shall adopt the standard for all future transmission lines.^{2/}

AUDIBLE NOISE

Introduction and Terminology

High voltage transmission lines produce audible noise^{3/} during periods of foul weather--rain, snow or fog. The noise is the result of droplets of water on the conductor surface. During fair weather conditions, some very small amounts of noise may be produced as a result of burrs or dust on the conductor surface, but it is generally acknowledged that this noise poses no problem. On the basis of Phase I data, foul weather may be expected, on the average, 16.2% of the time.^{4/}

1/Among the elements of such an extraordinary case would be a tractor-trailer, foreign to the area of the lines and hence unequipped with grounding chains, wandering off the road into the middle of a field under the lowest point of the line on a day when ambient temperatures are in the 90's or higher and the lines are loaded at their maximum. And even in this case, there would be no danger to most adults.

2/4.5 mA is a measure of induced current and depends not only on the voltage and height of the line, but also on the size of the object under it. To eliminate that variable, we shall set the standard not in terms of induced current but, rather, in terms of the electric field strength needed to induce that current in the largest object expected to be under the line at any given point. These field strengths, measured at one meter above ground, are 7 kV/m, 11 kV/m and 11.8 kV/m over public roads, private roads, and other terrain, respectively; the figures assume that the largest object likely to be on a public road is a tractor-trailer, the largest object on a private road is a school bus, and the largest object found off roads is a combine.

3/Audible noise is to be distinguished from other types of noise, such as interference with radio transmissions.

4/The actual measurements were made at four locations near the proposed rights-of-way and ranged from 7.7% at Canton to 23.6% at Syracuse.

Testimony concerning the effects of transmission line audible noise on humans was presented by staff's witness Karl D. Kryter, applicants' witness Karl S. Pearsons, and DEC witness Daniel A. Driscoll. In addition, John L. Fletcher testified, on behalf of the Department of Law, to the effect of audible noise on animals; no party challenged his view that the lines posed no significant hazard to domestic or wild animals.

The intensity of sound is measured in decibels (dB). The decibel scale is logarithmic, and a level of 70 dB, for instance, is considerably more than twice as loud as a level of 35 dB. Because all sound frequencies having the same physical intensity in dB do not appear equally loud, various techniques have been devised for weighting the intensities in dB's of the frequency components of the sound. The most commonly used technique is termed "A weighting"; sound weighted in accordance with this scale is expressed in dB(A) units.^{1/} Though all three witnesses used the dB(A) scale, Dr. Kryter warned that it may understate the annoyance effects of those sound sources having the frequencies of transmission line noise.

Sound levels experienced over time are described in various ways. L_{max} and L_{min} are the maximum and minimum sound levels produced during the test period. L_x , where x is a number between 1 and 99, represents the sound level that is exceeded x percent of the time. A composite rating for fluctuating sound over a particular period is the "equivalent sound level" or L_{eq} . Because noises at night

^{1/}Appendix C is a copy of Exhibit KKK, sponsored by witness Pearsons. The exhibit sets forth the dB(A) levels of various common sounds and is appended here only to provide general impressions of the dB(A) scale.

tend to be more annoying, the L_{dn} , amounting to an L_{eq} computed over a 24-hour period with a 10 dB penalty added to measurements taken between the hours of 10:00 p.m. and 7:00 a.m., has been developed. The annual L_{dn} is the average, summed on a logarithmic basis, of the daily L_{dn} 's for one year.

Potential effects of noise on humans include temporary or permanent impairment of the ears' functioning; other physiological effects such as increased tension or fatigue; sleep interference and the attendant annoyance; speech interference and the attendant annoyance; and annoyance independent of sleep or speech interference. All three witnesses agreed that the lines' noise levels would not be great enough to impair the ears' functioning, and Mr. Pearsons took the same position with respect to other physiological effects. Dr. Driscoll suggested that these other effects should be considered, but provided little data concerning their magnitude. There was also general agreement that speech interference, if it exists, would not be a significant problem.

The Administrative Law Judges' Recommendations
and the Positions of the Parties

The Recommended Decision

Rejecting proposals by DEC and staff, the Administrative Law Judges concluded that the possibility of annoyance from audible noise generated by the line was very remote and that the proposed right-of-way extending 125 feet from the centerline sufficed to reduce the impact of audible noise on residences along the corridor. They did, however, recommend that applicants be required to respond to complaints of annoyance and provide "such solutions as are feasible"; if

they are unable to satisfy a complaint, they should be required to report it to the Commission. The Judges explicitly rejected, on grounds of jurisdiction and practicability, staff's proposal that applicants be required to purchase homes beyond the right-of-way at which audible noise posed an unresolvable problem.

DEC's Position

DEC, on exceptions, continues to recommend that 765 kV lines not be located within 250 feet of the centerline of any residence. Existing houses within that zone would be the subject of an offer to purchase at fair market value; easements prohibiting future construction would also be purchased. Beyond that zone, and extending out to 600 feet from the centerline, DEC would require utilities to purchase an easement intended to compensate landowners for the annoyance of the lines' noise and to put future buyers on notice of the noise problem. DEC would not require the utilities to offer to purchase or move houses within that additional protective zone, nor does it suggest that any activity be excluded there. The Department would also require the utilities to set up an educational program to alert the public to the lines' potential noise and to describe their procedures for handling complaints. UPSET endorses DEC's recommendations.

The principal bases for DEC's recommendations, discussed in detail below, are its views about the likely effect of annoyance independent of speech or sleep interference and about the proper method for setting noise standards. It recommends an L_{eq} of 50 dB(A) as the standard for the edge of the right-of-way in all future EHV cases.

Staff's Position

Staff differs with the Administrative Law Judges in that it would require the utilities to purchase residences at fair market value if other solutions for eliminating noise problems proved unsatisfactory. It would extend this benefit without regard to the house's distance from the centerline; its earlier proposal would have limited the purchase option to homes located within 325 feet of the centerline. The bases for staff's disagreement with the Administrative Law Judges include its recognition that there will be instances in which the actual noise is greater than that predicted by the average figures on which the Judges relied; its unwillingness to take into account the ability of people to adapt to intrusive noises; and its skepticism about Hydro-Quebec's and AEP's operating experience.

Staff also recommends that an L_{50} of 54 DB(A) during rain and snow be adopted as the general noise standard to be applied to all extra-high voltage lines in deciding on the appropriate line design^{1/} and right-of-way width.

Applicants' Position

RG&E, the only one of the applicants to address itself to this issue in its Brief on Exceptions, does not except to the Administrative Law Judges' recommendations. It does, however, propose its own findings and conclusions on the subject; these include a statement that "the levels of noise estimated for the proposed lines meet or exceed the criteria in all current pertinent noise regulations, standards and guidelines."

^{1/}The size of the conductors is among the factors that determine the intensity of the noise.

Indoor Attenuation

Whatever the sound level is outdoors, it will be attenuated indoors; the degree of attenuation will depend, among other things, on what the building is made of, how high the noise source is, and whether windows and doors are open or closed. The witnesses at first differed greatly about the degree to which transmission line noise was predicted to be attenuated indoors, and RG&E, joined by staff and DEC, conducted on-site measurements of noise reduction through windows of houses similar to those found along the route proposed for its line. Unfortunately, those experiments failed to resolve the issue fully.

Staff's original position was to assume attenuation of 10 dB through an open door or window, and it used this figure in its initial estimate of indoor effects. Applicants, on the other hand, predicted attenuation of 19 dB(A) through open windows and 30 dB(A) through closed windows. DEC witness Driscoll assumed attenuation of 10 to 15 dB(A); elsewhere he calculated that open window attenuation for houses in northern climates ranged from 10 to 31 dB and recommended using a worse case figure of 10 dB. The United States Environmental Protection Agency, in its "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare Within an Adequate Margin of Safety ("EPA Levels Document"), used a figure of 15 dB(A) as the average noise reduction through partially opened windows.

Applicants' witness Pearsons' prediction of 19 dB(A) attenuation through open windows was intended to reflect the particular frequency spectra of the transmission lines as well as the climate and likely construction practices in upstate New York. These factors were also reflected in RG&E's attenuation study; the results of those experiments, as modified by staff, showed the following attenuation figures:

	Attenuation at -	
	<u>Center of Room</u>	<u>Sleeping Location</u>
Windows Partly Open (2 sq. ft.)	13.5 dB	16.5 dB
Windows Fully Open	8.5 dB	12.5 dB

The figures include a 1.5 dB downward adjustment in attenuation made by staff but rejected by applicants; staff felt the downward adjustment was needed in order to make the results of this experiment, which involved a close noise source, simulate properly the effect of a noise source as far removed as the transmission lines would be.

Despite this study, applicants continue to recommend their attenuation figure of 19 dB and claim it is confirmed by the unadjusted survey results showing average attenuation of 18 dB at the sleeping location with windows partially opened. Applicants also contend that the earlier figure, based on a study conducted by the Society of Automotive Engineers (SAE), is more reliable because it was derived from a larger sample; that, however, is questionable, for the RG&E survey measured one room in each of 14 houses while the SAE survey measured a total of 31 rooms, but in only 5 houses. Moreover, there is an even more significant flaw in the SAE study: its use of a noise source--airplanes--at a very high elevation. The record warrants the conclusion that the greater the angle at which the noise source intersects the window, the greater the attenuation. The SAE study appears, therefore, to overstate attenuation for purposes of predicting the indoor effects of transmission line noise, which originates at a lower elevation.

DEC also does not make staff's 1.5 dB downward correction but opposes staff's use of the higher sleeping location figures, believing it appropriate to measure

attenuation at the center of the room. It accordingly recognizes an average attenuation figure of 14.6 dB,^{1/} but considers 10 dB a better estimate to use when considering worst case conditions because the 14.6 figure is a mean value with a standard deviation of 4.4, resulting in some 16% of dwellings having predicted attenuations below 10.2 dB.

Although DEC witness Driscoll conceded on cross-examination that the study sample was too small to provide a basis for predicting that 16% of all houses would actually cause attenuation of only 10.2 dB, his underlying point, taken up by staff in its Brief on Exceptions, is an important one: whatever figure is chosen is only an average, and it must be recognized that there will be some houses at which attenuation will be less.

Noise Averaging

Applicants on the one hand, and staff and DEC on the other, disputed the propriety of averaging noise levels over the year. Applicants contended that the annual L_{dn} of the line would be 53 dB(A), below the L_{dn} of 55 recommended^{2/} by the EPA Levels Document as the guideline for noise levels around "residential areas with outside spaces and for farm residences." On this basis, they claimed the lines were unobjectionable. Staff argued, however, that there will be days when the lines will produce noise exceeding the annual average and that it is those days that must be taken into account. The lines' foul weather daily L_{dn} is 59 dB(A).

^{1/}This figure had been rounded up to 15 dB before staff's 1.5 dB adjustment was applied; hence the 13.5 dB figure in the chart above.

^{2/}The recommendation is designed to protect the public from undue annoyance, sleep interference and speech interference "with an adequate margin of safety."

The weakness of annualization, of course, is that it discounts the significance of the objectionable noise on the days when it does occur by its absence on most days during the year. The weakness of the daily figure is the opposite: it fails to distinguish between an objectionable noise that occurs infrequently during the year and one that occurs 365 days a year.

RG&E points out that the daily figure, no less than the annual, is an average and that the actual noise level at any time will most likely be higher or lower. What must be decided, then, is the period over which the noise is to be averaged, and applicants contend that the period should be long enough to include the natural cycle of variation in the noise--here, a year, since the noise will depend on the weather, which varies with the seasons.

As RG&E demonstrates in its Reply Brief, staff's witness did not consider use of the annual L_{dn} to be "outlandish." But he did think that the question needed to be approached on a case-by-case basis, and that, in this case, the daily L_{dn} provided a better measure, for five nights of uninterrupted sleep cannot compensate for the two nights on which a person is awakened. What the daily figure leaves out, however, is any recognition that being awakened two nights out of seven is likely, at least intuitively, to be less annoying than being awakened seven nights out of seven.

We recognize that all of the measures are averages, helpful in predicting general annoyance levels and in designing generally applicable standards for ambient noise, but not particularly useful in resolving individual problems. To predict sleep interference, the level of noise produced by

the lines when they are noisy must be compared with the level of noise known to interfere with sleep; this comparison can then provide the basis for fashioning a remedy for those people whose sleep is likely to be interfered with. This is the position ultimately taken by staff, and we are satisfied that it makes sense in this case, particularly if it is combined with careful monitoring of noise complaints.

Sleep Interference

Whether or not a particular noise awakens a person will depend not only on the intensity of the noise but also on factors such as the stage of sleep the person is in when the noise occurs, the amount of sleep deprivation present when the person goes to sleep, the age of the person, and his familiarity with the noise. In addition, annoyance associated with sleep interference will depend, in large part, on the length of time a person remains awake. This, in turn, will depend on the nature of the person's emotional reaction to being awakened and to the noise awakening him.

Applicants are satisfied that the lines as proposed will not interfere with sleep. Their witness Pearsons reasoned that a foul weather L_{eq} of 53 dB(A)^{1/} at the edge of their proposed 250-foot right-of-way would be attenuated by 19 dB(A) through open windows and that noise within a bedroom at the edge of the right-of-way would be 34 dB(A).

^{1/}The figure was provided in the Phase I testimony of applicants' witness Chartier. It is a coincidence that it is equal to the annual L_{dn} ; the annual L_{eq} is 47 dB(A).

This is below the 35 dB(A) recommended for bedrooms by acoustical consultants, according to Mr. Pearsons, and he therefore concludes that the majority of people living at the edges of the right-of-way will not feel that their sleep is disturbed even with windows partially opened during foul weather. Applicants find Mr. Pearsons' position reinforced by the absence of any data showing sleep interference being caused by a steady noise source of less than 40 dB(A).

Staff begins with foul weather L_{50} of 54 dB(A) at the edge of the right-of-way,^{1/} applies to it its predicted attenuation of 16.5 dB, and concludes that the average interior noise at the edge of the right-of-way will be 37.5 dB(A), approximately 2.5 dB(A) above the preferred design level of 35 dB(A).^{2/} It considers the 35 dB(A) design standard proper in the light of architectural studies and guidelines recommending it and despite the absence of actual data showing significant sleep interference at levels below 40 dB(A). It therefore concludes that the probability of widespread sleep interference or other annoyance in houses with closed windows--and hence with attenuation greater than staff's predicted 16.5 dB(A)--is "essentially nil"; in houses with open windows, the probability of annoyance from sleep interference "is not extensive." At the same time, staff stresses that all of the figures used are averages and that there may be people whose sleep will be interfered with. It therefore recommends that the applicants be required to deal with noise problems as they arise by

^{1/}This is the average of the Phase I data provided by Mr. Chartier and by staff's witness Comber.

^{2/}Applicants would substitute Mr. Chartier's L_{50} of 53 dB(A) and attenuation of 18 dB(A) (the latter to undo staff's downward adjustment to attenuation) and thus claim to satisfy the 35 dB(A) guideline even according to staff's mode of analysis.

screening if feasible^{1/}; if those steps fail, they should be required to offer to purchase the residence.^{2/} The offer would be extended only to persons owning and living in those houses at the time the line is energized and would last 18 months from then.

DEC proceeds in a different manner from staff and applicants. Instead of using the recommended 35 dB(A) indoor bedroom level, its witness began with the 45 dB(A) outdoor noise level specified in the EPA Levels Document for residential areas. The foul weather L_{eq} measured near the reflecting side of a dwelling will exceed this level within 650 feet of the centerline, and DEC therefore predicts sleep interference to that distance or further.

In considering sleep interference, we must bear in mind that it will be a problem, if at all, only during foul weather when windows are, nonetheless, open. While the matter is one of personal preference, windows are often closed in snowy and much rainy weather, and the lines are less noisy in fog, when windows are more likely to be open. There is ample basis in this record for concluding that sleep interference will not be a problem when windows are closed.

^{1/}DEC considers screening to be, in most cases, either futile or impracticable.

^{2/}In its brief on exceptions, staff recommends that the purchase possibility be available without regard to the house's distance from the line. It previously proposed limiting that remedy to houses within 325 feet from the centerline. At that distance the noise expected is about 49 dB(A), and the 35 dB(A) criterion for sleep interference can be reached even with attenuation of only 14 dB(A), 2.5 dB(A) less than staff's assumed average. Staff's witness had earlier taken the position that sleep interference was a potential problem at distances of up to 750 feet from the centerline. This was based on an attenuation figure of only 10 dB(A), a number now urged only by DEC.

Annoyance

Speech interference and sleep interference can be annoying; annoyance may also result, according to some authorities, simply from the presence of noise exceeding the ambient sound level. Although all three witnesses addressed themselves to the question of annoyance, only Dr. Driscoll expressly contended that it would result solely from a sound level above the ambient.

Mr. Pearsons testified that the EPA Levels Document specifies a guideline L_{dn} of 55 dB(A) for noise levels around "residential areas with outside space and for farm residences." This level was recommended to protect the public from undue annoyance, sleep interference and speech interference "with an adequate margin of safety." Given that the annual L_{dn} of the transmission line at the edge of the right-of-way is 53 dB(A), the facility will be, according to Pearsons, within the EPA guidelines. Moreover, Mr. Pearsons believes the ambient foul weather noise (L_{eq} of 52 dB(A) for summer rain) may mask transmission line noise.

Mr. Pearsons' testimony must be qualified in some respects. The EPA Levels Document, despite the "margin of safety" referred to in its title, contemplates that at the levels it recommends 17% of the people will be highly annoyed.^{1/} Moreover, the Levels Document uses an annual rather than a daily L_{dn} ; according to staff witness Kryter, the daily L_{dn} will be a considerably more annoying 59 dB(A). Finally, Dr. Kryter believes that the ambient noise may not mask transmission line noise but, rather, must be added to it to determine the total impact of the noise.

^{1/}All references to percentages of the population reporting annoyance should be discounted by the 10% of the population that will report annoyance under any circumstances.

Dr. Driscoll takes as his main source a recommendation of the International Organization for Standardization, ISO/R 1996-1971(e) ("ISO/R 1996"). That document predicts a "medium" community response, with "widespread complaints" when the L_{eq} from an intruding source exceeds the background sound level by 10 dB(A); Dr. Driscoll interprets this to mean 30% of the people highly annoyed and 5% complaining. A difference of 15 dB(A) would result in a "strong" response with "excessive community action"; Dr. Driscoll interprets this as meaning 40% of the population highly annoyed and 10% complaining. A difference of 20 dB(A) would result in "very strong" response with "vigorous community action"; Dr. Driscoll takes this to mean 50% of the population highly annoyed and 15% complaining. Using an L_{95} ambient level of 26 dB(A) (based on data submitted for the RG&E-Niagara Mohawk line) Dr. Driscoll predicted a "medium" community response as far as 1100 feet from the centerline, a "strong" response as far as 800 feet and a "very strong" response as far as 400 feet.

Dr. Driscoll's predictions were vigorously challenged on cross-examination. He conceded that the American and British delegations to the International Organization for Standardization opposed approval of ISO/R 1996, but he contended that the American delegation had opposed approval of the document not because it disagreed with its conclusions but, rather, because the document considered comparative noise levels exclusively, and did not take absolute levels into account. More significantly, the 26 dB(A) ambient figure is based on measurements taken during fair weather. Transmission line audible noise, in contrast, will occur only during foul weather, when ambient levels will often be

higher. Finally, it appeared on cross-examination that Dr. Driscoll himself may have failed to consider the relatively low absolute levels of noise involved and may therefore have overstated the percentages of people who would be annoyed by the various sound intrusions. Staff joins applicants in recommending that the ISO method not be used, contending that it does not appear to be based on established acoustical principles and annoyance level data.

DEC, excepting to the Administrative Law Judges' refusal to use the ISO method, points out that it is similar to one recently adopted by the Department for predicting general community response to noise. That method is contained in Title 4600 of DEC's Policies and Procedures Manual, and DEC contends that because it is the State agency charged with the primary responsibility for noise control, its procedures, of which administrative notice may be taken, should guide the Commission here. RG&E opposes administrative notice of the Policies and Procedures Manual (which was not received in evidence), arguing that it is merely an internal DEC document setting forth procedures for interpreting acoustical measurements, not a regulation or standard. RG&E suggests that DEC's request for administrative notice of its internal policies amounts to an effort to circumvent the State Administrative Procedure Act and State Environmental Quality Review Act, statutes that would govern the promulgation by DEC of actual noise standards.

Whether or not we take administrative notice of DEC's procedure, we need not follow it, for it is not a binding regulation or standard. The method recognizes that noises may be more annoying in rural areas than elsewhere and that strange noises are more troublesome than familiar ones; it tries to take these factors into account in a rather complex "normalized L_{dn} ." Staff says

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the procedure is too uncertain in application to be reliable and RG&E contends, correctly, that use of the procedure requires data and judgments not included in this record. While the fact that DEC has adopted the normalized L_{dn} argues in its favor, that fact alone is not conclusive and the record as a whole does not warrant its use.

Theoretical predictions of annoyance and complaint behavior are also belied somewhat by AEP's and Hydro-Quebec's operating experience. None of the witnesses testified directly to actual surveys of annoyance from operating 765 kV lines. On cross-examination, however, it appeared that Dr. Driscoll had participated, together with representatives of other State agencies including the Department of Agriculture and Markets, in a survey of the experience of farmers in the vicinity of the existing 765 kV lines in Ohio. The record discloses that, of the 18 farmers surveyed, only 5 mentioned noise as a problem and Dr. Driscoll's "impression from the discussions with them was that they didn't consider the noise to be a problem." Moreover, Dr. Driscoll had requested the Ohio Power Company to provide him a list of audible noise complaints about the two 765 kV lines which Driscoll had visited in Ohio; the company's reply to that request showed no noise complaints along the segments of the line visited by the New York team. Other materials supplied by the Ohio Power Company revealed a total of 20 audible noise complaints between March, 1972 and December, 1974 in connection with a line approximately 225 miles long but having narrower, potentially noisier, conductors than those proposed here. Of those 20 complaints, only 2 were related solely to audible noise and the remainder were not repeated after the other matters complained about were corrected. In its Brief

on Exceptions, staff argues that the Administrative Law Judges overstated the measure of comfort to be derived from AEP's and Hydro-Quebec's complaint experience. It points out that Hydro-Quebec's procedures, for instance, did not provide assurance that all complaints were recorded in the company's books. Staff may well be right, but the experience at least provides a basis for discounting DEC's theory-based predictions of large-scale annoyance problems.

Discussion and Conclusions

Staff and DEC both except to the Administrative Law Judges' failure to recommend generally applicable audible noise standards. Staff urges that an L_{50} of 54 dB(A) during rain and snow be adopted as the general noise standard for all extra-high voltage lines and that line design and right-of-way widths take that standard into account.^{1/} This is the noise level at the edge of the 250 foot right-of-way proposed by applicants. Beyond that point, staff would resolve complaints on a case-by-case basis; staff's total protective zone, therefore, would be potentially unlimited. DEC recommends more rigorous standards,^{2/} proposing an L_{eq} of

^{1/}Changes in a line's design can reduce the noise it produces. Opinion No. 76-12 foreclosed that option in Case 26529, for we had concluded that the need for dispatch and the remoteness of the area to be traversed argued convincingly for relying on operating conditions or a wider right-of-way to ameliorate any noise problem. Opinion No. 76-12, at mimeo pp. 18-19.

^{2/}It contends that an L_{50} of 54 dB(A) can be translated into a normalized L_{dn} of 77 dB(A), a noise level at which significant adverse community response is to be expected.

50 dB(A) to define the edge of the right-of-way, and an L_{eq} of 45 dB(A) as the noise level warranting the purchase of an easement. These standards would require, in the case of a line of the same design as PASNY's, a right-of-way of 500 feet and an easement-purchase zone extending an additional 350 feet on each side; the total area protected, therefore, would be 1200 feet wide.

The audible noise standard we ultimately select should depend in part on whether DEC's views on annoyance are correct. Operating experience thus far suggests that DEC is wrong, but that operating experience is not fully reliable and may have understated the level of annoyance. Before adopting a generally applicable standard, therefore, we would like to have the benefit of experience gained by operating the PASNY line in conjunction with a program, to be supervised by our staff, for measuring and reporting noise problems. We can afford to await these results before we promulgate final standards because noise does not appear to be a problem associated with 345 kV lines, and because no 765 kV lines other than those before us in these cases are expected to be in operation within the next few years.

Standards for the PASNY line, of course, must be devised now, and standards for the RG&E-Niagara Mohawk line must be set in time for the hearings on that line to consider how best to meet them. Our resolution of the biological effects issue has resulted in a right-of-way 350 feet wide; at its edges the foul weather L_{50} will be 52 dB(A). This more than satisfies the standard recommended by staff and approaches that called for by DEC. We are satisfied that audible noise considerations do not require precluding all residences on a wider right-of-way than this.

While an L_{50} of 52 dB(A) is a reasonable standard for the edge of the right-of-way, that level of sound may produce sleep interference beyond the right-of-way in a limited number of cases. Using an attenuation figure of 15.5 dB(A) (2.5 dB(A) below the average for partly open windows if staff's 1.5 dB(A) downward adjustment is rejected) the sound level in a bedroom at the edge of the right-of-way would be approximately 36.5 dB(A) in foul weather with windows partly open. If windows were fully open, the sound level, using a corresponding attenuation figure, would be 40.5 dB(A). The record as a whole supports the conclusion that 35 dB(A) is a proper maximum sound level for bedrooms, and we must provide a mechanism for relief where sleep interference is encountered.

We shall adopt a procedure for the PASNY line similar to that proposed by staff in its Brief on Exceptions. Noise related problems, as well as their solutions, will depend on individual circumstances such as a topographical configuration that amplifies sound or an individual's preference for sleeping with open windows. These considerations, together with the small number of problems that are likely to arise, argue for tailoring relief to each case as it arises, and that is what staff's proposal does. As a condition of our certification here, therefore, we shall require PASNY, if it receives a noise complaint from a person living beyond the limits of the right-of-way, to report the complaint to us, and try to resolve it. If it fails to resolve the complaint, that, too, must be reported to us; and it must then purchase the house involved^{1/} or move it to another location, unless it can show to our satisfaction that the complaint is unfounded or wholly unreasonable. The option of having a house purchased or moved, however, will be available only with respect to complaints filed during the first 18 months after the line is put into full operation, and will

1/If PASNY does buy a house to satisfy a noise complaint and then seeks to sell the property, it must give notice to the potential buyer of the reason for its having acquired the house.

apply only to houses located within 600 feet of the centerline.^{1/}
The details of this procedure should be set forth by PASNY in its EM&CP, and will be subject to our approval. We retain the right, of course, to impose different conditions in Case 26559 if some other procedure seems proper there.

PACEMAKERS

The cardiac pacemaker is an electronic device designed to provide an electrical stimulus which maintains or reestablishes normal heart rhythm in persons afflicted with a so-called "heart block." There are four main types of pacemakers, not all of which are equally sensitive to external fields.

The fixed rate or asynchronous pacemaker, first used about 1958, stimulates the heart at a preset rate, usually 70 beats per minute, regardless of any resident natural heart activity. The asynchronous pacemaker contains no sensing circuits and hence is unaffected by external fields.

The P-wave synchronous pacemaker senses the electrical activity in the atrium of the heart and provides a pulse in synchronism with it but only when normal heart action is absent. Because of its sensing circuitry, the P-wave device is highly sensitive to external fields. The R-wave synchronous pacemaker is similar to the P-wave type but is used where conducting fibers in the heart ventricles are defective and there is no risk of competing with a natural pulse. The R-wave inhibited pacemaker is designed to remain dormant for about 0.240 seconds of the 0.857 seconds required for each heartbeat. The device is alert for the next 0.617 seconds and if no natural heartbeat is detected, it will provide a stimulus to the heart.

^{1/}We have already required that all houses within 175 feet of the centerline be purchased or moved to establish a 350 foot right-of-way. The possibility of purchase because of noise problems, therefore, will exist in a zone 175 to 600 feet from the centerline. We adopt, in effect, the 1200 foot zone suggested by DEC as the area in which noise problems may occur. At the edge of this zone, the foul weather L_{50} is 46 dB(A) and the indoor standard of 35 dB(A) can be achieved with attenuation of only 11 dB(A).

The two R-wave types, known as demand pacemakers, can be affected by radar pulses, television transmitters, automobile ignition systems, anti-theft systems and many other devices. The catheter of any pacemaker, introduced into the heart through a vein or by open-chest surgery, may be either bipolar or unipolar. The latter type appears to be more sensitive to external fields. In general, however, the two types of R-wave pacemakers are only moderately susceptible to outside influences. In contrast, the P-wave type may be affected significantly by high-frequency, modulated fields like those generated by radar stations (the fields produced by the 765 kV are not high-frequency). About 80% of those now being implanted are of the demand type.

In Opinion No. 76-12, we said:

We conclude that while educational programs directed at users and manufacturers of pacemakers may be found justified at the conclusion of the Common Hearing, before the proposed facilities are put into operation, these programs can provide reasonable protection and the potential hazard to pacemaker users represented by a 765 kV facility does not justify delay of the construction of the facilities proposed by PASNY.¹/₁

We acknowledged that under certain circumstances the fields produced by extra-high voltage transmission lines on some portions of the 250 foot right-of-way could interfere with the operation of cardiac pacemakers, but noted that such lines were only one of a number of comparable hazards, such as radio transmitters, microwave ovens, certain electric shavers, etc., to which pacemaker wearers are exposed. Also, most pacemakers are designed to shift their mode of operation in order to cope with interference from ambient electric fields.

¹/Opinion No. 76-12, at mimeo p. 16.

The Administrative Law Judges have now concluded that the proposed transmission lines pose no more than an insignificant threat to pacemakers, and that even this minimal risk would be further reduced by the same improved designs needed to lessen the effects of the strong fields of home appliances and radar installations. They deemed it reasonable to require applicants to assemble a complete, nationwide list of pacemaker manufacturers and to serve on them copies of this Opinion. They also recommended that a similar mailing be made to all associations of cardiologists in New York State under a cover letter to be prepared by staff. Any disputes regarding the text of this cover letter could be brought to us for resolution.

The Judges rejected DEC's proposal that warning signs be posted along the right-of-way. They cited problems in composing a text for such a warning, the number of signs needed, the very few pacemaker wearers involved, and the substantial cost of maintaining these warning signs. The Judges also rejected the need for the utilities to fund and conduct a study of the lines' effect on pacemakers. They reasoned that the Commission should not take a position on the relative efficiency of medical devices, such decisions being properly left to rest with the medical profession. The Administrative Law Judges, finally, declined to suggest that the applicants prepare a regular schedule of reporting complaints to the Commission. They stated that the evidence presented in the case indicates that there may never be a complaint or problem. Therefore, they concluded, reports should only be filed when there is a complaint or an incident.

On exceptions, PASNY requests only that we clarify whether the Opinion is to be served on all cardiologists in New York State or only on their associations; the Judges'

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recommendation was ambiguous in this regard and PASNY considers it unreasonable to require service on all cardiologists. Staff and DEC take no exception to the Judges' recommendation although DEC states, without further comment, that warning signs are advisable to protect pacemaker wearers.

UPSET asserts that the Judges' conclusion that no substantial hazard to wearers of pacemakers is expected from the proposed 765 kV transmission line is unsupported by the record. It argues that the Judges completely accepted staff witness Toler's description of the different types of pacemakers and his calculation of the number of pacemaker wearers (he estimated between 100,000 and 300,000) but completely disregarded his statements that interference effects during exposure to both electric and magnetic fields is unknown, that pacemaker induced ventricular fibrillation has caused death and that certain unipolar synchronous pacemakers would be susceptible to the line's electric fields. UPSET rejects the Judges' comparisons to field effects of common household appliances as a basis for their conclusion that "modern pacemakers will not be seriously affected under 765 kV transmission" (emphasis as added by UPSET). UPSET also asserts that this conclusion reveals an emphasis on modern pacemakers and a failure adequately to consider adverse impact on older pacemakers.

UPSET also reasserts the need for warning signs along the right-of-way. Acknowledging that pacemaker wearers are effectively protected while sitting in a vehicle passing through the right-of-way, it argues that signs are needed to protect pacemaker wearers walking, bicycling or riding in open vehicles near the right-of-way. It contends the cost of such a warning system would be minimized by requiring

signs only where the right-of-way crosses public roads,^{1/} and suggests the Judges overstated the difficulty of devising a text for the warnings.

Notwithstanding UPSET's assertions to the contrary, the record as a whole supports the Administrative Law Judges' conclusions.^{2/} It is not disputed that electric field effects, whether attributable to household appliances, radio broadcasting or 765 kV transmission lines, may have an effect, possibly adverse, on pacemaker wearers. The Judges, and all parties other than UPSET, concluded that because few pacemaker wearers will be on this basically rural right-of-way other than while riding in closed vehicles which effectively shield them from any effect, and of these few most, if not all, will have pacemakers designed to withstand extraneous fields, the overall risk of the lines to pacemaker wearers is minimal. UPSET's apparent position is that any risk is a substantial threat to public health and safety.

We are satisfied that our earlier assessment of the risks relating to pacemakers^{3/} remains correct. The risk to pacemaker wearers does not seem great enough to warrant the program UPSET urges. We shall require applicants to serve this Opinion, under cover of a letter composed by staff, on all pacemaker manufacturers in the country and associations of cardiologists in the State. The cover letter should describe the location of the line and include illustrations of its towers. In this way, pacemaker wearers will be alerted to the possible danger the lines pose to them, a danger not very different from those to which they are already exposed.

^{1/}St. Lawrence County has 60 such road crossings in the 70 miles of transmission line passing through it, according to UPSET.

^{2/}RG&E points out that the medical testimony on which UPSET relies in part was stricken from the record.

^{3/}Opinion No. 76-12, at mimeo pp. 15-16.

CONCLUSION

We find, on the basis of the record in the common record hearings and in Case 26529, that the operation of the facilities proposed by PASNY in Case 26529, the construction of which we have previously approved, is needed to serve the public interest, convenience and necessity, and will have, if conducted in accordance with the conditions described in this Opinion and specified in its ordering paragraphs, the minimum adverse environmental impact considering the state of available technology and the nature and economics of the various alternatives. We also find that the standards and conditions here adopted should also be applied to the transmission line proposed by Rochester Gas and Electric Corporation and Niagara Mohawk Power Corporation in Case 26559. We shall issue presently an order requiring Niagara Mohawk Power Corporation to show cause why these standards and conditions should not be applied to its Volney-Edic 765 kV transmission line, which we certificated in 1974^{1/} but which has not yet been built. It is also our intention to apply these standards and conditions, to the extent pertinent, to the operation at 345 kV of the transmission lines already certified in Cases 26462 and 26758^{2/} and Case 26717^{3/} and to all future proceedings pursuant to Article VII of the Public Service Law.

The Commission orders:

1. Subject to the conditions set forth in this Opinion and Order and in all previous applicable orders, the certificate of environmental compatibility and public need previously granted, in Case 26529, to the Power Authority of the State of New York is extended to authorize the operation of the transmission facilities to which it applies.

1/Case 26251, Niagara Mohawk Power Corp. (Oswego-DeWitt, Oswego-Volney, and Volney-Edic), 14 NY PSC 266 (1974).

2/Cases 26462 and 26758, Long Island Lighting Company (Holbrook-Ruland, Holbrook-Newbridge, and Holbrook-Pilgrim-Ruland-Bethpage), 16 NY PSC 627 (1976).

3/Case 26717, Long Island Lighting Company (Riverhead-Brookhaven), 16 NY PSC 737 (1976).

2. The operation of the 765 kV transmission lines, here authorized is conditioned upon the following:

- (a) PASNY is to acquire a right-of-way sufficient to exclude existing residences in an area extending 175 feet on each side of the centerline of the certified route.
- (b) PASNY must acquire permanent rights to bar future residential development within a zone extending 125 feet on each side of the centerline of the certified route; it must also acquire rights to preclude, for a period not less than seven years, future residential development within a zone extending an additional 50 feet on each side of the centerline. The Commission reserves the right to require those additional rights to be made permanent or to permit earlier development if warranted by the result of the program of studies described in Ordering Paragraph 5.
- (c) PASNY shall report to the Commission and attempt to resolve all complaints concerning audible noise produced by the lines. In the event such a complaint is made by the owner of a house located within a zone extending from the edge of the right-of-way to a point 600 feet from the centerline of the certified route and cannot be satisfactorily resolved by other means, the Commission may require PASNY to offer to purchase or move that house. This option shall exist for a period of 18 months from the date on which the 765 kV transmission line is made fully operational. The resale by PASNY of any such house shall be on notice to the buyer of the events that resulted in PASNY's having acquired it.
- (d) PASNY shall contribute an amount, to be determined by the Commission but not to exceed 2% of the total cost of constructing the facilities here certified, toward the funding of the program of studies described in Ordering Paragraph 5.
- (e) PASNY shall undertake a suitable program, consistent with this Opinion, for grounding and bonding fixed metal objects on the right-of-way and large movable metal objects likely to be brought on the right-of-way. It shall also undertake a suitable program for informing persons living near the right-of-way of the possibility of induced shocks from the lines and the best methods for avoiding them.

- (f) PASNY shall serve a copy of this Opinion and Order, together with a cover letter to be composed by the Commission's staff, upon every manufacturer of cardiac pacemakers in the United States and upon every association of cardiologists in New York State.
- (g) PASNY shall establish a procedure for receiving, responding to, and reporting to the Commission every complaint concerning the operation of the transmission lines here certified.

3. PASNY shall not energize the transmission lines here authorized until it has agreed to comply with the conditions here imposed and has submitted to the Commission two copies of, and the Commission has approved, a detailed supplemental environmental management and construction plan (EM&CP) setting forth in detail its proposals for complying with the terms of conditions (c), (e) and (g) in Ordering Paragraph 2, above. Contemporaneous with its submission of the supplemental EM&CP, PASNY shall serve the Department of Environmental Conservation and the St. Lawrence-Eastern Ontario Commission, as well as any party to this proceeding who had previously requested copies of the EM&CP filed pursuant to Opinion No. 76-2, with a copy of its supplemental EM&CP and shall notify every other person included on the service list in this proceeding that it has submitted its supplemental EM&CP, indicating the location of the places where the supplemental EM&CP is available for inspection, that any person desiring additional information may receive it by written request to PASNY indicating the information of concern, and that any person wishing to comment on the supplemental EM&CP should do so by filing comments with the Commission and serving them on the applicant within 20 days of the submission of the supplemental EM&CP. PASNY shall report any proposed changes in the supplemental EM&CP to the staff, which shall refer them to the Commission for approval.

4. The Commission reserves the right, at any time during the existence of the certified facilities, to impose such reasonable restrictions on the operation of the line--including but not limited to its operating voltage and loading--as may be necessary to protect the health or safety of the public and any other protective measures, as a condition to the line's continued operation, that the Commission determines, after hearing, necessary as a result of the further research it is requiring or which may otherwise be brought to its attention.

5. The staff of the Commission is directed to submit, within 60 days, a proposal for a program of studies into the biological effects of the electric and magnetic fields generated by extra-high voltage transmission lines.

6. The staff of the Commission is directed to serve a copy of this Opinion on the United States Occupational Safety and Health Administration.

7. The standards and conditions here adopted shall apply, to the extent pertinent, to the transmission facilities for which certification is sought in Case 26559.

8. Except as here modified, the recommended decision of Administrative Law Judges Thomas R. Matias and Harold L. Colbeth is adopted as the Opinion of the Commission.

9. Except as here granted, all exceptions to the recommended decision of the Administrative Law Judges, and all outstanding motions, are denied.

10. These proceedings are continued.

By the Commission,

(SEAL)

(SIGNED)

SAMUEL R. MADISON
Secretary

STATE OF NEW YORK
PUBLIC SERVICE COMMISSION

CASE 26529 - POWER AUTHORITY OF THE STATE OF NEW YORK -
Massena-Moses 230 kV Transmission Line,
Massena-Marcy 765 kV Transmission Line, and
Massena-Quebec 765 kV Transmission Line

HAROLD A. JERRY, JR., Commissioner, dissenting:

I dissent.

INDUCED SHOCK

In an earlier opinion in this case (76-12), I dissented from various aspects, including the feature of induced shock. Nothing has occurred since that decision to alter my belief that insofar as the question of induced shock is concerned, the clearances authorized by the majority are too low. As I stated in my earlier dissent, I believe the clearance should be 70 feet over all roads and 50 feet off the road. These clearances, incidentally, are the same as those proposed by Rochester Gas and Electric in Case 26559 but higher than those required by the majority in the PASNY case (26529).

BIOLOGICAL EFFECTS

Since the earlier opinion in this case (76-12), a good deal of evidence concerning biological effects has been

introduced. It is perfectly clear that Marino's studies revealed biological effects in mice. The record supports this finding of fact, after allowing for possible flaws in Marino's techniques and statistical methods. The majority admits that the record contains "unrefuted inferences of possible risks" that cannot responsibly be ignored. But the majority then adopts a right-of-way for the 765 kV line "wide enough so that the field strength at its edge is no greater than that produced by a 345 kV line at the edge of its right-of-way." This works out to a 350-foot right-of-way for the 765 kV line.

I believe that the majority has settled for this width because of irrelevant concern over the widths of existing 345 kV rights-of-way rather than because of concern for the proper widths of 765 kV lines in view of the evidence in this case. In other words, the majority has been swayed by the problem of what to do with existing 345 kV lines if it adopts a 765 right-of-way with weaker field strengths at its edges than those present at the edges of existing 345 kV rights-of-way. Although the standard 345 kV right-of-way is 150 feet, some are narrower. At the edge of a 150-foot right-of-way, a 345 kV line generates a calculated field

strength of 1.6 kV/m. This is approximately the field strength the 765 kV line would generate at the edge of a 300-foot right-of-way. The majority has decreed a 350-foot right-of-way for the 765 kV line to allow for variations between actual and calculated field strengths.

In his testimony, Dr. Marino recommended a 765 kV right-of-way of 600 to 900 feet, applying a safety factor of 100 to the field effects used in his experiments. (In his brief, Dr. Marino went much further and recommended an even wider right-of-way.) The St. Lawrence County Planning Board recommended a protective zone of 1,800 feet within which owners would be given an option to sell. The Department of Environmental Conservation, applying a safety factor of 10 to Dr. Marino's experimental fields, recommended a 350-foot right-of-way. The PSC staff, using a safety factor of 25, recommended a maximum field effect of .4 kV/m. ($1/25 \times 10 \text{ kV/m}$) This would require a 550-foot right-of-way, but staff did not go this far. Instead, staff recommended that any resident would have an option to have his house purchased or relocated if the field strength outside the house were greater than .4 kV/m.

My position is based on staff's recommendation. I would create a 350-foot right-of-way within which no residences

would be allowed. However, anyone living within 275 feet of the centerline would have the option of being bought out or relocated. Thus, in effect, I would create a 350-foot right-of-way inside a 550-foot protective zone.

I am not troubled by the fact that I am recommending safety factors in this case that exceed those in existing 345 kV rights-of-way. It is common practice in air quality and water quality regulation, as well as in many other types of health and safety regulation, to "grandfather" existing standards that may be hazardous while prescribing much stricter standards for the future. We are now experiencing air and water quality standards that are known to be dangerous while waiting for the arrival of prescribed stricter standards at some future designated year.

In this case, if the mandated research program finally convincingly indicates the existence of health and safety problems where field effects are as high as 1.6 kV/m, the Commission at that time can determine what steps are necessary to protect those living too close to existing 345 kV lines. There is a permissible difference between the weight of evidence necessary to require changes in existing rights-of-way and the weight of evidence necessary to promulgate suitable

rights-of-way for future construction.

AUDIBLE NOISE

I pointed out in my earlier dissent that audible noise could have been reduced by increasing the size of the cables or by increasing the number of cables in each bundle. The majority refused at that time to make such changes since the Power Authority had already ordered the cables.

I disagree with the final position the majority has taken on audible noise. The majority will require any person bothered by the noise to complain to PASNY. PASNY must report the complaint to the PSC and try to resolve it. If it fails to resolve the complaint, the PSC will order the purchase of the house or its movement, unless PASNY can show that the complaint is "unfounded or wholly unreasonable." This option will only apply to houses located within 600 feet of the centerline.

I would allow anyone living outside the 350-foot right-of-way but within 750 feet of the centerline to demand the purchase or relocation of the house. The 750-foot distance is sufficient to reduce noise inside bedrooms with fully open windows to unobjectionable standards even with attenuation of only 10 dB(A), the lowest figure advocated by any witness.

I do not believe that any homeowner will take advantage of this buy-out option unless he is truly disturbed by the noise. The homeowners did not request that the line be built, they will not benefit directly from it, and I think they should be given every possible redress against interference with their privacy and comfort.

STUDY PROGRAM

I also disagree with the limit that the majority has placed on PASNY's contribution to the cost of the study program directed by Ordering Paragraph 5. I do not think that the cost of the program to any of the participants should be limited until the Commission has had an opportunity to analyze the study proposal and to ascertain its adequacy.

STUDIES (OTHER THAN DR. MARINO'S)
ON WHICH STAFF PRINCIPALLY RELIED

Noval, et al.,^{1/} exposed rats to 45 Hz, 0.0005 to 0.1 kV/m electric fields and found depression in the rats' growth rates, elevated levels of corticosterone in the rats' blood, decreased levels of choline acetyltransferase in the rats' brains and increased levels of tryptophan pyrrolase in the rats' livers. The authors contend that the blood and liver alterations indicate that the rats experienced stress as the result of the electric fields; Marino and staff argue that these experiments confirm Marino's findings.

RG&E responds that the Noval study has not been published (at least as of the time Marino testified) and that the NAS committee felt that the experiment had been conducted in a poor environment--a converted railroad car--the results in which "would be very difficult to interpret." It also contends that a similar study by Matthewson,^{2/} assertedly more carefully designed and controlled, contradicted the results of the Noval study. Staff attempts to dispel any impression of inconsistency by pointing to the distinguishing features that might account for the differences in the studies' conclusions; among these is the very circumstance that Noval's animals were kept in a railroad car and thus shielded from ambient electric fields.

1/J. Noval, Biochemical Effects in Rats Exposed to Extremely Low Frequency (ELF) Non-Ionizing Radiations, Annual Meeting of the American Society of Neurochemistry, New Orleans, La., March, 1974; J. Noval, A. Sohlen, R. Reisberg, H. Conye, K. Straub, and H. McKinney, Effects of Maintenance in 45 Hz Fields on Body Weight, Brain Choline Acetyltransferase and Liver Tryptophan Pyrrolase in Rats, Temple University Medical School, Philadelphia, Pa.; New Jersey Neuropsychiatric Institute, Princeton, N. J.; and Naval Air Development Center, Johnsville, Pa.

2.N. S. Mathewson, G. M. Oosta, S. A. Oliva, S. G. Levin, and A. P. Blasco, Effects of 45 Hz Electric Field Exposures on Rats, in C. C. Johnson and M. L. Shore, eds., Biologic Effects of Electromagnetic Waves (1977).

Krueger^{1/} found that the egg laying capacity of hens was significantly altered by exposure to a 60 Hz electric field of 1.6 kV/m. Applicants criticize the study for, among other things, the possibility that its results might be attributable to micro-shocks and the small size of the sample used. There is a difference of opinion between the staff and applicants over whether another study discussed on the record contradicts the results reached by Krueger.

Altman and Warnke^{2/} found that 50 Hz electric fields of 10 kV/m and greater caused abnormal behavior in bees, including death and abandonment of hives. Applicants' witness Carstensen tried to replicate Warnke's experiment and was unable to see effects at field strengths below 30 kV/m; staff suggests that this work should be ignored because Carstensen is no expert on bees. Applicants respond that staff itself had said that the alterations in bee activity caused by the field were so striking that they required no further statistical support; the same, say the applicants, can be said of the need for particular expertise to perceive them.

Applicants also stress, and point out that staff witness Frey agreed, that extrapolation of these results to humans would be extremely difficult. But that assertion is important only if one adopts the posture of insisting on a theoretical understanding of a phenomenon before ascribing significance to it in making public policy. Staff does not claim that the effect of these fields on the bees suggests

1/W. F. Krueger, A. J. Giarola, J. W. Bradley, and A. Shrekenhamer, Effects of Electromagnetic Fields on Fecundity in the Chicken, 247 Ann. N. Y. Acad. Sci. 391 (1975).

2/U. Warnke, Bienen unter Hochspannung, 13 Umschau 416 (1975); G. Altman and U. Warnke, Metabolism of Bees in 50 Hz High Tension Fields, 80 Z. ang. Ent. 267 (1976).

that the lines will produce harmful effects in humans; it says simply that the effect of these fields on the bees suggests that something is going on that an agency having responsibility for protecting public health ought to be concerned about.

Goodman, et al.,^{1/} exposed slime mold to electric and magnetic fields of 45, 60 and 75 Hz at strengths of 0.0007 kV/m and 2.0 gauss. He found delays in the creature's mitotic cycle and retardation in its protoplasmic streaming. Applicants' witness Miller criticized the study on the grounds that its results might have been skewed by electrode poisoning; staff responds that Goodman conducted tests to dispute this inference and satisfied himself that it was not valid.

Applicants also deny, on more general grounds, the relevance of Goodman's experiment. They point out that his experimental animals lived in a liquid medium, more conductive than the air through which the lines' electromagnetic fields would pass. The current density produced in Goodman's slime mold at his stated field strength of 0.0007 kV/m, according to applicants, would be produced in an individual standing under the transmission lines only if the lines produced a field exceeding 1,000 kV/m, a field impossible to achieve because it would be great enough for the air surrounding the conductors to break down, resulting in flashover. On this basis, applicants challenge the relevance of all experiments conducted in liquid media.

^{1/}E. Goodman, B. Greenebaum, and M. Marron, Effects of Extremely Low Frequency Electromagnetic Fields on Physarum polycephalum Radiation Research, University of Wisconsin-Parkside, Kenosha, Wisconsin; M. Marron, E. Goodman, and B. Greenebaum, Mitotic Delay in the Slime Mold Physarum polycephalum Induced by Low Intensity 60 and 75 Hz Electromagnetic Fields, 254 Nature 66 (1975).

Staff's response is that Goodman applied a range of field strengths to the medium, resulting in a range of current densities; the lowest of these current densities was within a factor of 2 of the current densities that might be induced in humans by the fields produced by the lines. They also contend that animals in a liquid medium provide a useful simulation of human cells, which exist in a liquid medium.

Southern^{1/} and Larkin^{2/} determined that migrating birds responded to weak electromagnetic fields of 0.0002 kV/m and 0.5 gauss at 45-76 Hz. Applicants point out that Dr. Southern himself believed that the effect on the orientation of birds would likely not be harmful and that the birds could compensate for it just as they do for naturally occurring magnetic disturbances. Applicants also allege inconsistencies and other flaws in the study, and point to staff witness Frey's acknowledgment of possible infirmities in the study and his unwillingness to base his professional opinion upon its results.

Moos^{3/} observed increased activity in mice during exposure to 60 Hz electric fields of 1 kV/m. Applicants point out that Moos himself stated that his data were insufficient to support definite conclusions; staff suggests this is because the study was published in 1964, at which time there had been very little research conducted on the effects of ELF fields. Applicants criticized Moos' experimental

1/W. Southern, Orientation of Gull Chicks Exposed to Project Sanguine's Electromagnetic Field, 189 Science 143 (1975); W. Southern, Influence of Disturbances in the Earth's Magnetic Field on Ring-Billed Gull Orientation, 74 Condor 102 (1972).

2/R. P. Larkin and P. J. Sutherland, Migrating Birds Respond to Project Seafarer's Electromagnetic Field, 195 Science 777 (1977).

3/W. Moos, A Preliminary Report on the Effects of Electric Fields on Mice, 35 Aerospace Medicine 374 (1964).

protocol; staff contends their attempt to undermine the credibility of the experiment by citing the investigator's failure to describe his efforts, if any, to eliminate vibration as a factor that could have stimulated the mice must fail unless they provide data on the magnitude of vibration required to affect mouse behavior, the magnitude of the ambient vibration, and the supposed vibration from the power source. Applicants again point to staff witness Frey's refusal to base his professional opinion on Moos' results taken in isolation; but even Dr. Marino stopped short of considering any one of the papers he cited as providing direct evidence of an effect that will occur.

McCleave, et al.,^{1/} exposed salmon and eels to extremely weak 60 and 75 Hz fields of 0.00007 to 0.0000007 kV/m and found slowed heartbeat rates. Staff successfully refuted the applicants' original efforts to discredit the studies on the grounds that fish have specialized organs capable of perceiving electromagnetic fields; in their Brief, applicants simply suggest that these organs, which do exist in other fish but have not been shown to exist in salmon and eels, might provide an explanation of McCleave's results. They also point out that all McCleave claims to have shown is perception of the field and that perception, if it occurs, "hardly seems likely to produce harm in humans." Their significant criticisms of McCleave's work are their usual doubts about its conclusiveness and their assertion, that it would take an electric field in air substantially greater than that produced by the lines to induce a field in water of the magnitude of that studied by McCleave. This

1/J. McCleave, E. Albert and N. Richardson, Perception and Effects on Locomotor Activity in American Eels and Atlantic Salmon of Extremely Low Frequency Electric and Magnetic Fields University of Maine, Final Report, AD778021 (1974).

assertion, again, presumes applicants' theoretical framework for analysis and is based on the middle of the range of field strengths used by McCleave.^{1/} Calculations based on the low end of that range would produce a field in air closer to that expected under the lines.

^{1/}Exhibit H-6, Table 1, p. 6.

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The magnitude of the electric field produced by a transmission line is directly proportional to the line voltage. If a conductive object, insulated from ground, is placed in such an electric field, a charge and a resulting voltage will be induced. A grounded person touching the charged insulated object will act as a current path from it to the ground.^{1/}

1/To the extent he is insulated, a charge may also be induced on a person in the electric field of the line. This induced charge can flow as current, should the person touch a grounded conductor such as a metal fence post. Because of the low level of current that could result in this situation--barely above the threshold of perception for even the most sensitive people--the parties do not urge that this phenomenon is a hazard.

There are two types of current that can flow into a person touching such a charged insulated object. The first is a transient current or spark discharge, which generally precedes and follows the second, a 60 Hz steady state current. The spark discharge occurs at the instant of contact with or separation from the charged object. The physical phenomenon is similar to what happens when a person walks across a carpet on a dry day, and receives a spark discharge upon touching a door knob. Transient currents are of very short duration--an extremely small fraction of a second--and very difficult to measure. Moreover, the levels at which transient discharges are perceived, and the expected reaction from them, does not appear completely understood. Accordingly, the record evaluates the induced shock question in terms of the better understood and more easily measured steady state current which flows through a person's body if he is grounded and has achieved good electrical contact with a charged, insulated conductive object.^{1/} Moreover, the record indicates that when steady state currents are limited to acceptable levels, transient shock levels are likely to be similarly limited.

The induced steady state current, which flows as a result of the induced charge being afforded a path to the ground, varies with the electric field at the location of the insulated conductive object, the voltage of the transmission line, the surface area of the conductive object and its position within the electric field. The current is less the greater the transmission line conductor-to-ground clearance, and the less the degree of insulation of the conductive

^{1/}Transient currents or spark discharges from the proposed 765 kV line could conceivably--under "ideal" conditions--cause gasoline ignition if a well-insulated vehicle were being refueled from a grounded pouring spout underneath the line. That probability is extremely remote; one witness testified that it is difficult even to intentionally ignite gasoline using spark discharges at the level likely to be produced by the line. The only measure that has been recommended to guard against even this remote possibility is an educational program to warn people not to refuel vehicles under the line.

object and the effective grounding of the person who touches it. Because the induced short circuit current can be reduced to insignificance if the conductors are raised high enough above ground, the question we must answer is whether the minimum conductor-to-ground separation now proposed by PASNY is sufficient to reduce the hazard to an acceptable level.

Staff witness Paul E. Stanley, Associate Director of the Biomedical Engineering Center of Purdue University, testified that the threshold of perception when the flow of electric current is recognizable by a slight tingling or stinging sensation at the point of contact, will for more than 50% of the population be about 1 milliampere (mA), and for more than 99% of the population approximately 1.5 to 1.7 mA. Normally, for a current level only slightly in excess of the threshold, the reaction of the subject will be no more than mild surprise. When the current through the subject is of the order of 2 to 4 mA, there will occur what some experimenters have called a "startle reaction"--a quick, gross physical response characterized by a jerking back of the portion of the body, usually the hand, touching the charged object.

For steady state currents, direct physical harm to human subjects can occur only when the current exceeds the "let-go" threshold, i.e., the level at which muscle contraction induced by the current prevents the subject from releasing his grasp on the conducting object. The phenomenon can, after a few minutes and if the subject is not forcibly removed, lead to burns on skin surfaces that are in contact with the charged object, or to respiratory difficulty if the electrical path through the subject passes through the chest areas. This latter result is relatively unlikely because the expected electrical path would probably pass from hand to foot, when a person standing on and in electrical contact with the ground touches a charged object. An electrical

path through the chest would be likely only if a subject's hands were simultaneously to touch a grounded and an ungrounded conductor on a portion of the right-of-way at a time when the field strengths are high.

In most circumstances the subject's initial reaction to the transient current produced by the charged object would be to withdraw his hand rather than grasp the object, so that the let-go situation would, in fact, be avoided. In any event, as long as other adults are present, the subject could be removed from the charged object relatively easily and any serious harm would be avoided. The average let-go current for men is about 16 mA. Staff witness Stanley testified that the safe let-go currents for men and women are about 9 mA and 6 mA, respectively, and for children he estimated it at 4.5 mA.^{1/}

Witness Chartier, of the Laboratories Branch of the Bonneville Power Administration, testified that inasmuch as the phenomenon of induced voltages and currents in the vicinity of electric transmission lines has been understood for years, commonly employed grounding practices and techniques have long been recognized as simple and highly effective methods for keeping them from having harmful effects. Witness Driscoll testified that a grounding and bonding program could be adequate to limit induced currents from stationary conducting objects such as buildings, roofs, fences, etc., to below even the threshold of perception for about half of the population. Grounding and bonding can be employed to limit induced currents with no change in the operating voltage or design of the proposed facility.

^{1/}A Russian scientific paper refers to 4.0 mA as the level at which 99.9% of small children would be able voluntarily to release their grasp of an object. The paper provided no details concerning the basis for the 4.0 mA figure. Moreover, it shows that Russian transmission line design criteria permit induced short circuit currents for similar vehicles greater than could be achieved from the applicant's proposed transmission facility.

Dr. Stanley testified that this technique of grounding can be applied with equal effectiveness to limit currents induced in any vehicle or machinery normally expected to be parked on the right-of-way under the proposed transmission facility. Staff observes, however, that it is not possible to assure that all vehicles which may traverse the right-of-way are equipped with proper grounding straps or chains, and therefore takes the position that the largest vehicles that might reasonably be expected to park beneath the transmission line must be postulated and the induced short circuit shock currents people might receive from touching them must be determined.

In order to determine the maximum steady state current that a person could possibly receive from insulated conducting objects in the vicinity of the proposed transmission facilities, PASNY and our staff sponsored various outdoor experiments. Dr. Deno, of General Electric's Project UHV, tested various vehicles and farm machinery of different sizes which might be found parked beneath the conductors on the transmission facility right-of-way. He measured actual steady state and transient currents from such vehicles and farm machinery under a 345 kV line and at the General Electric Project UHV testing facility near Pittsfield, Massachusetts. Those data were then scaled to yield the current levels for the proposed 765 kV lines, as a function of assumed conductor heights and lateral distance between the various vehicles and the centerline of the transmission facility. The first set of test conditions he used for his measurements and calculations was designed to demonstrate the maximum shock currents attainable under contrived, ideal conditions. Under these conditions the vehicles were parked parallel to the conductors, in the location of the lowest conductor-to-ground clearance, where the resultant electric field had its

maximum value, with the vehicles well insulated. Mr. Chartier testified that "tires on vehicles contain carbon, which is very effective in draining off electrostatic charges;" for Dr. Deno's tests in a recently harvested alfalfa field, therefore, rubber mats (without carbon additives) were used to achieve a higher degree of insulation from the ground. To achieve effective electrical grounding of the shock recipient in measuring short circuit currents, Dr. Deno used driven copper ground rods.

Dr. Deno also reported the expected value of the current which would flow through a person who might actually come into contact with a vehicle parked parallel to the conductors in the area of the right-of-way containing the maximum electric field for various conductor-to-ground clearances. These more typical conditions, which he designated a more "probable" case--but actually represents his estimate of the worst possible case under noncontrived conditions--were identical to the contrived, "worst" case conditions except that the copper grounding rods and artificial vehicle insulation were not included. Current-limiting ground straps were not affixed to the vehicles in either case.

The proposed facility is designed to operate at a maximum voltage level of 800 kV. The proportionalities between induced short circuit current and the line voltage and electric field, as well as evidence on the relationship between conductor height and field strength, can be used in a straightforward manner to extend the various tables introduced by Dr. Deno. The predicted steady state induced short circuit currents in the contrived, "worst" case, at maximum voltage and loading, with high ambient temperature, are as follows:

Contrived "Worst" Case for 800 kV Operating
Voltage and 48 Foot Conductor-to-Ground Clearance

<u>Test Vehicle (Artificially Insulated)</u>	<u>Maximum Short-Circuit Current Through Artificially Grounded Subject^{1/} (mA)</u>
Tractor-Trailer	6.5
Tractor-Milk Tanker	4.1
School Bus	4.2
Crop Wagon-Farm Tractor	3.1
Pitman Skyworker	4.0
Ford F100 Pickup Truck	1.0
Chrysler 300 Sedan	1.0
Oldsmobile F85 Sedan	1.0
John Deere Combine	3.9
Chevrolet Station Wagon	0.8
Dodge Dart Sedan	.7

DEC calls our attention to the fact that no reliable expert testimony has been provided in the Common Hearing record concerning the probability of finding any of the vehicles listed, or any similar vehicles, actually under the transmission lines in a situation meeting all of the criteria of either the "worst" or the "probable" cases. Potential induced short circuit currents in the "probable" case can be expected to be only a very small fraction of the contrived "worst" case values.^{2/} For example, a Pitman Skyworker, on dirt, and a John Deere combine, on alfalfa, had induced short circuit currents of .036 mA and .026 mA, respectively in the "probable" case with the line energized to 800 kV and the conductor 48 feet from the ground. Moreover, the table itself shows that, within the limits of experimental error

^{1/}The above values for 48 feet reflect the best record measure of the relationship between induced short circuit current and conductor height. Chartier's Exhibit X. In its motion, staff relied on a less precise measure of that relationship, Chartier's Exhibit S, and derived values for induced short circuit current that appear to be slightly understated.

^{2/}Dr. Deno did testify, however, that on one occasion subjects at Project UHV did succeed in achieving currents in excess of 90% of the contrived "worst" case.

and rounding-off accuracy, even for the contrived "worst" case it is impossible to exceed the safe let-go currents for men. In fact, only a very large vehicle, like a tractor-trailer, can provide a current substantially in excess of the 4.0 mA figure alluded to in the Russian literature as safe for children. Moreover, this result requires an extraordinary combination of circumstances: a large, mobile piece of equipment such as a tractor-trailer or school bus must be parked (1) in the right-of-way; (2) in the vicinity of a portion of the line having a 48-foot design clearance--which means in a field, off the road, highly unlikely for a tractor-trailer or school bus--at a time of (3) high ambient temperature and (4) near maximum loading and voltage with (5) the vehicle well insulated from the ground; the prospective toucher must be (6) outside the vehicle and (7) grounded when making contact with the vehicle--a situation generally precluded by field conditions since the vehicle and the person touching it would normally be resting on similar surfaces on the ground and thereby be relatively equally grounded or insulated.

Although the maximum steady state current shock levels predicted for the proposed transmission facility are not likely to cause harm in themselves, staff calls attention to the possibility that an indirect or secondary injury might occur as a consequence of the "startle reaction"--at the 2 to 4 mA steady state level--such as from jerking a hand back and catching it in moving machine parts. In most cases the expected steady state current would be below 1 mA so that no "startle reaction" would occur. A startle reaction generally requires the presence of the seven previously enumerated conditions; in order for that reaction to be harmful, five additional conditions, also unlikely to occur

in combination, must prevail: (a) the object on which the charge is induced must itself be, or be located near, a piece of mechanized equipment; (b) the piece of mechanized equipment must have unguarded moving parts in which unsecured hair, a hand or loose clothing might be caught as a result of the startle; (c) the moving parts must actually be in motion when the shock is received; (d) the hand receiving the shock, or associated loose hair or clothing must be in sufficiently close proximity to the unguarded operating machinery to be thrown into (and caught by) it; and (e) the victim must not receive a shock from any part of the vehicle until his hand or loose clothing is in just the right position for his recoil to cause the hand or clothing to become ensnared in the moving mechanism other than to move away from it.

The low probability of such a combination of circumstances is further attested to by the fact that no witness was able to identify any report of an indirect injury attributable to induced electric shock currents from the extensive American, Canadian and Russian experience with transmission facilities operating at voltages in excess of 700 kV. That probability can be even further reduced by requiring PASNY, as a condition for certification, to undertake a public education and warning program. Accordingly, we find that this particular risk does not impose an undue burden on the people of the State of New York.

The clearance for the PASNY line will protect, even in the contrived "worst" case situation, against current levels exceeding the very conservative let-go level of 4.5 mA for any vehicles likely to be found where the clearances are at the minimum. This degree of protection also assures that steady state currents received under the more "probable"

worst case conditions do not exceed the 1.0 mA level recommended as a design objective by witness Stanley. Mr. Stanley recommended this level to protect against indirect injuries caused by involuntary reaction to shock, as we have discussed. The witness did not make a choice, however, as to whether the 1.0 level should be applied to the contrived "worst" case situation or the more "probable" worst case condition tested by witness Deno, believing that to be a policy judgment for this Commission. We agree with our staff that for this purpose the more "probable" worst case conditions should be used. While persons can experience steady state shock which will approach "worst" case values, the record shows that such instances should be exceedingly rare. The record also shows that even the more "probable" conditions assume the unlikely concurrence of many factors, and that for indirect injury to occur additional conditions must coincide.^{1/} Thus, the risk of indirect or secondary injury is less than the likelihood of exceeding the 1.0 mA level. Moreover, as DEC's witness Driscoll concluded, designing a 765 kV line to meet the 1.0 mA contrived "worst" case condition steady state current level would make such a line impractical; indeed, such a standard could not be met even with a minimum design clearance of 70 feet. For all these reasons, we conclude that the design levels authorized here with respect to induced shock will protect the public as much as is reasonably possible while providing for the transmission of electric power.

That PASNY's proposed design for minimum conductor-to-ground clearances is conservative is further shown by the testimony of witnesses Louis Cohen and Howard C. Barnes concerning the operating experience of various utilities. In the United States, the ground clearance for 765 kV is generally a minimum of 40 feet and in the Soviet Union

^{1/}See pp. 27-28, supra.

clearances as low as 33 feet are used for 750 kV. The Soviet literature discusses conductor heights of 48 feet for 1150 kV lines over difficult terrain, the same as proposed by PASNY for its 765 kV line. Hydro-Quebec has over 2500 miles of 735 kV lines in service and will soon be implementing its third generation of 735 kV transmission line design. In the first generation, the minimum conductor height was set at 55 feet over highways and 45 feet elsewhere. In the second generation, the minimum height above ground was maintained at 45 feet over cultivable land, but reduced to 40 feet over noncultivable land such as heavily wooded areas; the minimum height above ground over highways was reduced to 49 feet 6 inches. It is planned to retain these clearances in the third generation design to provide for induced currents in situations comparable to our contrived "worst" case, having a maximum value of approximately 5 mA for farm vehicles and 7 mA for very large highway vehicles. The self-imposed Hydro-Quebec limits are more stringent than the criteria set by the Canadian Standards Association of 6 mA for agricultural vehicles and 8 mA for very large vehicles passing beneath transmission lines on highways, but still pose a greater shock hazard than would the PASNY line, even when that line operates at maximum voltage, under maximum load, and at high ambient temperatures.

Although PASNY's proposal is designed to provide a minimum conductor-to-ground clearance of 48 feet, witness Howard C. Barnes testified that except in rare instances the conductor would be more than 48 feet above ground. In order to sag to the 48-foot clearance level, the line would have to transmit 4,000 megawatts (MW) of power at an ambient temperature of 104° F, with a prevailing two foot per second wind speed. The witness asserted that "the probability of getting that combination, I would think, would be almost nil." While the line is designed to handle a maximum of

800 kV operation, with a maximum loading of 4,000 MW, it is highly unlikely that such conditions would occur simultaneously. Transmission line voltages tend to decrease as loadings increase. Conversely, high voltage situations are most likely to occur when the line is least loaded. More important, the maximum loading that could occur on the transmission line over the next five to ten years is far below its rated capacity. The line loading on the 765 kV line would be limited to no more than 1,900 MW so long as the only sources of generation are from Beauharnois in Quebec and the St. Lawrence Power Project. Even under those conditions, the loading on the 765 kV line would be somewhat less than 1,500 MW because of the sharing of loading with the underlying, existing transmission system. The earliest date for which one might postulate additional load as a result of a new connection to the Ontario 500 kV system would be in the mid-1980's. Even after this connection is made, it is unlikely that the loading on the 765 kV line would be much more than 2,000 to 2,500 MW, much less 3,000 or 4,000 MW. It would not be until such time as a new generating facility is located in that area that high loadings in the vicinity of 3,000 MW or more during contingency situations might arise. According to New York Power Pool plans, that date would not be before 1990. If the operating experience during that period of ten or more years were to indicate potential problems at high voltages and high transmission line loadings, steps could be taken to guarantee that the voltages on the line were limited to 700 or 765 kV. It is not likely that any additional equipment would be required in order to limit line voltages to 765 kV and there are a number of means that can be utilized to hold them down to what is determined to be an acceptable level on the basis of operating experience accumulated by that time.

For the foregoing reasons, we find that the 48-foot minimum conductor-to-ground clearance, over areas other than roads and highways, is adequate to reduce the hazard of induced short circuit currents to an acceptable level, in consideration of our reserving the right to impose operating restrictions when and if they appear to be necessary. In addition, we note that it may be possible to achieve a minimum ground-to-conductor clearance of 49 feet by increasing conductor tension while still remaining within the stress margins dictated by sound engineering practice. In order to follow the most conservative approach, PASNY will be directed to consider this design change in its Environmental Management and Construction Plan. Staff has defined a "public road," over which PASNY proposes to maintain a minimum clearance of 63 feet, as one "maintained by a political entity for public use." PASNY has not complained of such a definition and DEC supports it. Inasmuch as it seems reasonable to assume that large vehicles of the tractor-trailer class are more likely to be found on such "public roads" than elsewhere on the right-of-way, we will adopt staff's definition of a public road, and will extend it to include even unpaved roads maintained by DEC if those "trails" can accommodate large vehicles. Since the testimony indicates that under normal operation the ground-to-conductor clearance will be up to 8 feet higher than the minimum set by the design criteria, it appears that it will be impossible in such situation to achieve as much as a 4.0 mA induced shock current from large tractor-trailers traversing such public roads. Over privately owned roads we will adopt PASNY's design criterion to limit the minimum conductor-to-ground clearance to 52 feet, so that the maximum possible induced shock current will be less than 4.0 mA for all vehicles except those of the tractor-trailer class. Should the Common Hearings ultimately disclose a need further to protect against induced shock hazard, we will impose operating conditions to the extent necessary.

Commissioner Jerry's Dissent

From a substantive point of view, the most distressing aspect of this decision is the problem of shock. The line authorized here is too low. It seems certain that if the Power Authority arbitrarily and without authorization had not ordered and obtained the steel for the towers, the Commission would have required the line to be erected at greater heights than the heights authorized here.

The 765 kV line will induce an electric charge in insulated conducting objects near the line. Anyone who touches such an object and who is standing on the ground will receive a shock effect of two kinds--a "steady state" or short-circuit current and a "transient current" or spark discharge. Stationary objects, such as metal buildings, roofs and fences, can be grounded to eliminate hazard. The troublesome objects are vehicles of all kinds that ordinarily are not grounded and indeed are insulated in some degree by rubber tires. Although the conductivity of some tires is improved by the addition of carbon black, this matter is not quantified by any data in the record. Fifty per cent of all people can feel a steady state or short-circuit current of about 1.0 milliamperes. Direct physical harm from a short-circuit occurs only above the "let-go" level--the point at which people are unable to release the conducting object because of involuntary muscle contraction.

The harm that might be suffered above the "let-go" level includes respiratory arrest and suffocation. Our staff has stated that the minimum "let-go" level for men is about 9 mA, for women about 6 mA, and for children about 4.5 mA.

The Russians have had extensive experience with extra high voltage lines. The record refers to a Russian study that indicates that the so-called steady state or short-circuit current in the lines should be held at 4.0 mA to protect all but one-tenth of one per cent of small children whenever they are likely to be present. Thus it would seem reasonable to require that the maximum milliamperes be held to 4.0, at least at all places where a child might touch an insulated charged object.^{1/}

The staff sponsored tests with various kinds of large vehicles to measure possible shock effects. In one test--termed the "worst case"--ideal conditions were created for

^{1/}The majority makes much of the fact that the Russians themselves have built lines lower than the Russian study recommends. This only proves that the Russians are as reckless as we.

transmission of a shock. In a second test--termed the "probable case"--conditions were created resembling those that are more likely to occur than the ideal conditions used in the "worst case" test.^{1/}

The Power Authority has committed itself to the following clearances:

over improved or public roads	-	63 feet
over private roads	-	52 feet
over all other areas	-	48 feet

These clearances are too low. The Power Authority's line is designed to operate up to 800 kV and this figure certainly should be used in any calculations affecting human safety. According to staff's own calculations (not contained in the record but based on data in the record), steady state or short-circuit currents in the worst case possible are as follows when the line is operating at 800 kV and 48-foot clearance:

^{1/}"Worst case" data are not totally unrealistic. Dr. Deno testified at Page 445 that in one instance people standing on wet earth received currents in excess of 90 per cent of the "worst case" currents from a school bus parked on asphalt.

<u>Vehicle</u>	<u>48-foot Clearance Worst Case - 800 kV</u>
tractor-trailer	6.5 mA
tractor-milk tanker	4.1 mA
school bus	4.2 mA
Pitman "Skyworker"	4.0 mA
John Deere combine	3.9 mA

Tractor-trailers, tractor-milk tankers, school buses and the "Skyworkers" all equal or exceed the recommended Russian minimum in these circumstances. It may be argued that this type of vehicle is not likely to be found where the line is only 48 feet above the ground (areas other than roads). It should still be noted that in places where a tractor-trailer might be found (on a private road), its shock current is still more than the 4.5 mA recommended by our staff for children and, of course, more than the recommended 4.0 Russian minimum.

To meet the Russian recommended minimum for children would require clearances of about 70 feet and this is the clearance I recommend for all road crossings of any type if the line is activated to 765 kV. If the voltage is allowed

to fluctuate to 800 kV, 70 feet would still be high enough to meet the Russian recommendation, as the chart below indicates.

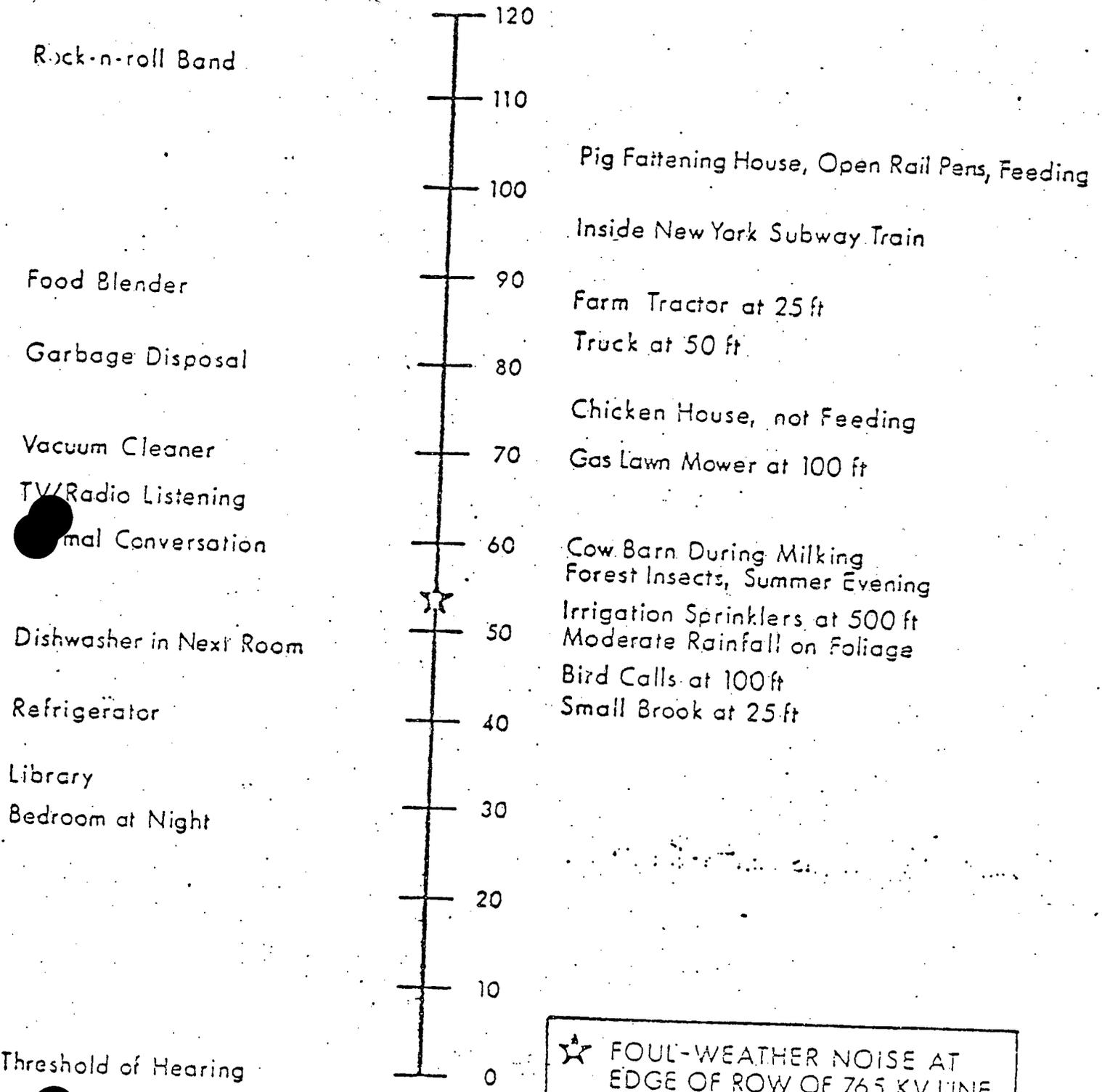
I also believe that the off-road clearance of 48 feet is too low in view of the short-circuit currents that will be created when the line is operating at 800 kV as set forth in the above chart. If the line is to be allowed to operate at 800 kV, off-road clearances should be increased to at least 50 feet. At this height all vehicles except tractor-trailers will meet the Russian minimum, as the chart below shows.

<u>Vehicle</u>	<u>50-foot Clearance Worst Case - 800 kV</u>	<u>70-foot clearance Worst Case - 800 kV</u>
tractor-trailer	6.1	3.6
tractor-milk tanker	3.9	2.3
school bus	4.0	2.3
Pitman "Skyworker"	3.8	2.2
John Deere combine	3.7	2.2

COMMON INDOOR SOUNDS

(dBA)

COMMON OUTDOOR SOUNDS



☆ FOUL-WEATHER NOISE AT
EDGE OF ROW OF 765 KV LINE

Comparison of Transmission Line Noise
with Other Familiar Sounds
(A-Weighted Sound Levels)