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The NIEMR/EMF controversy: the social construction of scientific knowledge and science policy in the ‘Gibbs’ powerline inquiry 1990/91

David W. Mercer
University of Wollongong


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Introduction

Before 1900 the electrical environment of the Earth was far simpler than today, consisting primarily of the Earth's magnetic field ... This environment has existed since life began, so living things have had about three billion years to adapt to it and develop uses for it. Since 1900, we have markedly changed this environment with the introduction of fields and frequencies that never before existed on Earth. This use of EM energy for power and communications has markedly accelerated since the end of World War II and we have now just about filled up the available space in the EM spectrum. This change in our natural environment is actually the most drastic alteration made by mankind and is far greater than any chemical contamination yet produced. This was done in the complete confidence, based upon the 'Thermal Effects Only' dogma, that no biological effects or actual harm to living things could occur. We now know that this was wrong. All living things are closely tied to the frequencies of our natural EM environment and the presence of abnormal, man-made fields produces serious alterations in basic life functions.


Against the backdrop of statements like that above, concern with the potential health effects of non-ionizing electromagnetic radiation (NIEMR) has recently taken its place alongside more well established environmental health issues such as toxic chemicals and ionizing radiation. A measurement of the growth of concerns with NIEMR has been the increase over the last decade of challenges to the siting of NIEMR emitting devices (in particular, in relation to the electromagnetic fields (EMFs) from high voltage powerlines and various telecommunications installations), and a number of government and industry sponsored inquiries and scientific reviews. Fitting into this pattern has been the recent New South Wales State Government Public Inquiry into Community Needs and High Voltage Transmission Line Development, chaired by ex-Chief Justice of the High Court of Australia, Sir Harry Gibbs. This Inquiry was held during the second part of 1990 extending into the early part of 1991. The bulk of its attention was devoted to the scientific controversy involving the potential health risks of powerlines and NIEMR/EMFs. The Gibbs' Inquiry can be seen as a historical setting providing valuable opportunities for the in-depth analysis of
the dynamics of an important contemporary scientific controversy and public policy issue. It also provides opportunities for reflection on theories of scientific controversy and the nature of the construction of science in public and regulatory settings. This study will build on these analytical possibilities in the following ways.

Part 1 of the thesis, 'Mapping the Terrain', will provide a historical background to the EMF Powerline debate. This history will aim to present a detailed and more comprehensive overview of the major themes and important players in this debate than the existing alternative accounts which, with few exceptions, tend to be popularist, fragmented or obviously partisan. It will be shown how the present EMF powerline debate is not a recent, or isolated, phenomenon but, rather, has linkages back into broader concerns with environmental planning and technological decision making, the longer standing microwave debate, a tradition of difficulties in establishing a credible NIEMR/EMF regulatory culture, and the emergence of widely disparate scientific perspectives relating to understanding the biological effects of NIEMR/EMF. This historical overview will be taken up to 1991 with a focus on the Australian context behind the establishment of the New South Wales Government's 'Gibbs' Powerline Inquiry' -- the subject of the case study of Part III of the thesis.

Whilst standing on its own as an overview of the NIEMR debate, the discussion in Part I 'Mapping the Terrain' will also provide the necessary context for the more detailed explorations of the Gibbs' Inquiry which follow in Part III of the thesis. This is primarily for two reasons. First, many of the issues and themes described in 'Mapping the Terrain' make up the raw materials that participants came to use during the Inquiry. Familiarity with these themes will greatly enhance the reader's understanding of the intricacies of the negotiations of EMF science and policy taking place in the Inquiry, which will be discussed later. Second, in 'Mapping the Terrain', it will be noted that the Gibbs' Inquiry was not a unique event, but rather an attempted quasi-legal administrative solution, punctuating the on-
going NIEMR debate which took place in the shadow of a number of similar, and controversial, proceedings such as the Victorian Powerline Review Panel, the Graves Report, and the Warren (OPIC) vs. ELCOM case. This continuity provides an important part of the context which helps explain two themes to be developed later in the thesis: (i) the way participants negotiated scientific claims, drawing on past proceedings and, in certain respects, treating the Gibbs' Inquiry as part of a larger on-going debate; and (ii) Gibbs' attempt to establish the legitimacy of the Inquiry by distancing it from its immediate context and the way this shaped the negotiation of the EMF issues, especially in relation to defining appropriate public policy.

Whereas Part I of the thesis will map the historical terrain of the NIEMR debate, Part II will 'map the terrain' of the academic discourse on the subject of scientific/technical controversy. The discussion will be divided into two chapters.

In Chapter 5, a model for mapping the dominant approaches to scientific controversy will be developed. This model will be constructed with several definitional axes in order to avoid falling into the trap of giving undue emphasis to the complimentary axes of epistemological and political orientation. In a number of contemporary studies of scientific/technical controversy one can observe a tendency toward an over-simplified account of the relevant literature, with a dichotomy being set up between so-called positivist controversy studies versus non-positivist or relativist controversy studies. Whilst this dichotomy does capture one set of distinctions amongst controversy studies, if deployed uncritically it can also disguise others. This dichotomy is particularly misleading when it is aligned to supposed political policy orientations. Sometimes it is argued that non-positivist/relativist accounts tend to back up less authoritarian and 'conservative' political viewpoints and intrinsically benefit political positions championing greater public participation in science. We shall see that these dichotomies simply do not capture, on the one hand, the complex possible political
viewpoints and differences in analytical approaches flowing from similar epistemological standpoints or, on the other hand, the ability for variable epistemological positions to be used in similar styles of analysis and arguments for similar political positions. Using this model, six main approaches to scientific/technical controversy will be identified and explained and it will be shown in a preliminary sense how these various approaches guide analysis of our case study.

In Chapter 6 these various approaches to controversy will be critically evaluated and a 'selective/eclectic model', or guide, for the analysis of scientific/technical controversies will be proposed. This model will accept the major tenets of sociology of scientific knowledge approaches to scientific/technical controversy but will emphasise the need to include explicitly a concern with the social construction of the content of scientific knowledge in settings such as the mass media, public inquiries, legal proceedings, etc. Interest in the construction of the content of science in these sorts of settings has normally rated behind 'harder settings' such as the laboratory or scientific research paper -- a situation that, it will be argued, is not justified. The model will also highlight the importance of acknowledging the symbolic dimensions of the use of scientific/technical authority in attempting to legitimise knowledge claims and the need to keep in sight the specific historical contingencies involved in any specific controversy.

In Part III of the thesis, the insights gained from analysis in the first two parts will provide an appropriate launching pad from which to investigate, in depth, the Gibbs' Inquiry as a specific site of the EMF scientific controversy. It will document the processes involved in the construction and negotiation of scientific and science policy claims within the Gibbs' Inquiry as a specific historical setting and also explain the context behind these processes and the ultimate outcome of the Inquiry.
In Chapter 7, it will be explained how the Inquiry was comprised of two related, but distinct, sub-debates. The first involved, primarily, the construction and deconstruction of EMF scientific knowledge claims. The second sub-debate primarily involved the construction and deconstruction of EMF policy claims.

The first sub-debate: 'Constructing/deconstructing EMF science' will be explored in Chapter 8. Drawing primarily from the sociology of scientific knowledge part of the eclectic model special attention will be directed to exploring the detailed scientific arguments of the Inquiry's two main adversaries, ELCOM and OPIC. This discussion will be organised around the proposition that each of the adversaries' claims displayed a shared structure of argument. Working with the analogy of the form of musical symphonies these arguments will be seen as being constituted by four movements, patterns or phases. In the process of analysing these patterns of argument, special attention will be paid to the types of rhetoric used, such as flexible images of scientific method etc. The types of rhetoric used will also be tied back to the specific social interests of the parties in question.

In Chapters 9 and 10, making up Section 2 of Part III of the thesis, the second sub-debate -- Constructing/Deconstructing Science Policy -- will be explored. Greater attention will be paid to the other elements of the eclectic model. This will involve detailing the ways the immediate historical context of the Inquiry shaped the way participants constructed/deconstructed claims in relation to their preferred EMF policy. The implicit legal and political frameworks, and philosophy of science deployed by Sir Harry Gibbs during the Inquiry will be outlined and special attention will be paid to the way EMF policy negotiations centred on interpreting the concept of prudent avoidance. The recommendations of the Inquiry, and their immediate implications for the on-going EMF debate, will also be commented upon.
In a sense, then, whereas Part I of the thesis 'Mapping the Terrain' will provide a macroscopic history of the EMF powerline debate, the discussion in Part III will provide a more microscropic detailed history. This detailed case study will provide insights into the EMF powerline debate sometimes overlooked at the broader historical level and also provide a vehicle to utilise the theoretical tools outlined in Part II of the thesis, in particular the eclectic model for the analysis of scientific controversy proposed in Chapter 6.

As a final introductory point, it is also important to briefly bring to the reader's attention some noteworthy features of the source materials which will be used in this study. During the period that this study has been composed, a number of new secondary sources and numerous reports on new EMF studies have appeared. This, of course, is an endemic problem of studying current debates. These studies have been incorporated into the analysis, commented upon, and duly acknowledged as far as possible.

Covering a contemporary debate has also provided difficulties in relation to making judgements about what knowledge is part of the public domain, and what can be taken as assumed knowledge. In addition, the subject matter has, at times, constituted something of a moving target, with protagonists actively re-shaping images of the state of play.

'Living debates' do provide, nevertheless, unique opportunities to observe and participate in history in the making. Particularly valuable in this context was the opportunity for me to attend a number of legal proceedings in the NSW Land & Environment Court during 1990, for instance: the Warren (OPIC) vs. ELCOM proceedings (involving the siting of a high voltage transmission line near Oberon in Western NSW); Radio '2 Double O' Wollongong vs. Wollongong City Council (in relation to the siting of radio transmitting towers); and attending the public hearings of the Gibbs' Inquiry. I was also involved in numerous EMF protests in the capacity of providing information to a number of protest groups and concerned
individuals. These involvements brought me into personal contact with a number of EMF scientists and activists and allowed me to observe 'first hand' numerous of the features of the NIEMR/EMF debate and the Gibbs' Inquiry noted in this study. The discussion in this study, nevertheless, will mainly rely on documentary evidence rather than interviews.

Documentary evidence has been privileged, for the following reasons: first, in many of my conversations with participants, they merely referred back to material they had written for the public domain. In controversial public debates, like the NIEMR debate, there is much at stake and key figures are accustomed to providing opinions in interviews. Such 'polished performers' rarely add anything to the existing body of 'documentary information'. Second, if, in conversation, indiscreet comments were made, it was normally stipulated to me that such comments should be taken as "off the record". For these reasons, whilst interviews and personal correspondence provided an important part of my 'learning curve', they will not be relied on extensively in the text. This 'privileging' of documentary evidence is quite consistent with much of the work in the social studies of science and history. It provides the advantage to the reader that the veracity of the account of this controversial debate can be more easily checked. It must be accepted though that the applicability and extension of the conclusions of this study must be kept in context with the source material that has been used. Other studies, privileging different forms of evidence may well have their place in comparing and extending the conclusions of the study which is to follow.
Part I
History of the NIEMR/EMF Powerline Debate: 'Mapping the Terrain'

Introduction

The contemporary scientific controversy over powerlines, and potential health dangers of electromagnetic fields (EMF), emerged from three closely related, but nominally separate, continuing debates. The first three chapters of Part I of the thesis will document the main features of these debates. Chapter 1 will examine the controversy over the siting of powerlines in the broader contexts of environmental concern and the politics of technological decision making. Chapter 2 will examine the emergence of the more general concerns of health risks from exposure to non-ionizing radiation electromagnetic radiation (NIEMR) and the so-called 'microwave debate'. Chapter 3 will examine the emergence of controversial scientific theories which have challenged traditional explanations of the nature of the interaction between NIEMR and biological systems.

These debates will be taken up to the present and linked to the EMF powerline debate in Chapter 4. In this chapter special attention will be paid to the emergence of EMF regulation and the implications of a number of scientific reports and public inquiries (ranging from the Sanguine Inquiries of the early 1970's and the New York Public Service Powerline Inquiry 1974-78, through to the draft report of the US EPA of June 1990 and its immediate aftermath.) The immediate Australian context of the Gibbs' Inquiry will also be discussed with attention being paid to the Richmond to Brunswick Powerline Dispute and the Victorian Powerline Review Panel 1986-89, and the OPIC versus ELCOM proceedings which took place in the NSW Land & Environment Court during 1990.
The historical accounts in this section should stand on their own merits as contributions to the history of the NIEMR/EMF debate, and also provide essential background for the more detailed discussion of the negotiations of EMF science and science policy in the Gibbs' Inquiry, which forms the substance of Part III of the thesis.
Chapter 1: The Siting of Powerlines and the Broader Environmental Context

Thus the power of eminent domain makes it possible for the power companies to distribute high levels of visual and audible pollution across the countryside arbitrarily, while the benefits of cheaper power are funnelled into the large industrial centers and sold at wholesale rates to large consumers. The degree of protection of an individual's rights depends on where he lives. (A concept that is certainly at odds with the principles on which this country was founded).


In the 1920-30's many Western nations saw the spread of high voltage powerlines. During these early days powerlines became intimately associated with images of progress via the spread of cheaper electrification. These positive images were enhanced in the depressed economic circumstances of the time, particularly in rural areas, where the purchase of 'rights of way' for the powerlines often provided farmers with much needed cash and, as was often the case, land was relatively cheap and plentiful.

From as early as the 1950's, powerlines began to lose their image as a symbol of progress: within many regions electricity supply was taken for granted while prime land became more scarce and costly. This 'progress image' eroded further during the 1960-70's as concerns for environmental quality and individual rights grew. Accordingly, powerlines frequently came to take on negative images as sources of pollution and symbols of the erosion of individual rights in the face of unacceptable, irreversible

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2 In Australia, see discussion in David Mercer, 'Conflict over a high voltage powerline: a Victorian case study', Australian Geographer, Vol.15, 1983, p.297. This author is a different one to the author of this thesis David W. Mercer.


4 Furby, et al., op. cit., pp.21-22.

Though timing for these changes in perception would have varied from one place to the next.
decision making of large institutions, such as governments and power authorities/companies.\(^5\)

The two most important studies of early powerline disputes are those by Louise Young, *Power Over People* and Casper and Wellstone, *Powerline: The First Battle of America's Energy War*.\(^6\) Whilst the seeds for the later EMF debate appeared in these earlier controversies, EMF took on much less significance than debate over the environment generally, and the politics of technological decision making. Even within the umbrella of health concerns, EMF was merely a suspected problem, mainly in the context of electric field exposure. In 1973, Louise Young put these concerns succinctly in her account of the dispute involving the siting of the first 765 kv powerline in the late 1960's/early '70's in the rural village of Laurel, Ohio:

> The long term effects of living most of one's life in such an unnatural environment have not been scientifically evaluated, but it is reasonable to suppose that the biological effects may be profound.\(^7\)

Health concerns not directly related to EMF, however, took on greater emphasis. These included electro-chemical pollution in the form of chemicals and gas produced by air being broken down by electrical discharges along high voltage power lines (corona discharge). The most important of these was ozone produced by the breakdown of oxygen, and nitrogen dioxide, produced when the nitric oxide produced by the breakdown of nitrogen and its reaction with oxygen in the atmosphere then reacts with ozone. Both ozone and nitrogen oxides were noted ingredients of 'smog' and suspected of, at the least, being capable of causing lung damage.\(^8\)

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(ii) Powerline planning is an exemplar of the challenges over balancing individual rights equity against net social benefits, etc.


\(^7\) Young, *op.cit.*, p.47.

\(^8\) *ibid.*, pp.17-27.
Other health concerns included:

(i) stress effects via noise pollution (again mainly a by-product of corona discharge),
and via electric shocks (produced when alternating electric currents that build up in
unearthed objects in the vicinity of high voltage power lines are discharged as
sparks when grounded by a person's touch);
(ii) interference with cardiac pace makers; and
(iii) potential exposures to increased concentrations of positive air ions.

Under the umbrella of 'pollution' powerlines were linked to concerns over energy
production and alternative energy sources, and were taken as powerful symbols of the
degradation of the rural environment by the uncontrollable spread of industrialisation.
Young (with resonances of Silent Spring, juxtaposed, to great effect, photographs of
the 'pristine' rural countryside with industrial wastelands featuring power station smoke-
stacks and tangles of powerlines.

Associated with these general health and safety and pollution issues, but of possibly
greatest concern, was the politics behind powerline planning, especially that surrounding
the perceived breach of individual rights in powerline authorities' compulsory acquisition
of private land for powerlines, the so-called right of eminent domain.

Though the Bonneville Power Administration Report, op.cit., notes the current decline in
concern with ozone from powerlines, see discussion p.68.

9 Young, op.cit., pp.46-47.
Plus Bonneville Power Administration, op.cit., p.71.
It is useful to note that the issue of air ions has been of greater concern in relation in DC
powerlines - the bulk of high voltage powerlines are AC which produce much less effect on air
ions.

11 Young, op.cit., pp.163-180.
12 ibid.
This allusion appears in highlighted extracts of reviews on the 1974 paperback edition, back
cover.
"After you've finished her book, put it on your reference shelf next to Rachel Carson's
Silent Spring. But do not leave it on the shelf, use it as a guide to obtain protective
legislation, better regulatory commissions, and increased understanding by the courts."
Senator Lee Metcalf, Western Political Quarterly.

The relative importance of these concerns to health and safety is revealed in Caspar and Wellstone's intimate account of the battles over the siting of a powerline in rural Minnesota during the mid 1970's. In this dispute, powerline protesters came to see the focus of 'formal debate' on health issues as part of a political ploy by the state to reduce the dispute to one over technical and scientific issues. The Governor of Minnesota had proposed that the (then) new idea of 'science courts' should be deployed as the fairest way to resolve the powerline debate.

Caspar and Wellstone summed up the protester attitudes as follows:

The farmers saw the science court in quite a different light. If restricted to health and safety questions, it would have been a fitting climax to the chain of statutory and procedural restrictions that had inexorably channelled them away from their basic concern about the powerline -- the sacrifice of their land without their consent for an allegedly greater social need whose validity they questioned -- into a forum that would consider only quite peripheral technical issues.

The political nuances of the perceived breach of individual rights also appears as a feature of Louise Young's account:

Thus the power of eminent domain makes it possible for the power companies to distribute high levels of visual and audible pollution across the countryside arbitrarily, while the benefits of cheaper power are funnelled into the large industrial centers and sold at wholesale rates to large consumers. The degree of protection of an individual's rights depends on where he lives. (A concept that is certainly at odds with the principles on which this country was founded).


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15 Caspar and Wellstone, (a) *op.cit.*, p.247.
16 Young, *op.cit.*, p.33.
issues and public protest are devoted a chapter but there is close to no discussion of EMF specifically. Further, in the Report of the State Pollution Control Commission of NSW of the Inquiry into a 500 kv line from Eraring to Kemps Creek, in 1978, EMF is raised as an issue, but only very briefly, rating no more than a couple of paragraphs in a report of thirty odd pages.  

In a brief account of the evolution of EMF powerline disputes in Britain, a number of similar features stand out. Hilary Bacon, a powerline activist, documents how up till the early to mid 1980's there was a close to total lack of both information and interest by government and power authorities concerning the issue of powerline EMFs. According to Bacon, whilst a number of people living near high voltage powerlines had begun to report health complaints, it was only after the work of Louise Young (1973-74) came to their attention that those who were concerned became aware that there was serious scientific interest in the issue. As far as presenting a case to the relevant power authority (CEGB) was concerned, this would end up relying on years of hard research effort and the making of fortuitous contact with a number of leading dissenting bio-electromagnetic scientists, in particular Andrew Marino. When this first British anti-EMF case was put in an official capacity to the Innsworth Inquiry 1978, it was more or less dismissed out of hand. The scientific work in question was rejected by CEGB officials, who described such scientists as no more than trouble makers. Further, the Inquiry didn't even see the issue as important enough to call a single independent medical assessor.

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18 State Pollution Control Commission, *Report and Findings of the Environmental Inquiry into the Proposal to Construct and Operate a 500,000 volt, double circuit electricity transmission line from Eraring Power Station to Kemps Creek in Western Sydney*, p.21.


The first powerline dispute in Australia, where the case of health risks of EMF was to be raised, and deemed worthy of a serious effort at rebuttal by power authorities, was in 1979 in the Moorabool to Portland 500 kv powerline dispute. 20

Whilst EMF had begun to take on a significant profile, it was not until the mid 1980's in the Richmond to Brunswick powerline dispute that EMF risks from powerlines would take on anything like their present significance. The timing of this was influenced by factors such as the emerging concern within the Australian trade union movement about the so-called microwave radio frequency debate generally; the beginning of serious media attention being given to the growing scientific controversy surrounding the claims of bio-electromagnetics scientists, such as Becker, Marino and Adey; and, no doubt, concern filtering through the world's power distributing authorities about the disruptive potential of the EMF issue in the wake of the somewhat open-ended findings of the New York State public service powerline inquiry, 1978. How these and other factors contributed to the maturing of the EMF debate will be discussed in more detail in Chapter 4.

It is clear from this brief survey that political issues surrounding rights of eminent domain, compensation, aesthetics, visual and acoustic pollution, the nature of technical decision making and the more general environmental issues surrounding energy policy, pre-dated the emergence of EMF health concerns per se, as the main ingredients of powerline disputes. Further, even now that the EMF debate has come to dominate public attention in most powerline disputes, these non-EMF issues still hold much significance.21 For the purposes of this study, it is useful briefly to consider how such broader issues may have impinged on the texture of the EMF powerline health debate.

21 For instance, whilst health and safety submissions took up the bulk of submissions before the Gibbs' Inquiry, other issues such as the siting of powerlines on public versus private land were always strongly present in the background. See discussion in Final Report, Inquiry into Community Needs and High Voltage Transmission Line Development, Sir Harry Gibbs, February 1991, Section 7, pp.75-80. It is also worth noting that general environmental concerns such as impact on wetland areas, bird life, and energy policy also were the subject of significant submissions to the Inquiry.
It is possible to speculate that literally any anticipated hazard from powerlines would elicit concern from the public to be affected. This is because most powerline siting controversies, even aside from EMF, have carried strong intimations that the individuals affected would suffer various sorts of loss of control. There has been a strong tendency for powerlines to be seen as involuntary impositions, imposing costs with no direct or obvious benefit to their bearers. Compounding such perceptions of loss of control has been the ease (in most cases) with which power authorities/electrical utilities have been able to be pigeon-holed by protesters as archetypical large-scale bureaucracies, untrustworthy and inflexible in the face of public dissatisfaction. Such perceptions, as noted above, have not been without some material basis: large scale technological developments, such as high voltage power lines, involve complex technical decisions, huge financial commitments and comprehensive planning with a tendency towards deterministic momentum developing.

Further, a number of studies have documented the way decision-makers, in many such bureaucracies, perceive that they are acting in the public interest, but only as far as such interests fit comfortably with the traditional decision-making structures within the

23 (i) ibid., op.cit., pp.35-37.
   (ii) Casper & Wellstone (a), op.cit., p.251 - In their study they report on the public views of local political candidate, Alicia Tripp, representing the opponents to the powerline. Her following statement encapsulates the anxieties surrounding loss of control in powerline disputes extremely well.

"What happened to the farmers in Western Minnesota is happening to all of us. In energy, in agriculture, in health care, in almost everything that matters to people, the same pattern of power is evident. Partnerships of large corporations and entrenched bureaucracies dominate the vital decisions that affect our lives and shape our future. Corporations call the tune; the government - our government - helps them carry out their plans. This is not democratic. The corporate planners and government bureaucrats who decide policies are not accountable to the American people."

bureaucracies involved. A good example of this can be found in Trevor Blake's report to the Victorian Powerline Review Panel. In this report he discusses the organisational culture and patterns of decision-making used by the State Electricity Commission of Victoria in planning powerline developments. Blake characterises the SECV's approach as follows:

... the prevailing organisation within the SECV remains committed to a belief in the primacy of technical judgement in resolving appropriate development decisions, given a basic purpose of facilitating economic progress through provision of an efficient electrical infrastructure system. The prevailing consensus of scientific and professional thought provide the general framework of analysis, while specific planning proposals are assessed on the basis of "objective" criteria. Economic considerations are the primary basis of planning evaluation, although "environmental" and "social" factors are incorporated as constraints in the design process. The role of the political process is to establish development objectives and the weight to be given to environmental and social factors. Public consultation is seen to have a proper role in revealing community concerns and priorities but not in providing a forum for "political" debate. Activist organisations which do not directly represent the broader mass of community opinion are deemed to be essentially subversive. 25

This devaluation of the effective 'scope of public participation' in powerline planning has easily shifted into approaches towards EMF. Questions about EMF have lent themselves, even more than other planning concerns such as aesthetics and costing of route options, to the search for objective criteria of judgement. Intrinsic scientific uncertainty and public participation have been easily excluded.

A passage often quoted in recent Australian powerline disputes encapsulates the attitudes noted above extremely well. It derives from the Graves' Report on the Health Effects of EMF's, a report endorsed by the State Electricity Commission of Victoria and sponsored by the Victoria Health Department in 1986:

... laymen, including community awareness groups, are not very likely to be able to effectively assimilate the biological effects of studies and actively translate the results into public health consequences and objectively based guidelines. Hence,

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25 Blake, op.cit., p.106. 
Plus Furby, et.al., op.cit., pp.35-37.
scientific evaluation and reviews, rather than public debate, will remain the best guide to policy in these areas...26

Whilst not all power authorities/utilities may have developed the same kinds of organisational culture and approaches to decision-making, there is quite a deal of support in the literature for the SECV approach, noted above, to be taken as reasonably common.27

It is not surprising then, that in a number of documented powerline siting controversies, questions about lack of control and unresponsive bureaucratic decision-making and perceptions of EMF risk have sat comfortably together. Most significantly, scepticism about the accountability of planning procedures has readily merged with mistrust of EMF safety assurances.28

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See also discussion of the work of David Mercer in the above report, p.68, for instance:

"During his discussion of recreation, amenity values and powerline corridors, Mercer argued that historically environmental and other groups seeking to challenge energy decisions invariably have encountered three powerful and largely unassailable assumptions:

(i) economic growth is the highest good. Therefore, commercial considerations are paramount and generally should take precedence over other values, such as equity, social justice or environmental integrity;

(ii) non-quantifiable parameters are much less significant than quantifiable parameters;

(iii) subjects and topics about which we have 'certain' data are generally much more important and should be awarded premier status by comparison with those about which have little or no information."

28 See also discussion in Falk, Badham and Smith, 'Public Accountability and Electricity Planning', report prepared for Victorian Department of Minerals & Energy, 1984.

See also discussion in Final Report of the Gibbs' Inquiry, *op.cit.*, Community Concerns (General) Consultation with the Public, pp.83-94. In this Gibbs outlines the often noted problems of accountability in electricity planning, particularly concerning high voltage powerlines but he does note some initiatives in Canada by power authorities which go against the traditional pattern.

See also Russ and Rosenthal, *op.cit.*, plus Smith & Rix, *op.cit.*

Casper and Wellstone, (a) *op.cit.*, p.243, explain this idea in the context of their case study in the following terms:

"In another era, the authority of the power companies or state agencies might have been believed. But Vietnam and Watergate and thalidomide babies had produced a populace with a healthy scepticism of authorities and experts. The farmers were genuinely concerned about the hazards to themselves and their families of living near the lines and viewed the power companies and state agencies as interested parties whose word could not necessarily be trusted."

See also discussion in Blake, *op.cit.*, pp.56-59.
A further linkage suggested between the more general politics of powerline planning and the EMF debate has been the possibility that EMF concerns act as surrogates for more crucial interests of protesters. This, it will be remembered, was hinted at in Casper and Wellstone's analysis of the proposed role of science courts in the Minnesota Powerline dispute. In Mercer's analysis of the Portland dispute, the issue is also raised. In the latter account, emphasis on health and safety is seen, in part, as the by-product of patterns of state/bureaucratic decision making, which gave precedence to issues most easily able to be framed in a technical form, such as health and safety. Mercer implies that the more holistic, subjective, emotional ways in which participants actually experience issues have risked being distorted and re-moulded in such processes, and hence, public participation further hindered.

Whilst these observations may have been true of early powerline disputes, more recently EMF has come to take on a much more primary role amongst powerline concerns. Given publicity surrounding dissenting scientific views on EMF, and the tendency towards power authorities making conservative claims in relation to EMF health risk, EMF has become, rather than a surrogate for broader political concerns, a rallying point around which broader political concerns have been attached. The enrolment of the support of the authority of dissenting EMF scientists to challenge the technical expertise of power authorities and government bodies should not be underestimated in terms of its symbolic value as a form of political challenge in itself.

29 Caspar and Wellstone, op.cit., p.247.
(ii) See also Blake, op.cit., p.20.
31 ibid.
32 Whilst the following study can be criticised for making unsubstantiated generalisations between social typologies and perceptions of risk, some interesting issues linking risk perceptions to broader politics are raised, see Steven Rayner and Loutllie Rickert, 'Perception of Risk: The Social Context of Public Concern over Non-Ionizing Radiation' in Non-Ionizing Radiation: Physical Characteristics, Biological Effects and Health Hazard Assessment, IRPA, 1988, ed. M. H. Repacholi, Australian Radiation Laboratories, Yallambie, Victoria, pp.39-49.
In this regard it is useful to see EMF as an issue in its own right that has, at different times, temporarily united different interest groups. This has occurred via such groups experiencing the contradictions in statements and behaviours of authority groups such as power utilities, etc. The experience of such contradictions and erosion of trust in the authority groups in question
Overall, whilst the general politics and environmental concerns surrounding powerlines pre-dates EMF as the major powerline issue, the ambience of these concerns has, no doubt, fed into, and continues to shape, the EMF debate, especially in regard to perceptions of risk and the tendency for the development of adversarial relationships between protesters and power authorities.

EMF first moved out from the background of these general political factors to become an issue in its own right when questions about the safety of non-ionising radiation were channelled into the powerline debate. This controversy, sometimes known as the 'microwave debate', had been brewing from the end of World War II and was to emerge publicly in the late 1960's to early 1970's.

should not be read simply as a starting point for any one form of political action, i.e. an expression of, for instance, environmental concern and a catalyst for fuller involvement in broader environmental political issues.

See for instance the analysis in R. Taplin and P. Tighe, p.110 in 'Australian Environmental Politics: An Analysis of Past and Present Issues', p.102-116 in Changing Directions: Eco-politics IV, Graduate Centre for Environmental Studies, University of Adelaide, 1989. In part of this study Taplin and Tighe argue for the symbolic value for environmental politics in general of the Richmond to Brunswick Powerline dispute. Whilst in this specific case their argument may be sound, it is useful to remember that alternative scientific evaluation by protest groups of the EMF debate etc. have also been the starting point for a variety of broader political actions. The Gibbs' Inquiry and the Oberon Mt. Piper to Marulan Powerline dispute (in which much of the scientific critiques formed by protest groups from the Richmond to Brunswick Powerline dispute were used) became, for instance, a launching pad for powerline activists to attempt to create their own political party directly addressing issues of Australian rural decline hoping mainly to tap into disaffected, National Party voters.

33 It is useful to bring to the reader's attention at this point the numerous ambiguous acronyms that have been used to describe various parts of the non-ionizing part of the electromagnetic spectrum. In many analyses the term NIEMR (non-ionizing electromagnetic radiation) is used. At other times, the acronym EMF (electromagnetic fields) is used to describe extra low frequency NIEMR. Yet again, the term 'microwave debate' has been used as a synonym for both the general NIEMR debate and EMF debate. If in doubt, please refer to Glossary.
Chapter 2: 
NIEMR as a health issue: The 'Microwave Debate'

(i) Introduction: Historiographic interlude

The reconstitution of the past in the historian's mind is dependent on empirical evidence. But it is not in itself an empirical process, and cannot consist in a mere recital of facts. On the contrary, the process of reconstitution governs the selection and interpretation of the facts: this, indeed, is what makes them historical facts.

... the facts of history never come to us 'pure', since they do not and cannot exist in a pure form: they are always refracted through the mind of the recorder. It follows that when we take up a work of history, our first concern should be not with the facts that it contains but with the historian who wrote it.


In this chapter, I shall rely heavily on already published accounts. This necessitates a few brief historiographical observations.

One of the few scholarly secondary sources on the history and social aspects on the non-ionizing radiation debate has been the work of N. Steneck, in particular, his book The Microwave Debate published in 1984.34 The following historical overview will draw in a number of places from Steneck's analysis, particularly on the early history of the US microwave safety standard, the first Western NIEMR health guideline. It is worth noting though that there are a number of 'blind spots' in Steneck's analysis. Most importantly, these surround his failure to explore the links between the microwave debate and the EMF/ELF powerline debate. This omission is quite puzzling considering the important and direct connections between the scientists involved in both sub-debates, which will be discussed later. Particularly surprising in this context is Steneck's failure to address the highly publicised 1978 New York State Public Service Powerline Inquiry. A further difficulty with Steneck's history is that it provides an incomplete account of the scientific positions which underlie the more public face of the non-ionizing radiation debate. Especially noteworthy in this context is his failure to look at the international dimensions of non-ionizing radiation: that is, the construction of the International Radiation

34 Publishing details for the texts noted in this historiographic interlude will appear later in Chapter 2.
Protection Association and also the emergence of bio-electromagnetics as an alternative scientific discipline to the thermalist i.e. conservative/traditional NIEMR science.

In fairness to Steneck, his major aims were to describe the US situation in relation to establishing the microwave safety standard and review the controversy provoked by Paul Brodeur's thesis about a conspiracy by the US and other Western governments to block public awareness of the potential risks of non-ionizing radiation. Steneck's review of the early phases of the establishment of the microwave safety standard and the impact of Brodeur's journalistic expose are detailed and plausible. If we are to attempt to gain a broader picture of the non-ionizing radiation debate, the factors just mentioned need to be integrated into the analysis. A further point is that the bulk of Steneck's work, though published in 1984, focuses on the events of the late 1970's. There have been a number of important shifts in the NIEMR debate from the late 1970's which need to be integrated into the analysis.

This chapter also raises another historiographic problem: the role of various sources which fit uncomfortably into categories as primary or secondary. Most important of these sources have been the two accounts of the NIEMR debate by investigative journalist Paul Brodeur, *The Zapping of America* (1977) and *Currents of Death* (1989) and also numerous books and articles directed at the lay public by scientists such as Robert Becker and Andrew Marino, such as *Electromagnetism and Life* (1982). These sources have commented on the science, and the politics of the science, involved in the non-ionizing radiation debate and have frequently been taken up as primary sources in the extension of the debate in legal proceedings, government inquiries etc. A number of other sources also have this ambiguous status as both commentary and primary sources. For instance, the health overviews produced by the World Health Organisation and the numerous government reports and submissions by public authorities and protest groups. Finally, and next to Brodeur, some of the most important primary but also secondary sources have been the newsletters *VDT News* and *Microwave News*. Since their launch in the
early 1980's these newsletters have provided brief commentary on public hearings, new studies and news relevant to the state of NIEMR science and public debate.
(ii) The Tri-Service Program: premature closure - the origins of thermalist guideline perspectives

The primary thrust of the program was essentially determined by the implicit assumption upon which prior work was based. It was assumed that the only way the energy could affect an organism was through overloading its heat-dissipation mechanism. Thus, little effort was expended to determine the effect of low-intensity energy. This assumption also resulted in an acrimonious dispute between those who contended that only thermal effects could occur and those who thought that non thermal effects could also occur. But the fruitless argument was really the result of a semantic problem. The participants were talking past each other, for there never was a common definition of the words thermal and nonthermal. It was also assumed in the Tri-Service Program that nervous-system function and behaviour could not be affected, so the possibility that modulation would be of consequence was essentially ignored.


The ambience of public mistrust of power authorities, because of the problems outlined in the previous chapter, was complemented by the linkages of the EMF powerline debate to the microwave or more general NIEMR debate.

From the outset of the development of 'wireless' technology, it was observed that heat could be induced in living things by exposure to non-ionizing radiation. (Because of technological limitations this involved only the lower part of the radio frequency range at this point in time, the early 20th Century.) These concerns lead to development of a medical treatment, radio diathermy, during the 1920's-30's. The heat induced by the application of radio waves to the body was seen as therapeutic for numerous ailments. The first data indicating potential harmful effects of such radiation can also be traced to this period. General Electric workers producing high powered, short wave tubes began to complain of dizziness, nausea and fevers. During the 1930's similar complaints arose amongst naval radio operators. Experiments with human volunteers suggested


36 N. Steneck, op.cit., Risk - Benefit Analysis ..., p.6
such effects did exist, but that they were nothing sinister, being merely the by-product of excessive heating or thermal effects, which could be avoided by cutting excessive high exposures.

After World War II, with the advent of radar and the use of a wider variety of higher powered devices emitting more diverse varieties of wave forms and frequencies, health concerns began to appear more frequently. In 1948, experiments at the University of Ohio and the Mayo Clinic, suggested that exposure to radar induced cataracts in dogs. Testicular degeneration was also noted in experiments with rats. In 1952, John McLoughlin, a medical researcher for the Hughes Aircraft company discussed a cluster of unusual cases of internal bleeding amongst radar workers. His reports were circulated to the military and government.\(^3^7\) In 1953, partially in response to these concerns, the US Air Force and Navy sponsored scientific meetings to address the issue of non-ionizing radiation safety guidelines. During this period, it became obvious to regulators that there was almost a complete lack of technical expertise capable of addressing the issue of setting guidelines. This issue, which continues within the present EMF powerline debate, points to the huge gulf of specialisation between, on the one hand, electrical engineers, who were looking at ways of applying non-ionizing radiation to technological contexts, and whose expertise was needed to attempt to measure and model potential human exposure patterns, and, on the other hand, the small number of scientists mainly trained in biology or medicine, who were exploring medical applications and theoretical hypotheses of NIEMR biological interactions.\(^3^8\)

In an attempt to pool expertise, the so-called 'Tri-Service programme' was established by the US government. This was one the first attempts in the Western world to systematically research non-ionizing radiation bio-effects. In 1959, still during the

\(^{37}\) ibid., pp.8-9  
plus Steneck, N., op.cit., The Microwave Debate, pp.33-34.  

\(^{38}\) N. Steneck, op.cit., Risk - Benefit Analysis, p.10.  
planning phases of the programme, a leading US bio-physicist, Herman Schwan, arrived at the first radio frequency guideline in the Western world (10 mW/cm\(^2\)) on the basis of theoretical speculation and mathematical calculation. He used a purely thermal or heating model of the threshold, plus a safety factor where the body could no longer safely dissipate heat induced in it by RF microwave exposure.

A number of historical accounts have revealed that the Tri-Service Programme quickly became little more than an attempt experimentally to verify the 10 mW/cm\(^2\) thermal guideline. One of the pioneering non-ionizing radiation researchers who had a special interest in behavioural effects, Alan Frey, described the Tri-Service Programme in the following terms:

The primary thrust of the program was essentially determined by the implicit assumption upon which prior work was based. It was assumed that the only way the energy could affect an organism was through overloading its heat-dissipation mechanism. Thus, little effort was expended to determine the effect of low-intensity energy. This assumption also resulted in an acrimonious dispute between those who contended that only thermal effects could occur and those who thought that nonthermal effects could also occur. But the fruitless argument was really the result of a semantic problem. The participants were talking past each other, for there never was a common definition of the words thermal and nonthermal. It was also assumed in the Tri-Service Program that nervous-system function and behaviour could not be affected, so the possibility that modulation would be of consequence was essentially ignored.

Experiments exposing beagle dogs to fatal levels of heating verified Schwan's 'engineering' calculation in establishing the level where acute harmful heating effects could be observed. Issues such as potential problems of chronic exposure or nonthermal effects were 'more or less' ignored.

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42 Schwan has since argued that it is important to acknowledge that there was awareness even if there was not consideration of such studies. In Chiabrera *et.al.* (1985) *op.cit.*, he proposes (p.14.):

"It has been indicated that I was unaware of the possibility of non-thermal dangerous effects and that therefore, our rationale [Tri Service program] was of limited usefulness. This was not so. As indicated above, I was probably more aware than any"
In 1966, the Program was terminated and the guideline was accepted by the American Standards Association for military personnel.  

of my young colleagues of all the work before 1940 and the thermal - athermal controversy. But I simply could not see how any rationale could be developed from these inconsistent and sometimes anecdotal results at non-thermal energy levels."

Whilst Schwan, for the historical record, is keen to emphasise awareness of athermal studies, he still is clear in rejecting their relevance for the process of setting safety guidelines. At another point in the article quoted above, (pp.12-13) he proposes, for instance, the following:

"An inherent problem with most of these studies [athermal studies] is that experimental observations in the absence of any valid interpretation tend to be subjected to inquiry or to be forgotten eventually. Only if they can be properly explained can they be of use in predicting effects under different circumstances. Indeed, this work has not been applied yet to health standard considerations."

The contradictions implicit in the public and private stances of government and military officials over the Moscow embassy problem did not escape public notice. On the one hand, most government and military officials had publicly maintained since 1960 that exposure to microwaves at or below the 10 mW/cm² level did not pose a threat to public health. On the other hand, some of these same officials had argued very persuasively in private that a microwave source whose highest power levels never went much above 1/1000 of the US standard had to be taken seriously and its health and behavioural effects subjected to rigorous scientific scrutiny. Clearly the two positions were not compatible in any obvious way. On the contrary, they seemed to be completely at odds and, in fact, perhaps indicative of a high-level conspiracy to conceal from the public the real dangers of RF radiation.


The 10mW/cm² guideline was to achieve only a precarious closure of the issue. First, closure had been achieved by dismissing the fact that the issue of setting safety guidelines for non-ionizing radiation had also been a pressing issue during the same period of time in Eastern Europe. This was done mainly because of a variety of communication problems, ignorances and arrogances which can broadly be grounded in Cold War attitudes and policies. Rather than work from the premise that bio-effects were restricted to thermal insult, the Soviets and Eastern Europeans had researched more widely and located a variety of effects, from blood disorders through to behavioural and subjective complaints of discomfort amongst non-ionizing radiation workers. These

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44 The dismissal of Eastern European research still continues on occasion. See for instance D.H. Sliney in 'Current RF Safety Standards' in M. Repacholi, 1988, op.cit., p.221. Talking of the Eastern European safety standards Sliney says: "For example, it has been alleged that very conservative levels were supported by workers' organisations in order to obtain extra benefits if they worked in hazardous environments."

45 The Cold War connection with influencing research is emphasised in particular in P. Brodeur, The Zapping of America, Norton, New York, 1977. See discussion pp.33-41. See also Steneck, N., The Microwave Debate, pp.63-66. See also discussion in Chiabrera, op.cit., pp.15-17. Schwan argues that in fact there was awareness of the Russian work but points out that the American work was preferred because it permitted closer scrutiny as it was reported in much greater detail. What is puzzling in regard to the role of Russian studies and the degree of consideration given to athermal studies in the work of Schwan is that whilst he would like it noted historically that he was aware of this material, he also acknowledges the general validity of Steneck's historical account of this same period of decision making - see p.17. Steneck's analysis proposes that such work was largely ignored.
effects had been observed at exposure levels from $1 \text{ mW/cm}^2$ down to even 50 microwatts/cm$^2$ (chronic exposure being an important variable). Furthermore, whereas in the US, ELF frequencies such as those associated with powerline and high voltage electronic devices had barely even been considered, in Eastern Europe reports of health complaints amongst switchyard workers and powerline workers had lead to the setting of electric field guidelines in the power frequency range i.e. 50-60 Hz. This meant that from the late 1950's to early 60's onward the Soviet Union and Eastern Bloc had safety guidelines for various parts of the non-ionizing electromagnetic spectrum barely even considered in the West, and for the radio frequency microwave part of the spectrum they had standards a thousand times more strict.

Misgivings about the US approach were to first become public with concern over radiation emissions from the burgeoning consumer marketplace for electronic goods. In 1967, a controversy emerged when General Electric released 90,000 faulty colour television sets which would have x-rayed viewers. This prompted the US Congress to press for renewed funding for research to establish safety guidelines covering not only ionizing radiation, such as the x-rays in faulty T.V.'s, but also non-ionizing radiation. This lead to the establishment in 1968 of the so-called ERMAC (the Electromagnetic Radiation Management Advisory Council) to advise the US President on radiation

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47 For a useful survey see Andrew Cutz and Karel Marha, 'Biological and Health Effects of Extremely Low Frequency Fields - A List of Eastern European Literature', March, 1988, Canadian Centre for Occupational Health & Safety.
Some Soviet and Eastern European ELF studies had come to Western scientific awareness during the late 1960's and early 1970's but only lead to some small poorly publicised studies conducted by power utilities.
regulation. It was this situation which was to prompt the re-kindling of research in NIEMR bio-effects.  

Further concern with regulation was encouraged by the release of microwave ovens, VDT's/VDU's in homes and offices from the early 1970's. In their demand for safety assurances, consumer groups and trade unions quickly unearthed the disparity between US and Soviet approaches. They also drew from the opinions of a number of dissenting Western scientists. Doubt about erstwhile safety assurances were given further impetus as health complaints began to come to light, from both radar operators and the first VDU operators, which were potentially able to be linked to NIEMR exposure. The fact that many of the technologies in question were highly novel and proliferating quickly further fuelled public concern. This double uncertainty concerning the health consequences of NIEMR and what exposures the new technologies might be producing, was not lost on the recently appointed ERMAC Committee. In 1971, for instance, they proposed the following:

The electromagnetic radiations emanating from radar, television, communications systems, microwave ovens, industrial heat-treatment systems, medical diathermy units and many other sources, permeate the modern environment, both civilian and military. This type of man-made radiation exposure has no counterpart in man's evolutionary background; it was relatively negligible prior to World War II. Power levels in and around American cities, airports, military installations and tracking centres, ships and pleasure craft, industry and houses may already be biologically significant. Unless adequate monitoring and control based on a

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52 A number of different trade union movements in different countries began to show concern with the NIEMR radiation issue from the 1970's. One of the first and most important was the Canadian Occupational Health & Safety Service who helped elevate the issue of NIEMR and VDU's in particular.

53 A good example would be Milton Zaret. See discussion at later point.


See also discussion in Brodeur, *The Zapping of America, op.cit.*, pp.72-95 plus p.315.
fundamental understanding of biological effects are instituted in the near future, in the decades ahead man may enter an era of energy pollution of the environment comparable to the chemical pollution of today. ... The consequences of undervaluing or misjudging the biological effects of long-term, low-level exposure could become a critical problem for the public health, especially if genetic effects are involved.\(^5\)

Many of the alternative scientific views drawn upon by concerned labour organisations and consumer groups included the work of Western scientists who had begun exploring athermal approaches to NIEMR bio-effects, some of them as early as the Tri-Service era of the 1950's/60's. Some important researchers included:

(i) Alan Frey, who put forward athermal hypotheses on the effects of microwaves on the so-called blood-brain barrier and animal behaviour and explored the phenomena of microwave hearing.\(^6\)

(ii) Milton Zaret, a New York ophthalmic surgeon, claimed to identify a specific form of microwave induced cataract not able to be accounted for on the basis of any thermal hypothesis.\(^7\)

(iii) W. R. Adey, at that time at the Brain Research Institute at the University of California, Los Angeles, had used a variety of extra low frequency pulsed radio frequency and microwaves to stimulate behavioural changes in test animals and alterations in brain chemistry.\(^8\)


\(^7\) See also discussion in Frey in Marino, *Journal of Modern Bioelectricity*, op.cit., pp.785-835.


(iv) Rutger Wever and researchers at the Max Planck Institute in Germany had observed the effect of ELF on circadian rhythms noting that when all other time cues are suppressed, the Earth's magnetic field was sufficient to maintain normal circadian rhythms.\(^{59}\)

(v) Robert Becker (later with Andrew Marino), a surgeon at the Veteran Administrations Hospital, Syracuse, NY, had experimented with extra low frequency fields, demonstrating the ability for weak fields to induce significant changes in growth patterns in experimental animals. He had also used such fields in the medical treatment of difficult to heal bone fractures and recorded a significant success rate.\(^{60}\)

The role of a loosely defined dissident fraternity of scientists within the emerging discipline of bio-electromagnetics will be discussed in more depth in Chapter 3.

In the meantime, the catalyst that would link these concerns was emerging. This was the discovery by the US that its Embassy in Moscow was being irradiated by a variety of low level microwaves, both amplitude and frequency modulated at extra low frequencies.\(^{61}\)

Doubting that it was anything to do with 'eaves dropping'\(^{62}\) or sabotage of

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It is worth pointing out that I have only included these (i.e. FN 55-59) as representative examples of quite a large body of scientific work which could be loosely described as preoccupied with athermal NIEMR bio-effects.

61 There are actually some disparities in accounts of the actual levels Embassy staff were exposed to. See Brodeur, *Zapping of America*, op.cit., pp.116-124.


62 It is still sometimes argued that the purpose of the signal may have been for 'eaves dropping'. Nevertheless it is unquestionable that, at the time, it was treated with concern in relation to suspected biological hazards and became an important stimulant to Western biological NIEMR research.

See discussion in:


(iii) Also Brodeur, *ibid.*, pp.116-124.
communication systems, the CIA initiated in 1965 a secret scientific research programme, code named Operation Pandora (in its later phases known as Operation Bizarre) to evaluate the biological effects of low-level NIEMR. This study was terminated in 1971 with mixed conclusions. All the while, the US Embassy staff and the US public were kept in the dark.\(^{63}\)

In 1976, this situation was to change. The US government informed Embassy staff that they were being exposed to microwaves, and that due to possibilities of harmful health effects, the Embassy was going to have protective aluminium screens fitted. This briefing was quickly leaked to the popular press. Continuing stories surrounding the issue exposed the fact that the US Ambassador to Moscow had acquired an unusual leukemia-like blood disease, whose symptoms involved amongst other things bleeding from the eyes. In addition, it become known that without the knowledge or informed consent, the Embassy staff had been undergoing medical monitoring. Further, the existence of Project Pandora was publicly exposed.\(^{64}\)

These stories were documented, sensationalised and placed in the context of statements and interviews with dissident scientists in a series of articles in the *New Yorker* magazine, which also canvassed the possible future risks of non-ionizing radiation.\(^{65}\) Later the author of the articles, Paul Brodeur, brought them together and dovetailed them into the book, *The Zapping of America*. Nicholas Steneck argues that Brodeur's work was particularly important in both publicising contradictions in US microwave policy and, further, making it appear plausible to many that this was not something of an oversight or bureaucratic bungle, but rather the by-product of deliberate high level government conspiracy of Cold War Western governments to mask the real dangers of microwaves. Steneck put it as follows:

\(^{63}\) Steneck, N. *ibid.*, pp.92-116.  
\(^{64}\) *ibid.*, pp.181-189.  
\(^{65}\) P. Brodeur, 'A Reporter at Large: Microwaves I and II', *New Yorker Magazine*, December 13 and December 27, 1976.
The contradictions implicit in the public and private stances of government and military officials over the Moscow embassy problem did not escape public notice. On the one hand, most government and military officials had publicly maintained since 1960 that exposure to microwaves at or below the 10 mW/cm\(^2\) level did not pose a threat to public health. On the other hand, some of these same officials had argued very persuasively in private that a microwave source whose highest power levels never went much above 1/1000 of the US standard had to be taken seriously and its health and behavioural effects subjected to rigorous scientific scrutiny. Clearly the two positions were not compatible in any obvious way. On the contrary, they seemed to be completely at odds and, in fact, perhaps indicative of a high-level conspiracy to conceal from the public the real dangers of RF radiation.\(^6^6\)

Brodeur’s cover-up thesis was accompanied by lengthy documentation and detailed discussion, the very things lacking in official responses to the Embassy controversy. In an era of mistrust in government due to Vietnam and Watergate, it is not surprising that the media adopted Brodeur’s work broadly and uncritically. In many ways, then, Brodeur’s work and its adoption by the mass media can be taken as the symbolic starting point for the current public scientific controversy concerning NIEMR. To quote Steneck once again:

That the microwave debate has taken off largely as a result of mass media activity cannot be denied. In case after case of public protest over some proposed RF project or problem, the cause of concern can be traced to information presented by the mass media. In so far as coverage of the RF bio-effects story in the late 1970’s was deeply influenced by The Zapping of America, the trail of public concern can ultimately be traced to Paul Brodeur ... Before the era of mass media activity in the late 1970’s there was no general public awareness of the potential dangers of RF radiation and to be sure, in cases where the public did not ask no one volunteered information on their own initiative.\(^6^7\)

Brodeur’s work linked a set of micro-political disputes into a fully blown public controversy. These micro-political disputes concerned: dissenting scientists versus establishment scientists; consumer and labour groups versus industry; and regulatory bodies versus uncertainty that had arisen since the ERMAC era. A simple but telling example can be taken from Steneck to measure public response. By 1979/80 Communication installations equivalent to ones that had been built in 1974 without public attention or special zoning permission were being subject to public protest and intensive


\(^6^7\) Steneck, N., *Microwave Debate*, op.cit., p.194.
litigation. In addition, it was Brodeur's cover-up thesis which was frequently being cited as a 'prima facie' case against the reliability of official safety assurances and for the need for independent evaluation of the existing body of scientific evidence.68

Official response to public concern did little to quell the growing malaise. The US Government (important to the rest of the Western world in its capacity as the main source of appropriate expertise) fell back on the traditional guideline approaches developed during the Tri-Service era.69 Bureaucratic and political complexity within the US occupational and environmental regulatory cultures, coupled with the intrinsic uncertainty of the relevant scientific issues, and sensitivity of military and business interests to regulation, produced a profound regulatory inertia.70 In the face of demands for something to be done, debate was skewed toward, and captured, by establishment industry and military scientists such as Schwan.

Such scientists could produce guidelines that offered continuity with past regulatory approaches and scientific certainty.71 Continuity was offered in the sense that such scientists favoured thermalist models for explaining NIEMR bio-effects. This meant research could be geared towards merely articulating, in more detail, the physical models dating back to Schwan and the Tri-Service era. Quantitative, rigorous experimentation with predictable outcomes could be generated and guidelines worked out in detail with increasing scientific detail.72 The trade-off for such continuity and certainty was

68 ibid., p.194.
69 Whilst RF standard setting has varied across the world, most regulatory activity in terms of the scientific rationales backing it up can be traced to the U.S. via ANSI and the EPA. Another important group, IRPA, also has strong linkages to thermalist science first established in this era in the U.S. See further discussion of the important role of IRPA with regulation particularly in relation to ELF in Chapter 4 (ii). See discussion in:
72 ibid., pp.234-240.
scientific plausibility and regulatory credibility (too much 'scientific' work coming to public view was being ignored).\textsuperscript{73}

From the late 1970's to the present, then, the microwave debate has been clouded by constant battles over setting safety standards/guidelines, and, given the failure of such standards to be deemed trustworthy, by persistent litigation in the form of personal injury claims and zoning disputes. Complicating these matters has been a continuing stream of suggestive but inconclusive scientific studies: persistent complaints of dissenting scientists about funding problems and suppression; and, as we shall see in Chapter 4, the growth out of the microwave debate of the complimentary ELF/EMF powerline debate. But, first, the following sections must pursue a more detailed picture of some of these key elements in the emergent microwave debate.

\textsuperscript{73} Via the growth during the late 1970's early 1980's of, as a legitimate discipline in its own right, Bioelectromagnetics. See discussion in Chapter 3.
(iv) The Inadequacy of Thermalist Guidelines
The false economy of forced scientific certainty

One view is we should "play safe" by setting low levels now and raise them only if later research shows higher levels to be harmless. This view usually appeals to those who are actually being irradiated in the course of their daily work.

The opposed view is that the level of radiation which everyone agrees causes demonstrable harm, should be found as accurately as possible and the permitted level should be set at a not-too-large factor of safety below the danger level. This view has more appeal to those owning or controlling sources of RF radiation.

Eloquent claims are made that this is the only "scientific method" of setting maximum exposure levels because they are then based upon "proven facts".

My view is that, far from being scientific, this procedure is unintelligent at best and often is disingenuous.


To expand on the concerns discussed above, I shall begin by examining the controversy over the setting of the first radio frequency safety guidelines and standards.

The standard that evolved in the US out of the political situation described above was the US National Standards Institute (ANSI) Radio Frequency Standard C95.1.1982. Whilst numerous standards across the Western world diverge on points of detail, many of the scientific presuppositions in this document appear in different forms across most Western radio frequency standards. The presuppositions embody a range of value judgements.

From Steneck's analysis of the ANSI standard\textsuperscript{74} and commentaries by Hollway\textsuperscript{75}, Dalton\textsuperscript{76}, and Shrecker\textsuperscript{77} (plus this author's first hand observations of a number of siting controversies involving the validity of the Australian RF standard), these value judgements embodied in the Western approach to RF standard setting can be identified. The values in question enter the standard via 'a complex' of intersecting, complimentary presumptions.

\textsuperscript{74} Steneck, N., \textit{op.cit.}, \textit{The Microwave Debate}, pp.229-243.


\textsuperscript{76} Dalton, \textit{op.cit.}, Chapter 3, 'The Microwave Debate: How Safe are the Safety Standards?', pp.33-46, c.f. footnote #51.

First of all, in setting RF non-ionizing radiation standards, it has been assumed that one must work backwards from the idea of established unequivocal hazard to safe levels, rather than address uncertain hazards from the outset. This approach tends implicitly to favour liberal (less restrictive) safety standards. There is an implicit shifting of the burden of proof onto those alleging they have been harmed.

For instance, in order to be acted upon, uncertain, subjective complaints such as headaches, dizziness etc. have somehow to be related back to the level at which a certain hazard has been established. It has sometimes been argued that the much lower Eastern European standards have been built on a more flexible approach which take into account well-documented reports of discomfort. Karel Marha, a leading Czechoslovakian researcher (who later moved to Canada and became an important catalyst in the emergence of VDT radiation disputes) explained the difference in the following remarks made at a symposium in 1969 in the US:

> The goal of the Eastern European standard was ... to prevent not only damage to the organism, but to prevent unpleasant subjective feelings as well.\(^{78}\)

The Western approach, only recognising thermal effects from a given threshold, quite simply could not even address the possibility of the effects identified by researchers such as Marha.

Compounding the difficulties in working backwards from the idea of well established hazard was the narrow and selective way a hazard was deemed to be well established in the first place. In the West, this has involved the development in relation to NIEMR of images of scientific rigour (used by regulatory bodies) that exclude a great deal of scientific work. From the Tri-Service era to the present, all but thermalist approaches to setting safety standards have been rejected.\(^{79}\) On occasion, this has even included the

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\(^{79}\) *ibid.*, p.235.
subtle shift from the argument that only more rigorous thermal studies should be used in regulatory settings to the very occasional claim that this is the only valid science.\textsuperscript{80}

This effect has frequently 'snow-balled', with research being directed towards the goal of further articulating scientific models generated by the standard setting index of certain thermal effects. What is already known is articulated in more detail whilst numerous less theoretically certain, but more or less repeatable and, arguably, more important scientific studies, are not considered and languish for lack of funding.

Numerous examples of how images of scientific certainty have been used to reject relevant scientific considerations can be put forward. Steneck, in his analysis of the US model safety standard C95.1.1982, for instance, proposes:

In the past US policy makers have used supposed scientific rigour to exclude most East European research on RF bio-effects from their deliberations. The framers of C95.1-1982 are no exception. "Some effects reported in the Eastern European literature were discounted because of questionable control procedures and lack of information on environmental parameters and physical measurements." An effect known as calcium efflux, which has been shown to be modulation specific at low exposure levels, was ignored because it could not be tied to any adverse health effects. The data used to set C95.1-1982 had to overcome the obstacles of "demonstrability ..., relevance, reproducibility, and dosimetric quantifiability." Data that failed to meet these criteria were not used.\textsuperscript{81}

Of course, what this image of scientific rigour excludes is the past and present uncertainties surrounding the very parameters in question. For instance, dosimetric quantifiability may be important but only if there is reasonable agreement as to what a relevant measure of dose is. At a symposium of bio-effects researchers promoted by IEEE in 1984, this very question was raised by long time NIEMR researcher, P.A.Czerski. Editor, E.J. Lemer reported Czerski's position as follows:

The main question in radiation protection is what the meaningful physical quantity is, he said. "What is the reasonable measure of the dose? The current measure is the average specific absorption rate - the amount of absorbed power divided by


\textsuperscript{81} Steneck, N., \textit{The Microwave Debate, op.cit.}, p.235.
the body mass." But there are a number of problems with relying on the specific absorption rate alone, he added. For example, the absence of an effect at one rate does not necessarily mean there will be no effect at a lower level. "You have power windows in existence that are well established", Dr. Czerski said, "windows in which there are effects in a given power range but neither above nor below."

Excessive concentration on the use of the specific absorption rate as a measure may obscure the fact that many of the biological mechanisms of effects are unknown, Dr. Czerski warned. Present standards are too simple and must be modified to take into account other variables, such as specific frequency sensitivities (other than the broad resonance derived from antenna theory), the duration of the exposure, peak pulse powers and modulation frequencies.\textsuperscript{82}

The issue of dosimetry and its relationship to images of scientific certainty can be explored further. Steneck argues that not only have images of scientific rigour been used to exclude relevant alternative scientific explanations with different dose models, i.e. cumulative doses etc., but have been applied in a selective way to enhance the guidelines' already liberal exposure limits. He focuses on the development of the method of quantifying dose of specific absorption rate or SAR. SAR is designed to account for the fact that with some frequencies more energy is absorbed by the body than with others.

The idea of SAR has been used to relax guidelines at frequencies where less energy is absorbed by the body. Nevertheless the spirit of rigour which revealed these different energy absorption rates also revealed the existence of energy hot spots in the body. The possibilities that this implied the need for more conservative guidelines, in certain contexts, was not taken up. This manoeuvre was partly achieved by guidelines being set on the somewhat uncertain basis of a body-averaged SAR.

The reasoning used by C95.IV members to dismiss hot spots from their deliberations is difficult to accept. They contend that whole-body averages can be used for calculating standards because such averages take hot spots into consideration. Average whole-body exposure is calculated by weighing hots spots and cold spots together to determine mean and average exposure. That for every above-average exposure spot within the body there is a corresponding below-average exposure spot is of no consequence at all if the above-average exposure produces damages. The average whole-body momentum delivered by a 1 ounce bullet travelling at 500 feet per second is about one hundred times less than that delivered by a 200 pound football player running at 12 miles per hour. This fact would offer little consolation if the point of impact of the bullet were the heart. That whole-body SAR may be within acceptable limits is also of little

\textsuperscript{82} E. J. Lerner, \textit{op.cit.}, pp.68-69, c.f. footnote #46.
consequence if the above-average exposure occurs in a place of vital importance to well-being.\textsuperscript{83}

In overview, these presumptions built into the approach to setting safety standards in the West\textsuperscript{84} can be seen to privilege the interests of industry and the military ahead of safety per se. Hollway, in a critique of the processes of setting the Australian radio frequency standard, added to Steneck’s concerns, providing a succinct overview of the situation:

One view is we should “play safe” by setting low levels now and raise them only if later research shows higher levels to be harmless. This view usually appeals to those who are actually being irradiated in the course of their daily work.

The opposed view is that the level of radiation which everyone agrees causes demonstrable harm, should be found as accurately as possible and the permitted level should be set at a not-too-large factor of safety below the danger level. This view has more appeal to those owning or controlling sources of RF radiation.

Eloquent claims are made that this is the only “scientific method” of setting maximum exposure levels because they are then based upon “proven facts”.

My view is that, far from being scientific, this procedure is unintelligent as best and often is disingenuous.


\textsuperscript{84} Whilst in Australia there is reliance on the IRPA group to set scientific rationales and the Australian safety standard sets a lower environmental exposure level for the general public than the U.S. guidelines, the Australian standard, nevertheless, still follows ANSI quite closely in occupational exposures and overall still works within a thermalist exposure rationale for guideline setting.


One of the few acknowledgements of athermal effects is not in relation to human exposure but the exposure of small animals. See p.4.

For a discussion on the ultimate thermalist basis for AS2772.1 see M. Repacholi, \textit{Report on Human Health Effects from exposure to Radio Frequency Emissions from the proposed Wollongong City Radio Transmitter Site, November 1990} (lodged with NSW Land & Environment Court). Some examples from this Report include: p.6:

\begin{quote}
3.15.: "No consistent biological effect has been found in molecular and sub-cellular systems exposed in vitro to RF radiation other than those effects occurring at SAR's that cause general temperature increases."
\end{quote}

\begin{quote}
3.16.: "No changes in chromosomes, DNA, or reproductive potential of RF exposed animals have been reported and corroborated in the absence of significant rises in temperature (SAR's >4w/kg). Similarly there is no experimental evidence to suggest RF fields cause mutations or genetic changes in bacterial test systems unless temperatures well above the normal physiological range are produced."
\end{quote}

\begin{quote}
3.17.: "There is no good evidence for RF radiation effects on haematological and immunological systems without some form of thermal involvement (SAR's >4w/kg)."
\end{quote}
Professor Steneck (Steneck, 1983) in criticizing the present ANSI standard (ANSI C95.1, 1982) states: "The assumption is made that when one is walking along the edge of a potentially dangerous cliff, the best way to keep from falling is to know exactly where the edge is. Theoretically, if all the twists and turns were properly plotted, one would not fall. (It is difficult not to point out in this regard that one could also avoid falling by not walking so close to the edge.)"

To expand this analogy a little, published research indicates that this "cliff" is probably undercut in unknown places, but pressure to site the path as near the edge as possible comes from those using the real estate - which in this instance is the RF spectrum.85

The circumstances surrounding the setting of the Australian radio frequency standard back up Hollway's argument. During meetings to determine the standard, the initial proposed level for 24 hour environmental exposure to RF of 40 microwatts (put forward by a CSIRO representative, David Hollway) was lifted to 100 microwatts after it was deemed unacceptable to industry and military representatives. But even this higher proposed limit would also have a short life: as the meetings drew to a conclusion, a letter from the Department of Communications was tabled, noting the radio frequency levels around Broadcast House in Adelaide exceeded the new proposed 100 microwatts levels. In response to this, the standard was summarily doubled to 200 microwatts.86 Given these actions, and the presumptions in favour of industrial and military interests, previously noted, the Australian Council of Trade Unions (ACTU) who had only been asked to attend the final phase of deliberations, withdrew from the standards setting committee, refusing to endorse the standard, arguing it did not accord with the most recent studies of athermal effects. John Matthews, in Health and Safety at Work: Australian Trade Union Safety Representatives Handbook, describes the ACTU's version of the history of the Australian radio frequency standard:

A committee of the SAA laboured for more than three years to produce a radiofrequency exposure standard which was simply going to be a reproduction of the ANSI proposal, until the ACTU obtained representation on the committee. Since then the debates have been acrimonious. Finally, in September 1984 the ACTU withdrew. The SAA has released a draft standard for public comment, but this has been condemned by the ACTU ...87

85 D. Hollway, op.cit., p.2.
86 Dalton, op.cit., p.41, c.f. footnote #51.
The inability of regulatory approaches to NIEMR to satisfy unions/labour organisations and achieve public trust, helped spark the second defining feature of the microwave debate, persistent inconclusive litigation and public hearings, it is to these that discussion will now turn. ⁸⁸

⁸⁸ See discussion in K. Massey, op.cit., c.f. footnote #50.
(v) Litigation
Reconstructing and Deconstructing Science
Competing Standards of Proof
Polarisation of Scientific Perspectives

If a person has testified in an unequivocal way in a court of law or a public hearing, he is,
psychologically, at least, constrained to maintain that position in future public utterances,
even in the face of new, dissonant data: And of course, such public commitments may affect
future pre-experimental design choices of these same scientists.
Rochelle Medici, 'Where has all the science gone?', in N.Steneck, Risk
Benefit Analysis, op.cit., p.190.

The first main source of litigation was compensation claims pursued by ex-US Air Force
radar operators. These claims came to be organised under the umbrella of the so-called
Radar Victims Network set up by ex-Air Force radar operator, Joe Towne.89

At its peak this organisation boasted more than 140 members. Many of the cases brought
forward by this group were settled by the Air Force out of court. Other
communications/broadcast/electronics workers have also brought injury claims to the
courts, this has included the often cited case of Samuel Yannon, which I shall discuss
shortly, and recently a case brought against the Boeing Corporation by a technician.90

Another important work related area of litigation and public inquiry involved VDU/VDT
workers. The first litigation took place when two New York Times copy-editors claimed
to have developed VDU induced microwave cataracts in 1976-77.91 Since that time (in a
debate worthy of treatment in itself)92 labour organisations/trade unions across the world

89 Dalton, op.cit., pp.72-73.
   Plus Smith and Best, op.cit., p. 180 and p. 237
   Plus Steneck, N., op.cit., Microwave Debate, pp.16-17 plus p.207-228
   Plus Johnson & Rix, eds., op.cit., p.56.
92 There are numerous overviews of the VDT radiation debate. For a good sample of views, see
   the following:
   (i) David W. Mercer, 'Visual Display Units (VDU's) Hazards or Helpers?', in Bankwatch:
n   a survey of major developments affecting the banking industry, Issue No. 3, prepared
   for the Australian Banking Employees Union by the Centre for Technology and Social
   Change, University of Wollongong, October, 1989.
have challenged the validity of non-ionizing radiation safety guidelines in relation to VDU work.93

Measurement studies have been lobbied for; scientific conferences specifically on VDU radiation organised94; and legal protection pursued for the rights of pregnant VDU


(iv) Demattio, B., op.cit., c.f. footnote #52.


(xi) Brodeur, P., 1989, op.cit., pp.229-300

(xii) The best source of information on the VDT debate can be found in the newsletter VDT News.


(v) See also discussions in most of the sources listed ibid.

94 For instance, there have been two major international scientific conferences on VDU health and safety featuring numerous reports on VDU radiation issue. The first in Stockholm in 1986 and the second in Montreal in 1990.

workers to be allowed transfer to non-VDU work without discrimination. This latter concern had been inspired by reports of numerous birth defects and miscarriage clusters amongst VDU workers in the late 1970's. These concerns are unlikely to abate, given recent scientific studies suggesting potential birth abnormalities amongst chicken and mice embryos exposed to weak EMFs and a number of contradictory epidemiological studies - one extensive study indicating significant rises in miscarriage proportional to time spent working in close proximity to VDU’s, another showing no increase.

Aside from personal injury claims, the other main form of litigation has surrounded zoning/planning issues. These disputes have involved local protest groups, councils,


For a particularly useful discussion on legal questions in relationship to VDU's and radiation, see:


Personal correspondences with:


(b) Gunnar Walinder, Swedish University of Agricultural Sciences, Faculty of Veterinary Medicine, Dept. of Pathology, Unit of Experimental Pathology & Risk Research, 16th November, 1988.


(ii) See also discussion in VDT News, 'Getting the Radiation Story Straight', January/February 1988, p. 11. Review of the so-called 'Hen-House Project'.

(iii) Brodeur, P., op. cit., pp. 290-300.

Two extensive studies (plus numerous smaller studies) have been undertaken.

The first of these by M. Goldhaber, M. Pollen & R. Hiatt in American Journal of Industrial Medicine, Vol. 13, No. 6, June, 1988 'The Risk of Miscarriage and Birth Defects Amongst Women who use Visual Display Terminals during Pregnancy', showed a significant increase in the rate of miscarriage relative to hours spent working with VDU's.

The second by Teresa M. Schnorr et.al., 'Video Display Terminals and the risk of spontaneous abortion', New England Journal of Medicine, v (324)(11) 14th March 1991, found no increase in the rate of miscarriage.

At the time of writing, a third prospective epidemiological study was still in progress (M. Marcus), see comments on this study's protocols in VDT News, Vol. 6, No. 5, September/October, 1989.

See also VDT News, Vol. V, No. 4, July/August 1988, p. 8 for overview of VDU epidemiology. See the same volume for commentary on Goldhaber and Pollen study also.
planning authorities, the electronic/communication industries and military representatives. There have been a number of well publicised 'zoning' disputes. Some examples include:

(i) the protests and public hearings taking place over many years from the mid 1970's involving the Sanguine (later Seafarer, later ELF) submarine communication facility in the US state of Wisconsin. This dispute will be discussed in more detail later as it supplied one of the important public links between the microwave debate and the present EMF/ELF powerline debate;

(ii) hearings and litigation (documented by Steneck in the Microwave Debate) surrounding the proposed development of a satellite up-link facility in the US, at Rockaway Township during the early 1980's;

(iii) protests over the so-called PAV-PAW's military facility in Cape Cod (documented by Brodeur in his second NIEMR book, Currents of Death);

(iv) clusters of Downs Syndrome births near radar facilities in Vernon County, US;

(v) there are also a number of Australian examples including the Woolloomooloo Radar Dispute and the Berkeley Radio Towers dispute.

In short, the regulatory controversy has left open the door for evaluation of NIEMR science to be pushed into legal and quasi-legal contexts. Because formal, generalisable decision making power and sufficient technical expertise to make decisions of lasting scientific credibility is beyond such bodies, it is not surprising that they tend to produce ambivalent judgements. Whilst immediate decisions of specific applicability can be

101 (i) Peter Vernon, 'Microwave and Health Hazard', Electronics Australia, October 1981.
(iii) See discussion in Dalton, op.cit., pp.33-46.
102 For the Woolloomooloo controversy see, for example:
(i) M.Regins, Woolloomooloo Community Centre Media Release, April 11, 1990.
(iii) 'Radiation from radars worries city residents', City Independent Newspaper, March 8th, 1990, p.3.
For the Berkeley controversy see, for example, 'Berkeley radio towers row deepens: '2 Double 0' to take Council to court', Illawarra Mercury, July 21st, 1990, p.9.
generated, decisions can be contested in future contexts. It can always be argued that decisions were made on the basis of lack of comprehension of the scientific evidence or that they are specific context-bound decisions. Perhaps legal burdens of proof may be satisfied in such contexts, but not necessarily scientific ones. Steneck argues that the last resort of litigation has done little to resolve the microwave debate.

When the divisiveness of chosen experts is added to the impossible task of finding solutions that have eluded the experts, it is not difficult to understand why the out of court settlement has been so popular. It is the legal community's way of avoiding decision making. Congress can pass the RF bio-effects problem along to the executive. The executive can drag its feet. Scientists can always ask for more time and money to gather more information. The media can popularize without facing up to the facts. And the legal process can put out small fires without getting burned by the main inferno. The circle of indecision is complete, the underlying problem remains. ¹⁰³

Taking Steneck's overview above as a point of departure, six main ways that legal and quasi-legal activities have shaped the NIEMR debate can be proposed. They have:

(i) helped publicise the NIEMR issue;
(ii) frequently provided evaluation of scientific evidence contrary to formal regulatory bodies;
(iii) provided contradictory assessments of the state of NIEMR science;
(iv) (by doing the above) produced a source of cognitive dissonance amplifying and helping to perpetuate the NIEMR controversy;
(v) provided a forum for many dissenting and establishment scientists to push their respective knowledge claims;
(vi) provided a context for the overt politicisation/polarisation and shaping of NIEMR knowledge claims.

These points stand out clearly in the following sets of examples. In the first set, the first four (i) - (iv) points, in particular, are exemplified - in the second set, points (v) - (vi).

In the first set of examples, the so-called Yannon case will be compared with the case of Mulhausen and Ryan against Litton Industries. Of the numerous other personal injury actions which have arisen possibly the most widely publicised and important one has been the case of Samuel Yannon. Yannon had been a technician on the Empire State Building - one of his jobs had been to adjust radio transmitters while they were operating and without shielding. This involved repeated years of microwave/RF exposure. Yannon developed numerous health problems and died. His widow brought a legal action against his employers, New York Telephone Co., claiming that he had died of 'microwave' - radio wave illness. A panel of the State of New York Workers Compensation Board, relying heavily on the evidence put before them by NIEMR researcher, M. Zaret, found in favour of Yannon's widow. The conclusion of the Panel was:

Upon review the Board Panel finds based on the entire record and particularly the testimony of Dr. Riev and Drs. Sanlillo and Zaret, that there was a direct causal relationship between the descendant's exposure to microwave radiation and his subsequent disability all of which ultimately resulted in his death. The Board's panel further finds that the descendant sustained an occupational microwave radiation disease of section 3, subdivision 2, paragraph 30 of the Workers Compensation Law and that his death was causally related to his occupation.

The result of the Yannon case was problematic. Although standards of proof in regulatory contexts dismissed chronic athermal NIEMR bio-effects out of hand, for some legal purposes, 'microwave-radio-illness' could be sufficiency well established to be regarded as an identifiable occupational illness.

Whilst the Yannon case helped fuel further public doubt about the reliability of 'regulatory bodies', its potential broader influence had to be put into context. Legal precedent could also be found challenging 'athermal effects' and the reliability of the same scientific voices. A good example of this problem can be taken from Steneck.

(ii) For a brief commentary on Yannon see P. Vernon, *Electronics Australia, op.cit.* p.16.
In 1975, a damage case was brought against Litton Industries by Helen Mulhausen and Agnes Ryan for alleged injuries from a microwave oven. In these proceedings, Milton Zaret (whose scientific opinions were to be accepted in Yannon's case) was called by the plaintiffs to give evidence. Zaret fared badly during cross examination, without waiting for proceedings to continue further, Zaret and the plaintiffs parted legal company. Mulhausen and Ryan asked for the case to be dismissed:

... without prejudice and without costs to any of the parties,

they concluded

we now believe that Dr. Zaret has no scientific basis for his claimed findings that we had microwave eye injuries and cataracts caused by exposure to leakage from a microwave oven. We believe Dr. Zaret has misled us and consequently caused us to expend enormous time and effort in futile and unnecessary litigation.\(^{106}\)

The legal record, as observed by Steneck, was/is littered by out-of-court settlements and contradictory legal decisions. Depending on the specific context, the form of hearing/tribunal, the resources brought to bear on the issue by various parties, decisions on the merit of this or that scientific position, have varied.

The next set of examples will discuss the important issue of the ways recourse to litigation have helped shape science in the microwave debate. The first point worth noting is the way such settings have contributed to the polarisation of (the) NIEMR debate. This derives ultimately from the un-erring regularity with which a small number of scientists have dominated NIEMR legal/quasi-legal hearings.\(^{107}\) In such environments, these key groups of normally 'elite' scientists tend to become the representatives of certain fixed viewpoints which are further elaborated and refined via the demands of legal process. These positions become entrenched via pressures not to


\(^{107}\) A good example for instance would be Edwin Carstensen who, according to Brodeur, 1989, *op.cit.*, p.188, had appeared in over twenty court cases extending from the New York State Public Service Inquiry in 1976 to hearings in Houston in 1985. It is interesting to note Carstensen appeared recently in a case that will be discussed at a later point in the thesis, the Warren (OPIC) versus ELCOM proceedings in New South Wales, 1990.
acknowledge uncertainties or new areas of research that may call for review of their 'evidence'. Further legal processes often demand acts of interpretation and synthesis going well beyond that of the expert in question, in doing this there is yet again a tendency to gloss over subtleties, shades of grey, that may inhere in the sub-disciplines being commented on.  

Scientists who become locked into such positions affect the direction of NIEMR science in two primary ways: they commit polarised overviews to the public record, and, by retaining their status as elite adversaries, they may also begin to shape their own research projects accordingly. Rochelle Medici, a long time NIEMR researcher, commented on the 'psychological' pressures which could shape the 'science' of NIEMR scientists who had become embroiled in 'legal hearings' in the following terms:

If a person has testified in an unequivocal way in a court of law or a public hearing, he is, psychologically, at least, constrained to maintain that position in future public utterances, even in the face of new, dissonant data: And of course, such public commitments may affect future pre-experimental design choices of these same scientists.

There is also evidence that such pressures on scientists taking 'public positions' have extended beyond these putatively "psychological" ones. There have been numerous claims, for instance, that a number of NIEMR scientists have 'developed' scientific positions specifically for use in adversary settings and purely on the basis of significant financial reward. Alternatively, there have been claims that some scientists have been victims of suppression, speaking up in public contexts resulting in cuts to funding. Whilst suppression can be used as a tool to silence scientists bringing knowledge to

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108 Some of these issues shall be discussed in more detail at a later point in the thesis.

109 This is not to assume that it is in fact possible to produce scientific knowledge immune from the shaping by social and psychological factors. The discussion of psychological factors in question merely exposes how specific factors, in a specific context, may have shaped knowledge claims.

109 Rochelle Medici, 'Where has all the science gone?', in Steneck, N., op.cit., Risk - Benefit Analysis, p.190.

public attention, it can also produce the opposite effect of scientists pushing their claims in public forums even harder and in more extreme forms.

A good example of the first 'extra psychological' factor is the case of Sol Michaelson, who, normally with Herman Schwan, appeared in numerous NIEMR hearings and legal proceedings. The motivation for his scientific position was challenged by a number of opposing scientists. Allan Frey and Andrew Marino both present evidence for their beliefs that Michaelson changed his scientific standpoint on NIEMR following upon it becoming a public issue and Michaelson's gaining employment as a representative of power utilities and military interests. To back up his claim, Frey, juxtaposes statements made by Michaelson in 1966 with statements he made in 1973 as a paid up witness in the courtroom.112

A good example of the second 'extra psychological' factor (scientists 'going public' because of perceptions of suppression) would be the case of Becker and Marino. They suggested that as a result of court appearances they had existing research funds cut and found that funding applications were rejected and their jobs threatened.113 They moved

(ii) See also discussion in Marino, A., op.cit., The Electric Wilderness, pp.116-117.

113 (i) See discussion in Marino, A., op.cit., The Electric Wilderness, pp.58-59, alleging the journal Science refused to publish his and Becker's 'legitimate' scientific work for political reasons, and pp.100-103, for allegations that Becker's laboratory and research programme was closed for political reasons.

Another set of well publicised claims of scientific suppression have followed research in to NIEMR and cataract formation. In the U.S., New York ophthalmologist, Milton Zaret has claimed suppression.

Zaret, Milton M., M.D., Scarsdale, New York, personal correspondence, 14th November, 1988:
"Thank you for the interest in my work. However, as my research about VDU radiation hazards is quite straight-forward, my work is not subject to "debate". All of my findings have been as described. The question of "ethics" is another matter. You might do better grappling with that subject. Good luck in your endeavour."

For an account of some of the controversy surrounding Zaret's work particularly as to the issue of whether or not he has been the victim of scientific suppression, see Steneck, N., The Microwave Debate, op.cit., pp. 162-165 plus pp.200-203.

In Australia, Fred Hollows, Professor of Ophthalmology at the University of New South Wales (and Australian of the Year, 1990) had appeared as a witness for an alleged case of microwave cataract on behalf of an ex-radar operation in 1985. He had also conducted research on behalf of the Australian Postal and Telecommunications Union. This research examined the rates of
from being well funded, mainstream research scientists with secure tenure, whose opinions had been regularly sought by government bodies to being, in Marino's term, inhabitants of a hostile scientific 'wilderness'. This 'real' or 'merely' perceived suppression has come to provide an important, readily acknowledged motivation behind the publication of their numerous quasi-scientific texts. These have been pitched to a non-expert audience, containing information and commentary on the politics of the NIEMR debate. Much of Brodeur's sensationalised journalism on the NIEMR debate has taken as its starting point the various published views of scientists such as Becker and Marino.

cataractogenesis amongst Telecom linesmen. He found that linesmen exposed to microwaves were 3 times more likely to develop cataracts than those not exposed. Hollows' study was published in the Lancet, Hollows, F.C. & Douglas, J.B., 'Microwave Cataract in Radio Linemen and Controls', Vol. 18, p.406, August, 1984. His work generated considerable controversy. Unions argued for modified work practices and Telecom, through its Chief Industrial Hygienist, wrote to the Vice Chancellor of the University of New South Wales suggesting that it was improper for Hollows to have published his findings without first obtaining Telecom's permission to study its workers. Finally, to close the incident, Hollows applied twice for a grant to do follow up study from the Australian National Health and Medical Research Council (NHMRC) and was twice refused even though his study was recommended by the NHMRC's own referees. See discussion in Dalton, op.cit., pp.73-74.
(vi) The Political Shaping of NIEMR Health Research: Arthur Guy's Life-time Rat Studies

... these authors [Guy and Foster] are not disinterested parties providing information on health hazards of microwaves.

... the authors base much of their article on the ANSI (American National Standards Institute) "standard". They do not tell the reader that ANSI is almost entirely funded by industry. Its officers and directors are almost entirely drawn from industry. The military, the biggest user of microwave equipment, initiated the ANSI microwave-biohazard committee, selected its first chairman and has largely determined what research would be carried out on the biological effects of microwaves. The authors do not reveal that conflict of interest or the fact that most of their own research funds have come from the military.


The third distinctive feature of the microwave debate has been the controversy over evaluations of the status and implications of a growing body of scientific studies testing for, or suggestive of, athermally induced biological effects. Evaluating such studies has become controversial. A number of scientists and commentators have claimed, there have been suppression of and limited funding provided for such studies, and a number of such studies have been unduly influenced by the interests of their financial sponsors. This influence, it is claimed, is reflected both in choice of experimental design and in the nature of the conclusions being drawn from the data generated by the studies. The fighting out of this controversy in public domains has meant further research has tended to fan the NIEMR debate rather than close it, the conclusions of studies in themselves being prone to constant reconstruction/deconstruction. The politics surrounding one study in particular exemplify the problems in question. The study that will be discussed is the Arthur Guy 'life-time rat study' sponsored by the US Air Force.

Guy, an engineer from Washington University, St. Louis, had been Chairman of the ANSI RF Guideline Committee from 1970. In September, 1978 the US Air Force, following up public concern over radar installations, commissioned Guy to do a study of long term low level RF health effects. The study which ultimately commenced in September 1980 involved studying 200 rats for their life times of 25 months - one

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hundred rats would be continuously exposed (21 hours per day) at 2.45 gigahertz at 0.5 milliwatts per centimetre squared, which is approximately 20 times lower than the safe thermal level, and the rats' absorption watts per kilogram would be from half the ANSI human guideline level to approximately the same as human level. A control group of 100 rats would not be exposed. Ultimately 155 different end points would be measured and the groups compared. This study was both the first and still the largest to the present long term low level study of RF MW athermal bio-effects. It's ultimate cost was between $4.5 - $5 million.

The study was embroiled in controversy even before it commenced. In January 1979, in IEEE proceedings, Guy reported his planned experimental procedures. In these plans there was no mention of tests for behavioural effects. Long time athermal bio-effects researcher, Allan Frey, put forward a detailed critique of Guy's proposed experimental procedures. He focused on (i) the absence of behavioural tests and (ii) the proposed use of pathogen free, or gnotobiotic rats. A unique population of rats, according to Frey, would not allow extrapolation: "to the general population of rats much less man". (This point would also be taken up more than a decade later in a critique of the study's results put forward by Robert Becker.) Frey also commented on whether the frequency being used was appropriate, and he also objected to the fact that such an important study, potentially a one-off because of its huge expenditure, had not been openly debated in relation to its experimental techniques amidst the scientific community more generally. When Guy's study actually commenced some behavioural measures were incorporated into its design, although Guy would not concede that this had anything to do with Frey's critique. And, rather than the incorporation of behavioural tests quelling the controversy, it actually fuelled it further.

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Frey and Medici\textsuperscript{118} argue that the behavioural tests chosen were so inadequate that it was actually worse than not doing such tests at all, and, further that this indicated a deliberately poor experimental design and the obvious invasion of politics into science. Frey, for instance, noted that in a previous report co-authored by Guy it was stated in relation to NIEMR bio-effects that "... behaviour is the most sensitive litmus of biological reactivity". Frey goes on to assert that:

Despite these comments, Guy made no mention of behavioural studies in his 1980 article on the opening phase of the Air Force-sponsored study, even though "all biological endpoints and procedures [for Phase II] are the same as described in the Phase I section. Various members of the scientific community, including me, raised questions about his exclusion of nervous system and behaviour measures. Only then did he include in his approximately $1.5 million study a nominal, relatively insensitive activity test for occasional use. The test involves placing a rat in a box for 3 min once every 6 weeks and measuring how far it walks. It is not even a standard open-field test. But the issue is not when he included this trivial test, but rather why for all intents and purposes he excluded all nervous system and behaviour tests..\textsuperscript{119}

Guy responded to Frey's criticisms in the following way:

This is in response to the statement made by Mr. Frey in the above mentioned paper indicating that we played a part in selecting the biological tests being conducted in our Air Force sponsored long term exposure study. We indeed did not select the endpoints. These were selected in the attached statement of work contained in the Request for Proposals (RFP) disseminated by the Air Force.\textsuperscript{120}

Guy also argued that the behavioural test in question was indeed an adequate one and noted that the Air Force ruled out extensive tests on central nervous system and behaviour because "it would have required placing electrodes in the rats' brains". This implicitly would interfere with the rats longevity - one of the test's main parameters. Frey's response to this was as follows:

This is nonsense! One does not have to place electrodes in the brains of animals to carry out tests of the central nervous system and behaviour. For Guy to have said that the Air Force ruled out such tests for this reason is to imply that the Air Force

\textsuperscript{118} Frey, \textit{ibid.}, p.226.
\textsuperscript{119} Frey, \textit{ibid.},p225.
\textsuperscript{120} Guy in \textit{ibid.}, p226.
personnel are incompetent or worse. Further, his words "... ruled out extensive tests ..." are grossly misleading. It implies a representative but not extensive set of central nervous system and behavioural tests were included; but they were not. Only one nominal, insensitive test for occasional use was included, if such could even be called a behavioural test.

Why did Guy take on a project which involved the expenditure of approximately $1.5 million of public funds with the known critical sensitive tests ruled out by the sponsor for a nonsensical reason? Is this science?121

From the outset then one of the most important and supposedly definitive NIEMR studies was shrouded in controversy. Much of this controversy was to seep into public forums. For instance, Frey and Guy had both been embroiled in a zoning battle surrounding satellite up-link facility at Bainbridge Island in Washington State. In 1981 the RCA Company retained Guy as a consultant. The issues surrounding the adequacies of Guy's experimental work in fact arose in a discussion of the EIS for the Bainbridge project.122

The controversy surrounding the Guy experiment entered a new phase when its preliminary results were released in 1984. Guy reported that the study revealed few differences between cases and controls; no defendable trends, and that overall the study produced negative and ambiguous results. It did, however, observe one striking difference. This was the fact that "primary tumours developed in 18 of the exposed animals but in only 5 of the controls".123 This result though was down-played. Guy argued that:

(i) the difference between tumours in controls and exposed rats was ambiguous because the exposed rats had the number of tumours that should be expected for that particular strain of rat. So it was not a difference between exposed rats and controls that they had observed but a difference between the control rats and normal rats;

(ii) that there was no single tumour type predominant in the exposed rats which is what one would expect if NIEMR was a carcinogen;

121 Frey in Steneck, N., ibid., pp.225-226
122 See Steneck, N., op.cit., The Microwave Debate, pp.210-218
123 Guy & Foster, op.cit., p.33-34
(iii) that given 155 different bio-effect endpoints were being tested, it should be expected by chance at least one striking difference would occur between controls and exposed animals. (This statistical shuffle turned the significance of a 13% difference between tumours in cases and controls to tumours equalling an insignificant 1/155 difference!);

(iv) that the study was too small to be able to test for the increase in any one kind of tumour anyway. "To demonstrate reliably a connection ... might require a study hundreds of times larger and more expensive than the Seattle study - a size that might be infeasible."124

Guy's version of the implications of these increased tumour levels came under numerous attacks. In 1984 the issue was brought to the mass media's attention by Washington epidemiologist Samuel Millham.125 Further, in the December 1986 issue of The Scientific American, Allan Frey, and Louis Slesin the editor of Microwave News, wrote letters responding to Guy commenting on implications of his study in an article in The Scientific American in September 1986. In Frey's letter, Guy is condemned and accused of misrepresenting the results of his study because of an obvious conflict of interest. Frey cites the numerous legal proceedings in which Guy, at that time, was scheduled to testify. As Frey put it:

"... these authors [Guy and Foster] are not disinterested parties providing information on health hazards of microwaves.

... the authors base much of their article on the ANSI (American National Standards Institute) "standard". They do not tell the reader that ANSI is almost entirely funded by industry. Its officers and directors are almost entirely drawn from industry. The military, the biggest user of microwave equipment, initiated the ANSI microwave-biohazard committee, selected its first chairman and has largely determined what research would be carried out on the biological effects of microwaves."

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124 (i) ibid., p.34
(ii) The study was never ultimately published in a peer review journal but rather formed a part of a nine volume, 4,000 page report (Vol.8) that had to be especially ordered from the Air Forces School of Aerospace Medicine.

125 See discussion in Brodeur, P., op.cit., pp.170-173.

Microwave News, Vol. 4 No.6, July/August, 1984, p.4 'Microwaves Promote Cancer', p.1 plus pp.4-5.
microwaves. The authors do not reveal that conflict of interest or the fact that most of their own research funds have come from the military.\textsuperscript{126}

In his letter, Slesin also accuses Guy of intentional misrepresentation. He notes that there was in fact a constant pattern amongst the rats' tumours. In the exposed group, 9 of the tumours had been of the rats endocrine system compared to 2 in the controls. He also notes that, as well as 18 malignant tumours in the exposed group, there were 6 benign adrenal tumours in the exposed rats and none in the controls. Slesin concludes:

That a principal investigator for a $4.5-million study should obscure his own positive results points to a basic feature of the "microwave problem": the domination of military funding for biomedical research on non-ionizing radiation and the reliance on engineers rather than biologists to do the research. Indeed, Foster and Guy are both engineers.

The proposition that microwaves can have non thermal effects is now widely accepted, even though it lacks a mechanistic explanation. Until we understand how microwave radiation interacts with living systems, the public will continue to be suspicious and the microwave problem will continue to be with us.\textsuperscript{127}

Further criticisms of Guy's study included a letter to \textit{Microwave News} by Ross Adey and Asher Sheppard quoted in Brodeur's \textit{Currents of Death}:

Their apology for the elevated cancer incidence has all the aspects of an option more often exercised by politicians ... if the facts are unattractive, bury your head in the sand (i.e. statistics) and hope that no one will notice the odd posture.\textsuperscript{128}

Criticism of the Guy study continues up to the present.\textsuperscript{129} The popular quasi-scientific book \textit{Cross Currents} by Robert Becker raises the issue high-lighted by Frey, a decade before, surrounding the choice to use gnotobiotic rats.

One can only conclude that the experiment at Washington was deliberately designed to sharply reduce the incidence of cancer and infectious diseases in the exposed animals. There can be no other reason for the requirement that the animals be gnotobiotic.\textsuperscript{130}

\textsuperscript{126} \textit{Scientific American}, December 1986, Vol.255, No.6, Letters, A.H. Frey, pp.5-6
\textsuperscript{127} L. Slesin, \textit{Scientific American}, \textit{ibid.}, p.9.
\textsuperscript{128} Brodeur, P., \textit{op.cit.}, p.173.
The controversy over guidelines and standard setting; the recourse to litigation to settle the practical problems involving scientific disagreement, the shaping of science by the pressures of such litigation; and, within this environment, the inability of scientific studies to provide closure, are all key features of the microwave debate which continue to the present and, as shall be seen, also permeate the EMF powerline debate. These factors have flowed into the EMF debate for three broad reasons: first, quite simply because so many of the institutions and scientists and relevant actors have been involved in both parts of the controversy; second, because depending on which scientific perspectives are accepted at a theoretical level the microwave and EMF debates are both parts of a unified larger scientific debate; and a third, because of specific historical contingencies which have linked these debates, some of which will be noted in Chapter 4.

But before going on to clarify the specific connections between the microwave debate and the powerline debate, it is important briefly to discuss what was described above as the third major input into the EMF powerline debate: the growth of new scientific perspectives within the emerging scientific discipline of bio-electromagnetics.

It is also interesting to note that at the time of Guy's results first coming to attention even a number of conservative reviewers acknowledged the implications of them. For instance, Martino Grandolfo, a member of IRPA, acknowledged:

"If confirmed, the new study would undermine the 1982 ANSI radio-frequency and microwave radiation exposure standard, because this standard asserts that the level of exposure used in the Guy study is safe. The findings are far from definitive, but a number of experts found the preliminary and yet unpublished data highly suggestive of a link between microwave radiation and cancer, possibly through a stress reaction."

Chapter 3:
The Emergence of Bio-electromagnetics;
The routinisation of athermal approaches;
W.R.Adey - calcium efflux and the cell membrane;
R.Becker & A.Marino - NIEMR as a biological stressor.

This area [athermal approaches to bioelectromagnetics] has grown from one in 1960 when less than a handful of scientists was involved to one today when we have three accredited scientific societies, two scientific journals devoted to this discipline in this country alone and literally thousands of scientists involved on a world wide basis. The question no longer is one of "Do very small EM forces have any bioeffects?" but "What is the level of hazard from abnormal EM energy?"


(i) Introduction

There have been, over the years, a number of eminent scientists (such as Szent Giorgi and Herbert Frolich) who have explored what might be described (from a 'whiggish' perspective) as athermalist approaches to the role of electrical interactions within biological systems. However, it has only been in the wake of the 'tri-service era'; with the Moscow signal affair and ensuing regulatory debates, that the various strands of research into biological effects of electricity or bio-electromagnetics have begun to consolidate into a scientific discipline in its own right. In 1978, the Bio-electromagnetics Society was formed. In 1981, the Journal of the Bio-electromagnetic Society was launched. Since then, annual conferences have been held and numerous collections of scientific studies published. Further, from 1982 the newsletter Microwave News reporting on current NIEMR research, with a special emphasis on health and safety issues, has been published providing visible communication, not only between researchers but for regulatory bodies, industry, the

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131 For some historical perspectives on early bio-electric or bio-electromagnetic research see discussions in:
(iii) Smith & Best, op.cit., pp.8-84, c.f. footnote #19.

132 B.Wilson, op.cit., pp.7-8, c.f. footnote #61.
133 E. Lerner, op.cit., p.52, c.f. footnote #45.
attentive public, and press. These developments, which show an emerging discipline not merely devoted to re-affirming thermalist approaches in the narrow context of industry and military interests, have been important in keeping the NIEMR debate open. (Though it should be noted that Bio-electromagnetics research still possesses significant industry and military contacts.)

Such institutional trappings and legitimate forums for scientific discussion have also, no doubt, been important in compensating for unstable and poorly co-ordinated funding for NIEMR research which continues to the present. Funding has fluctuated over the last decade. It particularly suffered during the mid-1980's via the policies of environmental deregulation of the Reagan era. Some important projects, though, most especially the New York Power Line project, stood against this trend. More recently, funding has been on the upswing, partially due to public concern flowing from continuous litigation, Brodeur's second NIEMR expose, *Currents of Death*, released in 1989, and the two recent US Government reports suggesting that concern over the

135 It is appropriate to think of the 'attentive public' rather than the general public when considering the impact of a journal such as *Microwave News*. This is the case for the following reasons:

(i) *Microwave News* has a particularly small circulation. (For instance, in Australia - at time of writing - no public or university libraries subscribe to it).

(ii) It has often been noted that media treatment of the content of specific areas of science is more likely to be sought by segments of the public who have specific as opposed to general interest in the topics being reported on.


136 For commentaries on the significance of the journal *Microwave News* see Philip Elmer D. Witt in *Time* magazine, 'Hidden Hazards of the Airwaves: An obscure newsletter uncovers the perils of the information age', July 30th, 1990, p.51.


health and safety of NIEMR is well-founded and demands further scientific research, the OTA Report (1989) and Draft EPA Report (1990).  

The emerging discipline of bio-electromagnetics has involved a wide variety of different types of scientific research, tapping diverse specialties and generating the need for new interdisciplinary expertise. Whereas one might expect the trend towards discipline crystallisation would generate more consensus in scientific debate as basic measures of replication, experimental techniques, quantification etc. are negotiated and become more settled (and there is in fact some evidence that this is beginning to occur amongst researchers\(^1\)), the underlying pressures of litigation, regulation and, as noted, the sheer complexity of evidence have seen the polarisation between athermal and thermal perspectives continue relatively unabated in many public debates. To no small extent, because of this, there has been a strong tendency for new studies to be read and deployed as 'for' or 'against' NIEMR health effects quite apart from any potential they may have to inform new biological and physical models.

An important element helping to entrench athermalist perspectives, given their diversity, has been a number of attempts to propose theories which unify athermalist perspectives. Whilst there are numerous athermalist lines of study, all vindicating the inadequacy of thermalist perspectives, there are fewer hypotheses attempting to propose unified mechanisms for athermal bio-effects. Two athermal bio-effect theories have been

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\(^{141}\) See Wilson, B., \textit{op.cit.}, c.f. footnote \#61 (i).

Plus Cunningham, \textit{op.cit.}, c.f. footnote \#138.

prominent in public debate. They have been the theory of Robert Becker and Andrew Marino which focuses on the idea of NIEMR as a biological stressor, and Ross

Robert Becker studied at Gettysburgh College, Pennsylvania, majoring in biology, obtaining his medical degree from New York University School of Medicine. In 1956, he became Chief of Orthopedic Surgery at the Veteran Administration Hospital, Syracuse. During the 1960s, he performed experimental work on injury currents and limb regeneration in salamanders and frogs and also attempted to apply this work to healing bone fractures in humans. He also performed experiments on human response time with exposure to NIEMR and had numerous papers published in journals such as *Science and Nature*. In 1964, he was awarded the Veteran Administration S.Middleton Award for outstanding achievement in medical research. In 1971, he was granted a medical investigatorship at the Veteran Administration Hospital. In 1972, he voiced public concern at a meeting of the IEEE about possible harmful effects of increased broad-scale NIEMR exposure to the public. In 1973, he served on the US Navy's Bureau of Medicine and Surgery Advisory Committee reviewing the research programme on the bio-effects of ELF radiation set up in response to the Sanguine Project. In the same year, he communicated the findings of this Committee to the New York Public Service Commission, who were reviewing siting policies of a proposed high voltage powerline from Massena to Marcy. In 1974, the New York Public Service Commission invited Becker to testify in hearings on the siting of the Massena to Marcy powerline. In 1976, Becker was invited to attend the New York Academy of Science Committee on Biosphere Effects of ELF for the Seafarer (ex Sanguine) Project. Becker refused because of his beliefs that the Committee was biased, targeting Sol Michaelson and Herman Schwan. (See discussion in Chapter 2). Later in 1976, his application for continuation of his medical investigatorship was deferred and his research grants from the US National Institute of Health were discontinued. In 1979, he won the Nicolas Andry Award of the Association of Bone and Joint Surgeons for outstanding achievement in the field of orthopedic surgery. In 1980, all Veteran Administration grants were terminated and his laboratory closed. Becker retired from the Veteran Administration and established a private research and consultation firm: Becker Biomagnetics. Biographical sketch taken from Brodeur, 1989 *op.cit.*, Becker & Marino, 1982 *op.cit.*, Becker 1989 *op.cit.*, and Marino, 1986 *op.cit.*

Andrew Marino, Ph.D. in Biophysics, New York State University. From 1964-80 he was an assistant to Robert Becker in the Veteran Administration Hospital publishing numerous joint papers on bio-electricity, bone healing and growth mechanisms. During this time, in 1973, he performed studies on the biological effects of 60 Hz. fields on growth patterns in rats noticing a range of harmful effects. Between 1974-78, he became involved as a key witness in the New York State Public Service Inquiry, involving the Massena to Marcy Powerline. In 1975, complementing his Ph.D. in bio-physics, he completed his Law degree and was admitted to the New York Bar. In 1980, upon the closure of Becker's laboratory at the Veteran Administration Hospital, moved to the Department of Orthopedic Surgery in Louisiana State University School of Medicine. In 1985, promoted to Associate Professor of Orthopedic Surgery. In 1986, he published an autobiographical account of his involvement in New York State Public Service Powerline Inquiry and the politics of the NIEMR debate. He has since appeared frequently as a public EMF advocate. Sources for biographical sketch - see *ibid*.

The theory of NIEMR as a biological stressor has been expounded in a number of different places. The text will rely mainly on discussions in:


(viii) Conversations with Andrew Marino during the Warren (OPIC) versus ELCOM proceedings, September 1990
Adey's\textsuperscript{145} theory which focuses on the ability of NIEMR to initiate biological change via the interruption of intercellular communication patterns at the site of the cell membrane via such 'experimentally replicated' mechanisms as so-called 'calcium efflux'.\textsuperscript{146}

A number of important broad similarities and differences can be observed between these theories. Looking first at the similarities, we can observe that both theories not only claim to explain how NIEMR can be harmful but also assert that they are revolutionary contributions to modern science. Second, both theoretical perspectives are applicable to the health and safety issues surrounding the NIEMR across the spectrum from the ELF of powerlines to the microwaves of radar devices.

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\textsuperscript{145} W.R. Adey, born in Adelaide, Australia. In 1939, he commenced studies at the University of Adelaide Medical School. Between 1943-45, Adey spent two years as Surgeon Lieutenant in the Australian Navy where he developed a familiarity with radar techniques. In 1945, he returned to Adelaide Medical School, commencing his doctoral studies. Upon graduating in 1949, Adey moved to Oxford University for two years as an Oxford Research Fellow in anatomy and physiology of the limbic system. In 1951, he was awarded a Rockefeller Grant in the US. In 1954, he took up a position as Professor of Anatomy and Physiology in the Department of Anatomy at the University of California (UCLA). In 1961, he joined the UCLA Brain Research Institute. In 1965, he became the Director of the Space Biology Laboratory in the Brain Research Institute, UCLA. From the late 1960's to early '70's, Adey was involved in numerous projects involving bio-effects of NIEMR. These were funded by organisations such as NASA, ARPA, NSF, the Air Force Office of Aerospace Research and the Office of Naval Research. This research involved such things as: studies of response times in animals exposed to NIEMR, early calcium efflux experiments, and some studies commissioned in response to the Moscow signal and Sanguine project. In 1976, Adey was a member of the National Science Foundation Discussion Committee on Seafarer (ex Sanguine) project. In 1979, he became Associate Chief for Research and Development at the Jerry Lee Pettis Memorial Veteran Hospital, Loma Linda School of Medicine, quoted in Brodeur, 1989, \textit{op.cit.} that he moved from UCLA to work in an environment free of 'establishment' views regarding cell and molecular biology. In 1978-79, as a member of the National Academy of Science Committee on biological effects of PAVPAWS missile early warning system, Adey published criticisms on US Air Force policy on health and siting of the project. From 1980's to present, he has been involved with scientific work on NIEMR and hypotheses of cancer promotion via effects of NIEMR on ODC ornithine decarboxylase, an enzyme important for cell growth which can be observed to be more active in malignant cancer cells. Its activity has also been noted to be stimulated by NIEMR. He has also spoken before a number of US Congressional hearings on NIEMR bio-effects but has been reluctant to appear as an expert witness in adversarial contexts. Source: Brodeur, \textit{ibid.}

\textsuperscript{146} The discussion of Adey's work above relies mainly on:


There are, nevertheless, some notable differences. First, Becker and Marino have been much more persistently publicly vocal in their dissent from mainstream science. Becker's theories have followed this pattern in particular. He has written a number of books which could be described as quasi-scientific, intended to appeal to both the public and technical expert. Becker has not been reluctant to locate his work as a bridge between the alternative and holistic scientific health movements and legitimate traditional science.\textsuperscript{147} Becker and Marino also make much of the politics of science, especially the claim that the military and industrial shaping of NIEMR research has helped to suppress athermal bio-electromagnetics.

Adey, by comparison, orients his work in terms of 'more traditional' scientific justifications. The power of detailed, empirical models and replication rate strongly in Adey's discourse. Adey's critique of establishment science is that it is incompetent and closed-minded.\textsuperscript{148} Whilst Adey has, at different times, attempted to explain his ideas to a non-expert public, he has also consistently proclaimed that the intrinsic complexity of bio-electromagnetic science is actually beyond most engineers and biologists and certainly beyond the grasp of the public, regulatory experts and social scientists. As far as suppression of bio-electromagnetic research, via military and industrial interests, Adey has made a number of ambivalent statements. At times he has been vitriolic in his criticisms of establishment science and the vested interests shaping its funding. Further, there have been occasions where he has not been reluctant to make such claims in public forums such as radio and television.\textsuperscript{149} Nevertheless, he has been equally vitriolic in

\textsuperscript{147} Becker, \textit{Cross Currents}, op.cit., see esp. Part I 'The History of Life, Energy and Medicine', pp.3-84.
\textsuperscript{148} W. R. Adey, \textit{The Sciences}, op.cit., pp.54-55.
\textsuperscript{149} See, for instance, comments made by Adey to a resident concerned over the siting of a radar uplink facility. Letter from Adey to Diane Stockley, November 4th, 1986, p.2: "You should feel free to transmit the contents of this letter to representatives of the media, including Mr. O'Brien, on the one hand; and on the other, to those mealy mouthed acolytes of an uninformed establishment who arrogantly presume to arbitrarily impose their ignorance on the medical welfare of others." For public statements of similar kind see Adey, transcript radio interview, May 6th, 1987 \textit{ABC Radio National Science programme}, p.3; and heated public exchange between Repacholi and
criticising Becker and Marino for moving beyond their expertise into 'pop science' theorising and political conspiracy theories. In the next two sections of this chapter - (ii) & (iii) - the key features of the theories of Adey and Becker & Marino will be examined, starting with the work of Adey.

Adey, 4 Corners, ABC TV, 2nd September, 1985, p.4-9; Parliament of the Commonwealth of Australia, Department of the Parliamentary Library, Current Information Section, transcript. Adey, The Sciences, op.cit., p.58.
(ii) Adey's Theory

For more than thirty years the equilibrium view has held sway in biology. Nobel Prizes in profusion have been bestowed on those who produced evidence that signalling across the cell membrane entails a large expenditure of energy, and their acolytes have dutifully indoctrinated succeeding generations in these ecclesiasticisms. They have seen flood tides of ions bursting across cell membrane boundaries as the sole, sufficient means of signalling and as the basic step in excitation, whether of a cortical neuron involved in forming a sentence, a nerve fibre that initiates a reflex, or a glandular cell that secretes a hormone. All have been lumped under a single rubric in the sheer brutishness of equilibrium models.


It is important from the outset to note that this review is a simplified one. It has, nevertheless, attempted to synthesise Adey's ideas from his own writings rather than secondary accounts.

A convenient point from which to begin explaining Adey's theories is to note his belief that there has been a conflict between two fundamentally opposed ways of looking at the communication processes among cells, which controls their functioning. These are the so-called equilibrium versus non-equilibrium viewpoints.

Adey explains the equilibrium viewpoint in terms of the metaphor of a table top strewn more or less randomly with dominoes. These dominoes, placed without any obvious order, can be seen as being at equilibrium. No great expenditure of energy has been used to impart that particular structure on them. He proposes that given this model, if a signal were to be sent from one side of the table to the other, in order to change the positions of the dominoes on the far side of the table by touching one or more on the near side, a considerable amount of energy would be required. For instance, a wild sweep of the arm or hand.
In a non-equilibrium scenario, the dominoes are standing on their ends, in a line, allowing all the dominoes to be toppled by simply tapping one. In Adey's words:

The first of these scenarios corresponds to the equilibrium view of cellular communication, which holds that a large expenditure of energy is required to overcome the noise, or randomly arranged energy, within a cell and to convey a message to the cell's interior that will significantly affect its functioning. The second scenario corresponds to the non-equilibrium view, which holds that information can be conveyed across a cell's membrane with a very low expenditure of energy.\footnote{ibid., p.54.}

Adey notes that the second scenario involves energy being expended in structuring the dominoes in a non-equilibrium state. Nevertheless the advantage in this is that small future additions of energy initiate significant communication.

Adey goes on to argue that thermalist approaches to NIEMR are bound to 'brutish, equilibrium models of cell communication'.\footnote{ibid., p.55.} Such models only acknowledge the idea that cellular change can be initiated by the penetration of the cell membrane by large amounts of energy. Non-equilibrium models provide the background for the athermalist possibility of significant alterations in cellular function by interruptions in the normal processes of intercellular communication initiated by small amounts of the appropriate forms of energy.

For more than thirty years the equilibrium view has held sway in biology. Nobel Prizes in profusion have been bestowed on those who produced evidence that signalling across the cell membrane entails a large expenditure of energy, and their acolytes have dutifully indoctrinated succeeding generations in these ecclesiasticisms. They have seen flood tides of ions bursting across cell membrane boundaries as the sole, sufficient means of signalling and as the basic step in excitation, whether of a cortical neuron involved in forming a sentence, a nerve fibre that initiates a reflex, or a glandular cell that secretes a hormone. All have been lumped under a single rubric in the sheer brutishness of equilibrium models.\footnote{ibid., p.55.}
This non-equilibrium model of cellular communication draws from and adds to current theories about the structure and function of the cell membrane. Contemporary models of the cell membrane see the cell surface being made up of a double layer of 'phospholipid' molecules similar to a double-layer soap bubble. In the bi-layer, large complex molecules act as receptors to communicate between the cell and its surroundings, and as channels for moving selected material in and out of the cell.

Adey emphasises that an important part of these natural cellular processes is the role of cell surfaces and special receptors in amplifying weak electrical signals. As in the domino analogy noted earlier, receptors and the cells' surfaces are able to amplify extremely weak signals at the cell membrane to initiate activity inside the cell, such as the manufacture of proteins, enzymes and hormones. Adey describes these amplification processes as follows:

From a synthesis of research in laboratories worldwide, a picture has already emerged of the essential steps in this amplification. Central to the process are negatively charged strands of protein that protrude from the fatty layer of the cell membrane (they somewhat resemble a field of waving corn) and serve as the cell's main electrochemical sensor. First, a packet of electromagnetic energy - generated by another cell or perhaps at the cell membrane by a chemical reaction - loosens a few ions of the calcium bound to the protein strands, a loosening that rapidly spreads across the entire surface of the cell in a kind of domino effect. In some cases, this triggers a second such rapid reaction - an enzymatic brushfire that also encompasses the entire cell surface. The signal originally embodied in electromagnetic energy, thus amplified, passes across the membrane to the cell's interior. It is not yet clear what form the signal is now in, but there is plausible evidence that it travels down the strands of the helical protein molecules that pass through the membrane.

Signals from electromagnetic fields reaching the interior of the cell have at least two main effects. They can alter the structure of the cytoskeleton - the fine tubes and fibres that convey signals from the cell membrane to the nucleus and other tiny bodies within the cell. And they can alter the activity of key enzyme systems that regulate growth, metabolism, and intercellular communication.¹⁵⁴

According to Adey, numerous pieces of experimental work suggest that weak athermal NIEMR (fields mainly below 100 hertz or modulations below 100 hertz on higher radio frequency or microwave carrier waves) can interrupt and alter the normal communication processes between cells essential for normal cellular functioning. Different effects can be observed with different types of fields and different types of cells. Stronger fields do not necessarily elicit great effects. What appears to be crucial are the types of modulation and frequency. These are sometimes described as 'windows' or 'resonances' where particular effects can be observed in particular kinds of cells. Adey relies on a number of 'information metaphors' to help try to explain the kinds of 'non-linear electrochemical sensitivities' involved.

The past several decades have seen the gradual accumulation of a diverse and incontrovertible body of evidence indicating that far more sensitive mechanisms are involved, that a broad range of electromagnetic radiation has important effects on the functioning of cells. These effects not only occur at low levels of energy but are in some cases very sensitive to subtle changes in the low frequency (below one hundred hertz) of the energy source. For example, the ability of some lymphocytes (white blood cells) to destroy tumour cells is less pronounced in a microwave field modulated at sixty hertz than in a microwave field with a higher or lower modulation frequency. Some enzymes in these lymphocytes are more likely to catalyze certain reactions at sixteen hertz that at, say, five or twenty-five hertz. Such acute responsiveness to electromagnetic radiation occurs across a wide spectrum of cells, in the brain and the pancreas as well as the ovary; even the rate of bone growth has been shown to vary with slight changes in the electromagnetic environment. These sensitivities may be a general biological property; they may represent an intrinsic language of tissue by which cells "whisper together".155

One of the key experimental pieces of evidence for Adey's hypothesis has been the so-called 'calcium efflux' effect or the alteration of the flows of calcium ions from brain tissue when exposed to weak EMFs. Especially important in 'replications' has been the indication of a tuning curve, that is, the effect appears to be 'frequency and modulation specific' and varies proportionally to the strength of the Earth's or an imposed background static 'DC' field, i.e. tuning tends to argue against efflux being an experimental artefact. 156

155 *ibid.*, p.55.
156 See for instance the work of Blackman & Liboff and the concept of cyclotron resonance and, more recently, Lednev in providing more detailed causal hypotheses.
The linking of the calcium efflux effect to cancer causation has relied on a number of subsidiary hypotheses. Often it has been suggested that NIEMR plays the role of a cancer promoter by disturbing hormonal activity and the immune system, or, by working in a synergistic way with things such as chemical cancer promoters, enhancing potentials for carcinogenesis. Some critics argue that whilst Adey's work delivers a heavy blow to thermalist NIEMR perspectives, it falls short of demonstrating an NIEMR health risk at this point in time. (This will be discussed further in Chapter 8.)

Adey's work, whilst being persistently at the edge of the NIEMR controversy, has still managed to maintain links with establishment science. This credibility has made it an important resource in public NIEMR debates, in litigation, or for those wishing to challenge the validity of safety standards.

(iii) Becker & Marino's theory

The prototypical action of stressors is to promote (not initiate) disease, and this is the role that environmental fields play in the incidence and prevalence of human disease. No specific agent can accurately be said to cause any chronic human disease, and EMFs in the environment should therefore be viewed as one of a range of factors that can tax a subject's adaptive capacity. When the total body load of environmental stressors exceeds an individual's capacity, its immune surveillance mechanisms are impaired and disease occurs. Electromagnetic fields are one such disease-promoting factor. No other view in the literature fits all the data.  


If Adey can be seen as one of the important symbols of legitimate science, arguing for stricter NIEMR regulation, Becker and Marino could be juxtaposed as the dissident voices of those challenging the credibility of 'establishment science' itself.

Becker's work, in particular, represents one of the consistently important links between bio-electromagnetics or electro-biology and the public. It was particularly his and Andrew Marino's involvement in the New York Public Service Powerline Hearing from 1974-78 which helped stimulate research such as the New York Powerline Project and the current powerline EMF controversy. Apart from innumerable scientific articles, mainly looking at the influence of electricity in the healing and growth processes, especially in the context of bone regeneration and orthopaedic surgery, Becker and Marino have produced a number of quasi-scientific books aimed at the attentive public. These books combine overviews of scientific literature, reviews of past scientific work, the politics of contemporary bio-electromagnetics, and original scientific hypotheses. These eclectic webs of considerations pertaining to bio-electromagnetics have done much to promote public debate; but, quite possibly, diminished Becker and Marino's more specialist standing in the scientific community.

158 (i) Adey, R., The Energy Around Us, op.cit. p.58 criticises Becker's appeal to conspiracy theories and argues that this may compromise the way many people approach Becker's work. Note: Becker's reply, in his defence, to Adey in 'Letters to the Editor', The Sciences, January/February, 1986.
Like Adey, Becker and Marino promote the idea that a scientific revolution is in progress. Whereas Adey's work is grounded in more specific claims about a revolution in cell biology (though, as the reader may have already noted, Adey's rhetoric does get somewhat extreme), Becker, goes further, proclaiming that the complete modern 'biomedical/scientific world view' is undergoing a radical process of transformation.\(^{159}\)

Rather than focus on any single or simple line of study as likely to provide exclusive insights into NIEMR bio-effects, such as Adey's search for mechanisms at the level of the cell membrane, Becker and Marino argue for the need for so-called cybernetic models.\(^{160}\) Reductionist models, characterised by Becker and Marino as relying on the study of specific parts of an organism, building increasingly complex models, and forming basic laws observed at such levels, are inadequate for understanding bio-electricity. They put forward two reasons for why this is the case. First, philosophically, Becker and Marino favour the view that:

> The biological system is seen as more than a sum of its parts and it is held that one cannot understand an organism's essential characteristic/life by studying sub-systems below a certain structural level because life does not exist beyond that level.\(^{161}\)

Second, pragmatically:

> The amount of whole animal data presently available is much greater than that involving model systems and, for this reason, the cybernetic approach gives a more general and more useful picture of bio-electrical phenomena.\(^{162}\)

\(^{(ii)}\) It is interesting to note that, for instance, in the OTA Report which possesses an immense bibliography on EMF health and science that there is little reference to the work of Becker and Marino.

\(^{(iii)}\) Questions surrounding the credibility of some of Becker & Marino's claims extended into Gibbs' Final Report where he singled out some of this work as being quasi-scientific and carrying a negative public impact. Gibbs' Final Report, op.cit., p.33 plus p.56.

\(^{159}\) See discussion in Becker, Cross Currents, op.cit., p.26.

\(^{160}\) Becker & Marino, Electromagnetism and Life, op.cit., p.159.

\(^{161}\) ibid., p.160.

\(^{162}\) ibid., p.160.
Given this cybernetic approach, a range of well established, empirical observations of EMF inputs and biological outputs can be generalised into empirical laws about component processes. Whilst such laws should not conflict with basic science, they do not need to be bound to specific detailed causal models. Becker and Marino summarise four key empirical laws that can be drawn from a wealth of athermal bio-electromagnetic research.

1. EMFs can alter the metabolism of all body systems, including the nervous, endocrine, cardiovascular, haematological, immune-response, and reproductive systems.

2. The effects on each tissue or system are largely independent of the type of EMF. The studies suggest that there are common physiological pathways for spectrally different EMFs, and that the major consequence associated with specificity of the EMF is that it determines the magnitude or direction -- as opposed to the existence -- of the biological effect. One the other hand, certain spectral characteristics -- pulse modulation frequency seems to be one of the most important -- can fundamentally modify the biological response.

3. An organism's response to an EMF is determined in part by its physiological history and genetic predisposition; individual animals, even in an apparently homogeneous population, may exhibit changes in opposite directions in a dependent biological parameter.

4. Although high-field-strength and long-duration studies are exceptions, EMF-induced biological effects seem best characterized as adaptive or compensatory; they present the organism with an environmental factor to which it must accommodate. 163

Because of the variety and complexity of these bio-electromagnetic responses, they argue that "the consequences of EMF exposure must be understood in terms of an integrated response of the whole organism".164

Putting this evidence together, they argue that unnatural forms of EMF are best seen as a special form of biological stressor. They work from the analogy with cold stress, where, for instance, as in biological studies on EMF, there are measurable cellular and molecular

163 ibid., p.161.
164 ibid., pp.161-162.
See also detailed discussion in Marino & Morris, op.cit., pp.209-213.
changes in the adrenal system. Although these changes have been initiated by neuronal or hormonal activity, the stressing agent -- the cold, or EMF -- does not need to be present in the tissues where such responses are being measured. As a stressor EMF has the special feature that unlike cold or anxiety or most other stresses, which are detected peripherally and ultimately consciously perceived, electromagnetic stress is not immediately perceptible. The numerous end-points and empirical laws noted can be seen then as the by-product of electromagnetic stress. Whilst stress is not perceived, Becker and Marino argue after the analogy of certain animals which perceive electromagnetic information, such as birds with navigational activity, that all living organisms must have evolved important natural receptors to EMFs. In higher organisms, such as humans, there is some evidence that sites where EMFs may be received may be glands such as the pineal, which has an important role in the secretion of hormones such as melatonin. Further analogies for the idea of receptors to EMFs are drawn from glandular responses to light and darkness, circadian rhythms and their response to the Earth's magnetic field, and the ability of the human eye to amplify minuscule amounts of electromagnetic energy in the form of light into significant activity in the brain.  

Becker and Marino's work has been subject to a number of criticisms even within bio-electromagnetics. Adey, for instance, whilst acknowledging Becker's extremely significant contribution to the role of bioelectricity in the context of orthopaedic surgery and growth mechanisms, accuses him of theoretical naivete and being far too brisk in jumping from his significant practical achievements to general theory. Adey also accuses Becker and Marino of being far too ready to see the suppression of bioelectromagnetic research as the result of a military and industrial conspiracy.  

These criticisms aside, the importance of the work of Becker and Marino in providing a catalyst for the modern powerline EMF controversy should not be under-estimated, as the next chapter discusses.

165 Becker, *Cross Currents*, op.cit., pp.77-78.
Chapter 4: 
The Immediate Context of the Current NIEMR Powerline Debate

(i) The Merging of the Microwave Debate with Powerline Protests: The 'Sanguine' Controversy and the New York State Public Service Powerline Inquiry

It was the first time even in the US that scientists, moreover scientists with the right degrees, experience, and requisite professional affiliations had presented hard evidence in an official forum that a health risk could result from exposure to powerlines.


An important bridge between the microwave debate, described in Chapter 2, and the contemporary powerline/EMF debate was the controversy aroused during and after the inquiries into the potential health effects of the US Navy's proposed submarine communication system originally known as Sanguine, later Seafarer, and then Elf. The project was based on the concept of producing a more than 20,000 square mile antennae in the State of Wisconsin, the US. This would be done by burying in the appropriate configuration, 6 feet underneath the surface of the ground, 6,000 miles of ELF emitting cables. These extra low frequency signals could communicate with submarines almost anywhere on Earth, even in the deepest oceans.

In 1969, the US Navy and the RCA Corporation constructed a small test site, and soon after nearby residents began complaining of electric shocks and suspected health complaints. The issue was soon picked up by environmental groups. The US Navy, in response, set up a programme to study potential biological effects of ELF fields such as those that Sanguine would produce. By 1970, the first of these studies were completed. In these early studies a number of worrying biological effects were observed. The initial concern raised by Sanguine quickly spread into the powerline debate. Louise Young in an epilogue to the second edition of *Power Over People* (as noted earlier one of

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the first sources to publicise the general environmental and political problems of powerlines) and in an article to the *Bulletin of Atomic Scientists*, publicised the early Sanguine studies and the questions they raised.\textsuperscript{168} The attention given to Sanguine's potential hazards also lead environmentalists to the Eastern European literature\textsuperscript{169}, which as noted earlier, had acknowledged extra low frequency NIEMR as a health hazard since the early 1960's.

In 1973, a committee was formed to produce an overview of the likely hazards of Sanguine ELF fields for the Navy. One of the committee members was Robert Becker. Becker highlighted the fact that high voltage powerlines produce similar, if not more powerful, ELF fields than Sanguine. The committee, much to the Navy's displeasure, recommended that it was indeed possible that Sanguine constituted a potential source of biological hazard. The studies reviewed by the Committee suggested a number of puzzling and potentially worrying biological effects of ELF/EMFs.\textsuperscript{170}

The report of this committee was quickly made into a classified secret document. It is not impossible that this report would have lain dormant for many years had not Becker communicated its results to the New York Public Service Commission in 1973 when he became aware of inquiries surrounding EMF and establishing policies for the siting of the Massena to Marcy powerline.\textsuperscript{171}

\textsuperscript{168} (i) L. Young, 1974, *op.cit.*, Epilogue 1974, pp.189-199  
\textsuperscript{169} *ibid.*, p.35.  
\textsuperscript{170} Becker in *Cross Currents*, *op.cit.*, p.202 notes the committee made the following statement:  
"This committee went on record to recommend that the Electromagnetic Radiation Management Advisory Council (ERMAC, the White House agency that had the overall advisory capacity in this area) be apprised of the positive findings evaluated by this committee and their possible significance, should they be validated by future studies, to the large population at risk in the United States who are exposed to 60 Hz fields from powerlines and other 60 Hz sources."  
\textsuperscript{171} *ibid.*, p.203.
Following up on Becker's concerns, the New York Public Service Commission approached him, in 1974, to testify in their powerline siting inquiries. Becker, with Marino, agreed to produce submissions for the inquiry. The significance of these submissions was not lost on Marino. In Marino's autobiographical account of the New York Public Service Inquiry, he noted:

It was the first time even in the US that scientists, moreover scientists with the right degrees, experience, and requisite professional affiliations had presented hard evidence in an official forum that a health risk could result from exposure to powerlines.  

The significance of this was also not lost on power industry groups who sought leave for one year to organise their case. Becker and Marino were to be pitted in public hearings against familiar 'microwave debate' figures Michaelson, Miller and Schwan. During the year's recess of the Inquiry, Marino undertook experiments to help strengthen his and Becker's case. This is in keeping with our earlier observations about the microwave debate having been shaped by litigation and regulatory pressures. In his personal account of the New York Public Service hearings and their aftermath, Marino, who had a law degree as well as his biophysics Ph.D., quite explicitly describes how legal requirements shaped the preparation of his scientific case.

Although the evidence was clear, the problem in a legal forum was to present in such a way that the power companies' lawyers could not effectively challenge it. Part of the difficulty arose from having to extrapolate from effects seen in animals, under a variety of controlled lab conditions, to the certainty of effects in humans living near the lines. I had to anticipate that the company lawyers would focus on the uncertainty of effects in humans. How do you know there will be definite effects in humans? they would ask. .....

So my conclusion was this: "Exposure to the [NIEMR] of the proposed line will probably cause biological effects in some individuals." 'Probably' meant 'more likely that not'; it was the best I could do and not expose myself to a trap during cross-examination.

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173 (i) *ibid.*, pp.28-29.
(ii) An interesting discussion surrounding this very issue of legal and political imperatives and their role in shaping scientific evidence can be found in an article produced by Marino, Becker and the social scientist Alan Mazur in 'Separating Factual Disputes from Value Disputes in Controversies Over Technology', *Technology in Society*.
Marino's account of proceedings contains numerous rich examples of political and judicial shaping of expert testimony. The Public Service Inquiry hearings became drawn out and controversial and much to the chagrin of one of the Public Service judges Becker and Marino allowed themselves to be interviewed by the US Sixty Minutes T.V. programme. After four years of hearings, in January 1978, the Inquiry's judges came forward with their recommendations. Marino was severely criticised in these judgements both in his personal demeanour and his scientific work. Nevertheless, the Inquiry's recommendations noted that the hypothesis that EMF could produce harmful health effects could not be dismissed.

New York's legal system required that the judges recommendations be reviewed by the New York Public Service. This was done and, in June 1978, the official decision of the New York Public Service Commission was lodged. In keeping with the earlier ambivalent report of the Judges, the final decision acknowledged that the proceedings had raised 'unrefuted inferences of possible risk which could not be ignored'. Unlike the Judges' report though, the official decision was critical of the failure of the power industry to attempt to 'test-replicate' Marino's experimental work and their preference instead for attacking Marino's personal credibility. The final decision, hedging its bets on safety issues, called for extended rights of way for the proposed line in question - a 765 kv. line - so that the field levels it produced at the boundary were no greater than existing 345 kv. lines.


175 ibid., pp.70-75.
176 ibid., pp.77-86.
177 ibid., pp.90-94.
Overall there were two important implications from this final decision and the proceedings. First, they constituted a pool of resources that could be added to the domain of public knowledge about NIEMR. Marino and Becker's publicly available testimony, for instance, could be added to the concerns raised by Louise Young and by publicity surrounding the protests in relation to the Sanguine project. This resource could also be linked to the microwave debate which, as previously noted, was becoming a public controversy about the same time. Thus, from 1978 onwards, we see in disputes as far apart as Australia (1979-1980 Portland Powerline dispute\textsuperscript{178}), and in Britain (1978 the Innesworth Inquiry), extensive references to Becker and Marino and to the New York Public Service Inquiry.\textsuperscript{179} The New York Public Service Inquiry constituted for power authorities a source of sufficient concern that EMF now had to be addressed in siting new powerlines even if the issue was to be treated dismissively.

Second, one of the recommendations in the final report of the New York Public Service Inquiry, was that the concerns raised by Becker and Marino demanded further research. The report proposed that this research should be undertaken by independent scientists but much to the displeasure of the relevant power authorities, they were to provide the funding. This recommendation led, after initial legal manoeuvres of power authorities trying to absolve themselves from funding commitments, to the New York State Powerline Project. In 1980, the power authority of the State of New York (PASNY) and seven other US power companies, agreed to provide $5 million for powerline research.\textsuperscript{180} In 1981 the composition of a supervisory panel was decided and contracts for EMF research advertised. The findings of the New York State Powerline Project (NYSPLP) were publicly released in 1987 with a number of the results of individual studies filtering into the popular press towards the latter part of 1986. These findings can

\textsuperscript{180} Marino, A., \textit{The Electric Wilderness, op.cit.}, pp.95-97.
be taken, for purposes that will be discussed later, as the symbolic point of departure for considering the current phase of the powerline EMF debate.

In the intervening period, from the New York State Public Service Inquiry findings of 1978 to the release of the NYSPLP Report in 1987, the powerline EMF debate 'matured', that is, it followed the pattern, noted previously, of the microwave debate to which it has always been closely linked. Thus, for instance, we see the familiar pattern of regulatory responses failing to provide plausible closure; a stream of suggestive but inconclusive scientific studies gaining progressively more media attention, and the persistent deconstruction and reconstruction of science in legal and quasi-legal contexts with numerous disputes over the siting of new high voltage powerlines and ELF communication systems. Looking at these factors in order we can begin by briefly examining the emergence of ELF regulation.
(ii) IRPA, ELF Regulation - from thermalist perspectives to induced currents
The False economy of forced scientific certainty - revisited

These conclusions [IRPA's] suggest to me that the epidemiological data were not used in arriving at conclusions on exposure levels. Thus any subsequent work which depends on the World Health Organization's evaluation of the data would similarly, presumably not take the epidemiological data into account when considering what might be acceptable exposure levels. ...

It is my opinion that while the epidemiological data relating EMF to cancer are clearly inconclusive, they should not be ignored when considering what might be acceptable long-term increases in the average ELF exposure of particular populations.


As previously noted, much of the regulatory activity in regard to non-ionising radiation protection, had been preoccupied for much longer with RF and microwaves, not considering the extra low frequency part of electromagnetic spectrum as worthy of the same attention. This was the case particularly in the US (with ANSI providing an important model). Hence, the fact that safety standards for NIEMR in the West normally treat ELF separate from RF MW, the latter standards normally addressing the electromagnetic spectrum from 300 hertz to 300 gigahertz. Nevertheless, many of the theoretical models involved in assessing potential dangers of NIEMR extend across microwaves to ELF. Indeed, frequently, the same bodies of scientific expertise and individual scientists address both ends of the spectrum. This is particularly true of scientists working from an athermalist perspective. For instance, the cellular effects described by Adey apply to ELF and microwave and radio frequencies modulated at ELF. Further, many technologies, in fact, emit mixtures of frequencies of NIEMR. For instance, it is common for telecommunications systems to transmit via RF frequencies but carry information modulated at ELF frequencies and, in the case of powerlines, there can be complex harmonics and coupling effects with nearby electrical devices providing
complex patterns of exposure. Similarly, Becker and Marino's 'chronic stressor model' suggests that the whole variety of NIEMR constitute different potential stresses. Finally, as pointed out by Steneck, and as discussed earlier, the tendency for 'radio frequency' regulators to attempt to map every last biological effect at every last frequency, implied a particular philosophy of managing risk that did not realistically address the uncertainties constituted by NIEMR.

Within a thermalist framework though, it is possible to see why ELF would be of less concern for health and safety management. For instance, ELF radiation such as that emitted by powerlines is, for practical purposes, incapable of causing rises in temperature of biological tissue. Shorter wave lengths of RF/MW from metres to millimetres are capable of transmitting much more energy than ELF waves hundreds to thousands of kilometres long. Further, such long waves mean that even the concept of 'radiation', in the context of powerlines is a questionable one. For practical purposes, exposure issues related to the so-called 'near field' within the first wave length, where electric and magnetic fields can be treated as separate entities. The issues then involve exposure to electric and magnetic fields rather than radiation per se. Within a thermalist perspective then, the idea of setting exposure levels worked from the basis of induced currents, analogous to the physical energy models of standard absorption rates resulting in heat. The question was: when (if at all) will harmful biological effects occur via currents induced in humans exposed to an electric and magnetic field, and at what level of field strength will particular levels of current be induced?

Rather than work backwards from the dangerous heating test of Schwan and Michaelson as in RF MW, for ELF, regulators worked backwards from electrically induced fibrillation of the heart, or tetanus of breathing (when muscles go into spasm from

181 See discussion in Smith & Best, op.cit., p.33, cf. footnote #19 (i).
induced electrical currents) and other high level effects such as the sparking of magneto phosphines in the eyes and the long standing engineering concerns with spark discharges and let-go currents (induced when people earth unearthed objects that have acquired charges by being in an electric and magnetic field) would also be taken into account. As with RF/MW frequencies, athermal studies, i.e. studies not pre-occupied with the immediate physical effects of induced currents, did not meet the requisite standards of scientific certainty to be considered in the process of setting safety regulations. Much research, then, was geared to exploring further the immediate health effects of ELF fields, which were relatively well understood, according to existing physical models. These could be euphemistically described as weak electrocution effects of powerlines. Regulatory uncertainty was also favoured by the relatively small number of ELF bio-effects studies and, in keeping with NIEMR studies generally, the lack of co-ordinated research.


183 See discussion in M. H. Repacholi, 'Acceptance of Scientific Literature', in 'Introduction to Non-Ionizing Electromagnetic Fields' in Repacholi, ibid., p.12.

NB: This section is totally reproduced without acknowledgment from a much criticised check-list for establishing the scientificity of NIEMR health and safety effects initially put forward by Michaelson in 1979.

For reference to these see discussion in Grandolfo, p. 622 in Chiabrera, et.al., op.cit.. For criticism, see R. Medici, in Steneck, N., ed., Risk - Benefit Analysis (a), op.cit., p.191. Medici makes the following comments in relation to 'the Michaelson check list' for establishing the scientificity of EMF bio-effects hypotheses.

"One is astounded to find these kinds of comments [check list] in a professional publication. They are not scientific comments rather they are journalistic ones. How should they be interpreted? One interpretation is that the author feels that he is uniquely competent in EM research, that he has encountered results that agree with his own, and that he therefore feels compelled to give his engineering readers a short course in how to do science."

184 See discussion in R. Pool, 'Flying Blind: The Making of EMF Policy', in Science, op.cit. In this article he refers to the comments of biologist and EMF researcher, Reba Goodman, who comments on the sparseness of funding making 'replications' and 'testing' of experiments difficult ...

"Everybody's working on different projects ... It's crazy, it's the money.", p.24.
One of the key regulatory groups attempting to build benchmarks for ELF regulation, plus NIEMR generally, has been the International Non-Ionizing Radiation Committee of the International Radiation Protection Association (the INIRC of IRPA). The INIRC of IRPA was created in 1977 in close association with the Environmental Health Division of the World Health Organisation. Its main role is to provide background information and regulatory recommendations on NIEMR, much of its funding being provided by the United Nations Environment Program. The INIRC of IRPA, whilst strongly associated with regulatory bodies in the US, and elsewhere, rhetorically at least proclaims an independent world perspective. Nevertheless, the role of IRPA, as will be discussed in more detail in Chapter 4 (vi), has been more important in Europe and Australia than in the more complex regulatory environment of the US.

During the period in question (1978-1987) the INIRC of IRPA produced a number of documents in relation to ELF/EMF. These include two environmental health criteria (supposedly authoritative summaries of scientific evidence) concerned with ELF (EHC 35 Extremely Low Frequency Fields, 1984 and EHC 69 Magnetic Fields, 1987) and a number of reviews, most importantly World Health Organisation Health Series No. 25, Non-Ionizing Radiation Protection, 1982. These documents embody the quasi-thermalist induced current perspective outlined above. Not unlike the ANSI RF standard, the INIRC of IRPA and WHO documents provide a scientifically conservative outlook on NIEMR. The similarities are not that surprising if we consider the important influence in the formation of both groups by experts such as Schwan and Michaelson. There are numerous points where IRPA's scientific conservatism stands out.

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187 See also documents produced on RF radiation, Health Criteria, No. 16, 1981.
First, because the very structure of committees, reviews, bureaucracy etc., IRPA's documents tend to be a number of years behind leading research. In the 1982 WHO Handbook, this problem is, quite surprisingly, acknowledged and, in fact, the rationale is defended.

It will be obvious, considering the time spent in compiling this work, that some literature references are not as recent as one would wish. However, the reader will appreciate that the objective of this book is not to provide (even if it were possible) an up to date literature review. What is important is that the fundamental information contained in this publication is sound and will remain valid for some years.\textsuperscript{189}

Considering the lack of funding until quite recently for athermal research, IRPA's preference for working mainly from older so-called well-established studies tends to favour more serious consideration of thermalist studies.

Second, not unlike the case with ANSI standards, strict prescriptions for scientific certainty are proposed. In \textit{Health Criteria 69} (completed in 1986, published in 1987, compiled and edited by Michael Repacholi) this is displayed quite clearly. In regard to health and safety assessment the document states from the outset that:

(i): In making an assessment of the health risks from exposure to magnetic fields, criteria must be developed for which effects are to be considered a hazard for human health. The difficulty in defining the health hazard occurs when value judgements are involved that may not be based on scientific analysis.

(ii): Strict guidelines must be established prior to reviewing the literature on the biological effects of exposure to magnetic fields.\textsuperscript{190}

In practice, these pre-requisites for what can be included in guideline setting rationales were interpreted to work against the serious consideration of much (arguably highly

\textsuperscript{189} ibid., p.11.
\textsuperscript{190} \textit{Environmental Health Criteria, No.69, Magnetic Fields}, published under the joint sponsorship of the United Nations Environmental Program, the World Health Organisation and the International Radiation Protection Association (IRPA), WHO, Geneva, 1987, p.119.
relevant) EMF science. For instance, much in-vitro work, such as Adey's, was rejected on the basis that it had been designed to test for causal mechanisms and generate hypotheses, and was not sufficiently 'detailed' or 'certain' to be incorporated into safety guidelines. Further, it was argued in the health criteria that the bulk of EMF epidemiological studies should also be excluded because of methodological weakness and difficulties with exposure dosimetry.

The narrowness of IRPA's guideline setting scientific rationale has not escaped criticism. In a review prepared for the Western Australian Environment Protection Authority by Professor Bruce Armstrong, at that time (1987) Professor of Epidemiology and Director of Cancer Research in Western Australia for the NHMRC, the following criticisms were made:

It is my opinion that in its Environmental Health Criteria document No. 35 entitled "Extremely Low Frequency (ELF) Fields", the World Health Organization rejected as non-contributory to the setting of recommended exposure levels the evidence that ELF may be related to human cancer. In section 6 of this document which reviewed the human data, a number of not well justified criticisms were levelled at some of the epidemiological studies. ... These criticisms are not explained and some of them make little sense.191

Armstrong then goes on to suggest that IRPA and the WHO's false rejection of the adequacy of all epidemiological EMF studies severely compromises the exposure levels set in their recommendations.

These conclusions [IRPA's] suggest to me that the epidemiological data were not used in arriving at conclusions on exposure levels. Thus any subsequent work which depends on the World Health Organization's evaluation of the data would similarly, presumably not take the epidemiological data into account when considering what might be acceptable exposure levels. ...

It is my opinion that while the epidemiological data relating EMF to cancer are clearly inconclusive, they should not be ignored when considering what might be acceptable long-term increases in the average ELF exposure of particular populations.\textsuperscript{192}

IRPA's conservative scientific perspective rejects 'in vitro' studies that suggest potential harmful effects, as well as epidemiological studies, this can only leave the familiar quasi-thermalist induced current model for evaluating the effects of exposure to ELF. IRPA's approach is based on the following two assumptions:

(a) There are no indications that a specific time-varying magnetic field effect exists at tissue field strengths below the value at which induced eddy currents may cause biological effects. Reports on calcium efflux (Adey 1981; Blackman \textit{et al.}, 1985b) and on effects in chick embryos (Delgado \textit{et al.}, 1981, 1982, Ubeda \textit{et al.}, 1983, Juutilaiaen \textit{et al.}, 1986), if confirmed, would appear to be due to other mechanisms.

(b) When possible health risks for man from exposure to time-varying magnetic fields are evaluated, the biological effects mainly considered are those that originate from a direct action on the cells in nerve and muscle tissues. The physical quantity determining the biological effect is the induced electric field strength in the tissue surrounding the living cell.\textsuperscript{193}

A further factor enhancing IRPA's conservatism was that even heated disagreement and 'natural scientific uncertainty' tended to be buried in an authoritative final statement of the so-called facts. The practical aims of health criteria and regulatory suggestions militate against formally acknowledging scientific disagreement. At best, the only hints of substantial disagreement within the scientific community have been the regular addenda of statements acknowledging the need for further funding for studies and, in the 1984 document \textit{Health Criteria No. 35}, the proposal for guidelines to embody an 'as low as reasonably achievable' (ALARA) rationale. Though, in the 1987 \textit{Health Criteria No.69} ALARA is not mentioned and in the actual 'rationales' within IRPA, WHO documents

\textsuperscript{192} \textit{ibid.}, p.2.  
\textsuperscript{193} WHO, (IRPA) 1987, \textit{op.cit.}, p.120-121.
ALARA is actually argued against.\textsuperscript{194} There has, in fact, been a deal of political fall-out in response to such smoothing over efforts. For instance, one of the members of the IRPA committee that composed the 1984 \textit{Health Criteria No.35}, Richard Phillips from the US EPA, is quoted as proposing that, in relation to a number of important conclusions, the 1984 Committee came up with:

... a compromised statement so we could get out of that meeting and not be there for three years ... without a statement of that sort we would have never reached any kind of consensus agreement between the research biologists on the committee and the more clinically oriented people on that committee (the health people: physicians, health physicists).\textsuperscript{195}

Richard Phillips, in another context, also described problems with the composition of some of IRPA's committees. He particularly singles out Michael Repacholi's 1986 Committee involved in reviewing \textit{Health Criteria 69}. He puts it in the following terms:

I also question the make up of that committee. How representative it is of the research community and all the community? I think it's loaded with respect to one particular viewpoint ... \textsuperscript{196}

\textsuperscript{194} For instance M. Repacholi representing the Australian Radiation Protection Society and IRPA at the Gibbs' Inquiry proposed:

"So, firstly, the two issues are prudent avoidance, which because of the nature of the fields it is expected although more research is necessary from all the non-ionizing radiations we have, we know there is a threshold above which there is an increasing probability of adverse health effect, but below which no adverse health consequence is identified. This is common right through the non-ionizing radiations, and so because of the theoretical concept, the ALARA principle, or the As Low As Reasonably Achievable concept, is not appropriate."


For further discussion see David W. Mercer, Submission to Panel on Electromagnetic Fields and Health (Victorian Government) 10th December, 1991.


\textsuperscript{196} \textit{ibid.}, plus discussion in \textit{Microwave News}, May/June 1989, 'IRPA Revises ELF Guidelines, Cancer Risk not Convincing'.
The establishment of WHO, IRPA Health Criteria and regulatory suggestions for ELF/EMFs would provide a useful resource during this period\(^\text{197}\) for power authorities to attempt to quell rising public disquiet surrounding the issue of EMF in siting new powerlines.\(^\text{198}\)

The WHO/IRPA health criterion and proposed EMF guidelines would prove to be as contentious as their radio frequency counterparts. From the mid-1980's (as noted earlier) scientific disagreements over NIEMR began to take on a renewed mass media and public profile. Further, not only did organised protest groups critical of NIEMR regulation begin to emerge but a stream of scientific studies incompatible with the IRPA 'rationales' continued to appear. It is to a brief review of these studies that we shall now turn.

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\(^{197}\) It is somewhat puzzling that Health Criteria 69 which was to be released in 1987 and is still the most current health criteria on magnetic fields should have had its final review in 1986 when, to the full knowledge of all participants, the results of the NY State Powerline Project were due to be released in early 1987 (perhaps this was merely in keeping with IRPA's conservative agenda)

\(^{198}\) See discussion on the use by powerline authorities of the authority of IRPA's and the WHO's safety guidelines in Australia in discussion of environmental impact statements in a later part of the thesis.
(iii) New studies
The growing importance of epidemiology
Wertheimer & Leeper, and Millham

An excess of electrical wiring configurations suggestive of high current-flow was noted in Colorado in 1976-1977 near the homes of children who developed cancer, as compared to the homes of control children. The finding was strongest for children who had spent their entire lives at the same address, and it appeared to be dose-related. It did not seem to be an artefact of neighbourhood, street congestion, social class, or family structure. The reason for the correlation is uncertain; possible effects of current in the water pipes or of AC magnetic fields are suggested.


During the period described in the previous section, scientific studies suggesting that low level ELF/EMFs were biologically active continued to appear. These included work on alterations in melatonin levels in experimental animals; promotion of cancer in 'in vitro' cell cultures with exposure to ELF fields; replication of calcium efflux experiments; with an additional hypothesis explaining how such calcium movements may occur (cyclotron resonance); birth defects in chicken and mice embryos with exposure to pulsed EMFs; alterations to growth patterns in multi-generational animal
studies\textsuperscript{205}; and studies of the alteration of processes of RNA/DNA transcription due to EMF exposure.\textsuperscript{206}

Whilst no simple consensus on biological mechanisms\textsuperscript{207} could be found across these studies, many of the results were complimentary to the theories of Becker and Marino and Adey, and, at the very least, suggested the inadequacy of thermalist/quasi-thermalist induced current bio-effect models so popular with regulators. Most important during this period for the public face of debate was the growth of a number of epidemiological studies suggesting links between NIEMR and various forms of cancer.

The first, and most important, of these was Wertheimer and Leeper's 1979 exploratory study\textsuperscript{208} on the links between exposure to low level magnetic fields and childhood leukemia. They had observed a significant increase in the likelihood of childhood leukemia for children living in houses which were in close proximity to heavy gauge electric wires and power transformers. These later conditions ('wire code configuration') provided an indication of raised magnetic field levels. Wertheimer and Leeper's study, by focussing on magnetic fields, i.e. electric fields being largely shielded by trees and/or housing materials, suggested that in the future studies should pay greater scrutiny to magnetic fields when considering EMF bio-effects.

A number of other epidemiological studies followed Wertheimer and Leeper, looking at residential cancer rates and EMF exposure. Overall, the results of these studies were

\textsuperscript{205} See discussion of the so-called Battelle Studies by Phillips, R. and Kaune, in Bonneville Power Administration, \textit{op.cit.}, pp.31-32.
\textsuperscript{206} Goodman and Henderson, see discussion in \textit{ibid.}
\textsuperscript{207} See discussion in Bonneville Power Administration, \textit{op.cit.}, pp.29-53.
\textsuperscript{208} (i) See discussion in Brodeur, P., 1989, \textit{op.cit.}, pp.15-22
inconclusive with a number of them being small studies or studies with fairly obvious methodological limitations.\textsuperscript{209}

Whilst the results of these studies were inconclusive, and were initially treated with scepticism by most public health authorities, by the mid 1980's it was acknowledged that there was a need for further study. As such, one of the key areas of research in the New York State Powerline Project was to be an attempt to replicate the Wertheimer & Leeper hypothesis. \textsuperscript{210}

The other strand of epidemiology which came to prominence during this period (pre-NYSPLP) followed from the work of Samuel Millham.\textsuperscript{211} In 1982, through the study of death certificates, he observed a high rate of a variety of forms of cancer but mainly lymphomas and brain cancers amongst workers in what could be classified as the electrical trades. Millham's work sparked a number of other studies across the world. By 1987 the majority of these were revealing consistently (though relatively small) higher rates of brain tumours amongst electrical workers.\textsuperscript{212} Millham's hypothesis initiated heated debates over problems of exposure classification and potentially unidentified confounders. This emerging pattern of laboratory and epidemiological studies inspired little change in the guideline rationales proposed by groups such as IRPA. Against the


\textsuperscript{210} See discussion in Brodeur, P., 1989, \textit{op.cit.}, pp.84-85.

\textsuperscript{211} See discussion in \textit{ibid.}, pp.73-79.

background of such studies another factor which would serve to maintain controversy over ELF was the continuation of the *Sanguine* saga.
(iv) Public Inquiries, protests and litigation
The contemporary EMF debate begins to take shape

The AIBS Report maintains consciously or unconsciously, a double standard of scientific review. Experiments which show positive results, such as the calcium efflux measurements, are rigorously critiqued throughout the report, where experiments with null results receive a less thorough review.

Commentary on AIBS Report: Biological and Human Health Effects of Extremely Low Frequency Electromagnetic Fields, covering letter, State of Wisconsin Department of Natural Resources, Carol D.Besadny, reproduced in I.MacMillan, 'The 0.5 milligauss guideline ...', 1990, Appendix 5.

Opposition to Sanguine had led the US Navy to alter its original 1960's proposal for a mega-antenna. After transmuting through its Seafarer phase, described in the first section of this Chapter, which involved controversy over the composition of a panel reviewing its biological effects213, it was finally to take form as a proposal as an above ground antenna which was named Elf. Protests against this final incarnation of the submarine communication system continued. In 1984, on the basis of legal technicalities, i.e. US national defence interests, the US Supreme Appeal Court declared that the Elf project should be given the go ahead. The US Navy, sensitive to the public relations problem that still remained, decided to produce yet another review of ELF bio-effects. To this end they commissioned a report on EMF bio-effects from the American Institute of Biological Sciences (AIBS Report). This Report concluded that:

Exposure to ELF electric and magnetic fields in the range of those produced by the Elf communication system does not pose public health problems.214

213 (i) See discussion in Marino, A., The Electric Wilderness, op.cit., pp.60-61, 70-72, 80-81, 32-33.
214 Dalton, op.cit., p.52.
This report nevertheless could not close the issue. Typical of the NIEMR debate it was controversial from the outset. Robert Becker was originally invited to appear on the Committee, but he declined.

I initially accepted; but later resigned from the Board when full details of its administrative structure were revealed to me. These details indicated that the deliberations of the Board and its subsequent report could not be unbiased.215

The Board's conclusions also came under attack. A review from a committee assembled by the government of the State of Wisconsin, for instance, stated that:

The report clearly demonstrates the inability of contemporary science to either define or discredit possible detrimental effects of ELF radiation.216

The report of the Review goes on to provide a detailed and damning critique of the politics of the AIBS Report and its contents.

First, it notes that the objectivity of the AIBS Report was compromised as many of the members of the committee received substantial funding from utilities or the US Department of Defence.

Second, there was evidence that the final report summary had been selectively edited to misrepresent the opinions expressed by committee members in the more detailed original report.

216 State of Wisconsin Department of Natural Resources, Carol D. Besadny, 'Commentary on AIBS Report - Biological and Human Health Effects of Extremely Low Frequency Electromagnetic Fields', covering letter. This commentary is reproduced in MacMillan, 1990, op.cit. as Appendix 5.
Concerns expressed by committee members in the text of the full report have in many cases, been edited out of the report summary or re-written so as to change their meaning.\textsuperscript{217}

Third, the AIBS Report utilised selective criteria of scientific adequacy. Studies suggesting adverse effects were invariably described as 'unproven' or 'uncertain' whereas studies that suggested there was no cause for concern were described as 'proven and reliable'.

The AIBS Report maintains consciously or unconsciously, a double standard of scientific review. Experiments which show positive results, such as the calcium efflux measurements, are rigorously critiqued throughout the report, where experiments with null results receive a less thorough review.\textsuperscript{218}

Whilst the Elf system ultimately went ahead, the AIBS attempts at closing the debate were unsuccessful. Further, the kinds of problems highlighted by the State of Wisconsin review guaranteed further public disquiet.

A number of powerline protests highlighting EMF also emerged during this period. One of the most widely reported was the Klein (Texas) Independent School District against Houston Lighting and Power Company in November 1985. The School District opposed Houston Lighting and Power's construction of a 345 kv transmission line across the School District's property. They alleged that Houston Lighting and Power had:

... grossly abused its discretion by building the line near their schools, thereby alleged presently a health risk from the fields produced by the line.\textsuperscript{219}

\textsuperscript{217} ibid., p.1.
\textsuperscript{218} ibid., p.2.
\textsuperscript{219} Brodeur, P., 1989, \textit{op.cit.}, pp.198-199.
A jury heard six expert witnesses, four for the School District and two for the power company. It found that the power utility had acted with reckless disregard and conscious indifference for the rights and welfare of the persons affected. The power company sponsored journal, the *EPRI Journal*, pointed out that there was a semantic point that the jury had not been asked to find on the question of EMF science itself. Nevertheless, the significance of the jury's conclusion remained: the School was awarded $104,000 actual damages and $25 million in punitive damages. (The latter damages were to be overturned in a higher court on the basis of a legal technicality.) Ignoring the issues thrown up by athermalist EMF hypotheses could be extremely costly for power authorities.220

In Australia, at about the same time, the first major EMF powerline debate was brewing. This surrounded a proposal to build a powerline from Richmond to Brunswick in Victoria. Dispute over the line originally centred on a variety of environmental landscape and aesthetic concerns. Health came to the forefront though during 1985.221 The Electrical Trades Union and Postal and Telecommunications Union had been concerned over health and safety of microwave and radio frequency emitting devices for a number of years. 222 Their concerns were to coalesce with broader public and community concern via an ABC *Four Corners* television programme of the 18th June, 1985 titled 'Airwaves Warning'. 223 This programme featured interviews with scientists such as

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221 (i) See discussion in Dalton, *op.cit.*, pp.53-59.
   Plus see *Evidence of Adverse Health Effects following Exposure to Electromagnetic Radiation compiled in the Federal Office of the Australian Postal and Telecommunications Union, 1985.*
223 (i) See transcript 'Airwave Warning', ABC TV *4 Corners*, 18th June, 1985, Reporter: Kerry O'Brien, Producer: Dasha Ross;
   (iv) A good indication of the attention this programme gained amongst establishment science in Australia was the following statement released by IRPA's Michael Repacholi:

"As a scientist knowledgeable of the research and surveys on the effects of electromagnetic radiation and their implications on human health, I was concerned the *4 Corners* programme presented an unnecessary bias. Most
Becker and Marino and canvassed many of the pressing issues surrounding the microwave/ELF debate. In the face of public agitation, and given the force of a well organised community response via the Collingwood Residents Association and relevant trade unions, the Victorian government agreed to an 'independent assessment' of the health issues. From the outset this assessment process was to be unlikely to settle the issue, as Dalton, a participant in the dispute, put it:

The experts' brief was not so much to advise the SECV [State Electricity Commission of Victoria] over the health effects of its lines as to clarify the situation for the community.224

Rather than create a panel tapping into the diversity of scientific views on EMF, the Victorian government invited, as their 'independent' consultant, Professor Graves from the University of Pennsylvania. Graves arrived in Victoria fresh from being the chairman of the controversial AIBS report committee, previously described.

Yet again, from the outset, an attempt to close an EMF debate was to be unsuccessful. Community groups, aware of Graves' reputation, sought some kind of scientific balance, and so invited to Victoria the noted athermalist oriented EMF researcher, Jerry Phillips.

The Graves Report225 was to come under serious attack. Protesters claimed that it merely repeated, at numerous points, the problems identified by the State of Wisconsin review of the AIBS report.226 In response to the Graves Report, the Collingwood scientists from the United States interviewed in the programme gave opinions and conclusions that are not shared by the vast majority of scientists or of the World Health Organisation."

Comments on ABC 4 Corners programme, June 18th, 1985, Clause 64 Report, Wagga Wagga to Darlington Point Line, p.15.

224 Dalton, op.cit., p.55.
Community Protest groups, with Phillips' assistance, produced an alternative report on the EMF issue. This report, authored by Ian MacMillan, was to become an important resource for protest groups in Australia opposing high voltage powerline projects. In fact, much of the material to be put to the Gibbs' Inquiry by protest groups can be traced back to the work of MacMillan involving the Richmond to Brunswick dispute.

At about the same time that the Richmond to Brunswick dispute was drawing media interest, the results of the New York Powerline Project were coming to public attention. The findings of the New York Powerline Project can be seen as a convenient symbolic point marking the contemporary phase of the EMF debate.
The impact of the New York Powerline Project

Previous epidemiologic studies on adult and childhood cancer have been questioned because of serious methodological shortcoming. The results of the Savitz study on childhood cancer change the situation considerably because it was designed to minimize flaws in previous studies, and because [the study] was conducted under the supervision of a panel of independent scientists. Even though the Savitz study also has certain limitations, it indicates an excess risk for childhood cancer, in particular leukemias, associated with high current wiring configuration near the homes. Although this study basically confirms the results of the previous studies, the causal relationship is still no more than a hypothesis. However, the basis for this hypothesis is now stronger.


The New York State Powerline Project released its final report on July 1st, 1987 to much international publicity. Although the report's regulatory recommendations and the language of its overview were ambivalent and generally conservative, this did not stop the report from having a significant impact.

First, whilst the Report's summary highlighted that there were considerable uncertainties in the conclusions of its scientific studies, it did acknowledge clearly that EMF concerns had to be taken seriously. In keeping with the Report's ambivalent style, statements implying the need for caution in relation to EMF health and safety were balanced against noting uncertainties especially in regard to the absence of adequately explained causal mechanisms for EMF effects. In its summary for instance, the Report proposed in relation to magnetic fields the following:

It is clear from the results of the studies sponsored by the Project, as well as from many other recent studies, that both 60 Hz electric and magnetic fields can affect certain biological systems. Magnetic field effects were found in a number of the projects in this program. However, the mechanisms responsible for these effects are unknown.

In relation to neurobiology and behaviour, yet again, similar ambivalence was displayed.

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At the onset of this Project there was a serious question as to whether there were demonstrable neurobiological or behavioural effects of exposure to electrical and/or magnetic fields. Data accumulated by our contractors as well as a rapidly building literature on retinal magneto receptors in birds and mammals leave little doubt that such effects can be observed in well designed experiments.

In contrast, our knowledge of the mechanisms by which these effects are mediated has not advanced significantly.\(^{229}\)

The Project's main epidemiological study was an attempt to replicate the Wertheimer and Leeper hypothesis by David Savitz.\(^{230}\) The implication of Savitz's study were possibly the most significant for public debate of all the summary conclusions and recommendations in the Project.

Savitz's study had attempted to answer the questions of EMF dosimetry by comparing Wertheimer and Leeper's wire codes with actual measures of magnetic fields. Overall, wire codes were shown to be consistent with raised household magnetic field exposures. The Savitz study was extremely comprehensive and difficult for power utilities to critique on methodological grounds. Further, Savitz was an eminent epidemiologist.\(^{231}\) The results of Savitz's study showed a significant statistical increase in childhood leukemias at magnetic field exposure levels of 2-3 milligauss, a level literally 500 times lower than that mooted as an appropriate exposure guideline in the work of IRPA.

\(^{229}\) See ibid.

\(^{230}\) Savitz study was later to be published as 'Childhood Cancer and Electromagnetic Field Exposure', American Journal of Epidemiology, 128, 21-38, 1988.

\(^{231}\) For discussion of Savitz, see MacMillan, op.cit., 1987, 4/3 - 4/7

For discussion of Savitz study as a confirmation of it or not, see:

(a) "Wire-coding as an indicator of residential magnetic field exposure", V. Delpizzo, pp.104-118;

(b) "Wire-coding configurations are poor surrogates for magnetic field exposures", D.W.Keam, pp.126-144; and

c) 'Epidemiology Electromagnetic Fields and Cancer', M.R.Salzburg, pp.145-172;


See EPRI Journal, op.cit.
The significance of the Savitz study was not lost in the summary of the New York State Powerline Project, although, again, it called for caution on the basis of the uncertainties surrounding causal models.

Previous epidemiologic studies on adult and childhood cancer have been questioned because of serious methodological shortcomings. The results of the Savitz study on childhood cancer change the situation considerably because it was designed to minimize flaws in previous studies, and because [the study] was conducted under the supervision of a panel of independent scientists. Even though the Savitz study also has certain limitations, it indicates an excess risk for childhood cancer, in particular leukemias, associated with high current wiring configuration near the homes. Although this study basically confirms the results of the previous studies, the causal relationship is still no more than a hypothesis. However, the basis for this hypothesis is now stronger.232

Whilst in the polarised contexts of public inquiries and litigation Savitz's study has been challenged on the basis of its magnetic field exposure model and low statistical significance233, more frequently, it has been accepted, even amongst staunch thermalist scientists and power industry figures, as dictating the need for further research and study.234

The Savitz study and the numerous biological effects reported in the New York Powerline Project added fuel to rejections of the credibility of thermalist approaches and, by implication, the regulatory suggestions of bodies such as the INIRC of IRPA. Adding to this trend were a number of the Project's final recommendations. These included calls for a new generation of laboratory and epidemiological studies and for efforts into researching means of power delivery that would reduce magnetic field

233 See detailed discussion in Chapter 8 (ii) & (iii).
exposures: its conclusion acknowledging the political problems surrounding NIEMR/EMF health assessment stated:

Further research on the biological effects of electromagnetic fields is very important. It should be administered by an agency, preferably federal, which is credible by virtue of being clearly independent of partisan influence.235

Since the report of the New York Powerline Project, the EMF debate has escalated. The prior pattern of litigation, problematic regulation and scientific uncertainty has continued with renewed vigour to the present. Across the world, numerous protests and legal actions, as well as a number of government reviews of EMF policies have taken place, providing important sites for the 'reconstruction' and 'deconstruction' of science, as noted in the earlier discussion of the microwave debate and early powerline disputes. No doubt this consolidation of the legitimacy of EMF concerns in the public eye was helped by the publication of Brodeur's second NIEMR expose *Currents of Death* late in 1989.236 Brodeur traces the development of the EMF debate, focussing on the work Wertheimer, Adey, Becker and Marino from Wertheimer & Leeper's first epidemiological study on childhood leukemias and powerline magnetic field exposure through to numerous pieces of litigation flowing in the wake of the New York State Powerline Project. Brodeur's account, much of it written like a detective story, paints the image of a small devoted body of EMF researchers battling against the odds of deliberate military and power industry suppression of research which implicates EMF as harmful. Much of *Currents of Death* is an extension of material, partly available in the public domain in the publications of Becker and Marino and *Microwave News*. Not unlike his approach in the *Zapping of America* published a decade before, Brodeur's major aim again seemed to be to provoke public attention. This approach is exemplified by the dust jacket of *Currents of Death* which exclaims:

Utility companies, the electronics industry and the military have mounted a heavily financed public relations campaign to minimise the impact of such

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findings [health hazards of EMFs], and the federal government has done its best to sweep the issue under the rug. Fortunately, as Brodeur dramatically recounts in *Currents of Death*, a small group of pioneering scientists has persisted in a long battle to bring the problem to light. This book could be the spark that ignites a firestorm of public outrage.

While certainly not stimulating a firestorm of public outrage, *Currents of Death* stimulated a flood of media attention and public concern surrounding the EMF issue in the US\(^{237}\) [though not so much in Australia, as will be discussed shortly].

Complementing this increased public exposure of the EMF debate was the release, in 1989, of the US Office of Technology Assessment Report on EMF (OTA Report) and the Draft EPA Report in 1990. These reports (which will be discussed in more depth in Chapter 8 (iv)) broke from traditional guideline setting approaches. The former recommended the policy of prudent avoidance, suggesting that the possibility of EMF harm could no longer be ignored and, the latter was to classify EMF as a possible carcinogen setting off major controversy.

Presently, a new generation of post-New York Powerline Project studies are underway, with many results due to be published in the mid-1990's.\(^ {238}\) Anticipations of these results, debates on the adequacy and significance of the OTA and Draft EPA Reports, and assessments of the accuracy, or otherwise, of Brodeur's conspiracy claims, in the main, form the currency of the present EMF debate.

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\(^{238}\) See discussions in Cunningham, *op.cit.*, Granger-Morgan in *IEEE Spectrum, op.cit.*


Plus in *ibid.*, 'A radical approach to electromagnetic fields', p.16.


To conclude this historical overview, we need to address the Australian context for the EMF debate from the time of the release of the work of David Savitz and the New York State Powerline Project up to the time of the announcement of the Gibbs' Inquiry in 1990.
(vi) **The Current Australian Context of the EMF Debate**

It doesn't take much thought to predict what would happen if this court action is successful. There would be claims against every existing powerline in the State. [In relation to the Oberon Powerline dispute hearing, OPIC (Warren) vs. ELCOM in the NSW Land & Environment Court]


In general, since EMF concerns had arisen in the late 1970's/early '80's, Australian power authorities and state health departments had tended to place reliance on the recommendations and guidelines produced by IRPA.\(^{239}\) The media attention given to the

\(^{239}\) An interesting exercise which exemplifies this point was a search undertaken by the author of the treatment of the EMF health debate in Environmental Impact Statements and Clause 64 Reports over the last decade for proposals for powerlines in New South Wales. Nearly all these EIS's addressed the health issue by merely quoting from a section common to ELCOM publicity handouts quoting IRPA and WHO overviews on EMF.

See, for instance, the following EISs and Clause 64 reports on powerlines:.

- 'EIS for Electricity Transmission line between Wagga Wagga and Darlington Point in S.W. New South Wales', March 1985, Gutteridge, Heskins and Davy Pty Ltd., pp.48-49;
- 'EIS Electricity transmission line between Liddell Power Station and Muswellbrook Sub-station', Sinclair Knight and Partners Pty Ltd., September 1985 A.9-A.11;
- 'Electricity transmission line between Kempsie and Coffs Harbour, EIS', Kilpatrick Green Pty Ltd., October 1985, pp.90-92;
- 'Electricity transmission line from Nowra to Ulladulla', October 1985, Daines & Moore, 6.8 pp.92-94;
- 'Electricity transmission line at Wagga Wagga, EIS', July 1986, Sinclair Knight & Partners Pty Ltd., pp.48-49;
- 'Electricity transmission line from Lismore to Mullumbimby, EIS', October 1987, Sinclair Knight & Partners Pty Ltd., Appendix G. G.1-G6;
- 'Electricity transmission line from Mt. Piper Power Station to Marulan Sub-Station', *op.cit.*, pp.174-180;
- 'Clause 64 report for Electricity transmission line from Mt. Piper to Marulan', April 1988, pp.21-22;
- 'Prospect Electricity EIS, Sydney North to Kenthurst, 132 kv. sub-transmission line', Forsite Landscape Architects & Planners Pty Ltd., September 1987, pp.81-82;
- 'Coffs Harbour & Grafton Clause 64 report', July 1988, pp.32-33 plus Appendix 3.

It is useful to consider that notwithstanding the several different consultants being engaged in all the passages cited above not only is IRPA and the WHO argued to be the sole authoritative voice on the EMF health issue but there is plagiarism of actual wording between these supposedly 'independent' overviews.

The issue of the limited cross section of opinion relied on by ELCOM in the EMF debate was also an issue during the OPIC, Warren vs. ELCOM case. Einfield, QC for OPIC, cross examined P. Flannagan, from ELCOM, on this theme. The role of Dr. Repacholi, from IRPA,
work of David Savitz and the New York State Powerline Project provided important resources for challenges to the dominant EMF approaches that had been developed in Australia. Given that, as noted previously, the IRPA recommendations had been sluggish in acknowledging new scientific work, the reporting of the Savitz study in the media and debate of its implications raised serious questions about the trustworthiness of both IRPA and power authorities.\(^{240}\)

In this context, in Australia, the Richmond to Brunswick dispute (touched on above in section (iv)) was to transmute into a comprehensive review of the whole issue of powerline planning. On the 31st March, 1988 the Victorian Powerline Review Panel was established. After more than a year of consultation and deliberation it released its final report in July 1989.\(^{241}\) The Report's conclusions in the immediate sense signalled a victory for protest groups; its recommendations included:

(i) significant undergrounding of the proposed line;

(ii) the need for the State Electricity Commission of Victoria to improve its sensitivity to public participation and environmental issues generally; and

(iii) the establishment of a panel to investigate ongoing concerns of powerline EMFs.\(^{242}\)


\(^{241}\) There are a number of reports produced in relation to the Victorian Powerline Review Panel. These included:


For brief surveys of the on-going processes of EMF evaluation in Victoria, see 'Inquiry into Powerline Threat', Directions in Government, March, 1991, p.6.
These recommendations were nevertheless balanced by the Report's generally conservative overview of the EMF issue. The Panel, in a sense, turned the tables on traditional arguments that power authorities were unresponsive and undemocratic in imposing involuntary risks on segments of the population. It concluded that any policy towards avoidance of EMFs might also be undemocratic, imposing social costs or limits on the development of electricity infrastructure, which the populace may not want.

Would the community accept that there should be imposed on its various activities, its daily life, a new level of EMR above which it may not risk itself - even if this meant a re-allocation of resources such as to result in fewer trains, parks, new hospitals, or better (safer) street lighting, or for that matter, access to new appliances within the home?

In response to this question, it seems that there has not yet been the sort of democratic, consultative and political processes that would allow a government, or a public utility, or a community group to claim that the community as a whole would accept potentially strict new prescriptions.243

Further, its basic findings on EMF health were merely to reinforce the IRPA/WHO guidelines.

Beyond the review process, Panel is not aware of any argument that IRPA/WHO are wrong in this particular instance of fields exposure when they are trusted on other standards. More broadly, the Panel recognises that the World Health Organisation has a justly deserved reputation as an important organisational instrument in achieving global reforms and is not likely to be an unwitting accomplice in the protection of power utilities rather than the public health.244

A number of other powerline disputes began to gain public prominence around this time in Australia. Concerns no doubt boosted by the publicity given to the Brunswick to Richmond powerline dispute and the report of the New York State Powerline Project.245

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243 ibid., p.191.
244 ibid., p.190.
It was partly in response to a number of these protests in New South Wales that the Gibbs' Inquiry into the EMF powerline issue came to be called in 1990. Whilst the Gibbs' Inquiry would address a variety of these disputes, one in particular should be singled out -- this debate concerned the proposed Mt. Piper to Marulan line, which had simmered for almost a decade, and was to result in an important test case in the New South Wales Land and Environment Court immediately prior to and partially contemporaneous with the Gibbs' Inquiry.

In 1980, the New South Wales Government announced a proposal to build a $1.2 billion power station at Mt. Piper, south west of the Hunter Valley. This power station was to be linked to the NSW power grid via a 500 kv. powerline extending 160 kilometres to Marulan, near Goulburn.246

Opposition to the proposal mounted quickly amongst various groups of landholders anxious to have the line by-pass their properties. After some government indecision, the project was given the go-ahead in 1985. Between 1985-87 the Electricity Commission of New South Wales produced an Environment Impact Statement on the proposal.247 The route recommended in the EIS was challenged by a group of 80 or so farmers and landholders who called themselves the Oberon Powerline Investigation Committee.248 The Committee argued that the choice of the route had been shaped by political expediency rather than merit: that the New South Wales Electricity Commission (ELCOM) had been reluctant to direct the line through public land, mainly state forests (pine plantations), which would have involved battles between various government bureaucracies. OPIC also argued that in order to justify the preferred route, which went close to homes and prime farmland in the Oberon district, ELCOM had influenced the

246 Background discussion in Judgement, Warren vs Electricity Commission of New South Wales, No.40308/89, 31st October, 1990 in the Land & Environment Court of New South Wales, Cripps, J., p.10.
247 ibid., p.11-12.
248 ibid., p.1.
content and objectivity of the EIS. In particular, it was claimed that the EIS misrepresented the state of science in relation to the potential health risks of EMF for those living and working in close proximity to the proposed line. 249

As usual in the case of powerline disputes, the feelings of protesters ran high. As Oberon farmer, Pat Cosgrove, put it to the media:

I'll do bloody anything to stop ELCOM. I'll get my 12 gauge shotgun out if need be. I know fellers who will blow the electricity towers up if they have to. I think it could come to people being killed. I know it will get pretty violent. 250

In December 1988, OPIC initiated proceedings in the New South Wales Land & Environment Court. Ultimately the matter was to be heard in sittings in that Court starting in June 1990 with a final judgement being brought down on the 31st October 1990. The latter part of these proceedings coincided with the preliminary hearings of the Gibbs' Inquiry. 251

To support their case OPIC engaged two bioelectromagnetics scientists from the US: the founder of the cyclotron resonance hypothesis, Abraham Liboff, and by now a seasoned public campaigner, Andrew Marino. From Australia they called on Vincent Delpizzo

249 ibid., pp.2-5.

Also of note was discussion surrounding the adequacy of the EIS's appraisal of the potential impact of the line on Aboriginal sacred sites.

The issue of the adequacy of environmental impact statements particularly in relation to Kinhill, one of Australia's largest engineering consultants was, at the time of the Warren (OPIC) vs. ELCOM case and the Gibbs' Inquiry, a highly contentious one; feeding off, in part, the controversy over the siting of the Sydney Airport third runway. It provides yet another piece of the subtle historical texture surrounding the Gibbs' Inquiry.


250 See Stephen Skinner, 'Power Battle', The Sun Herald, January 7th, 1990, p.18. Though in conversation with William Gilmore from OPIC, it was clear that most of the farmers favoured the more sophisticated approach of appealing to legal and political recourse.

251 Gibbs' Inquiry was announced 28th May, 1990 and it's Final Report tabled to Parliament 28th February, 1991.
from the Australian Radiation Laboratories, who had recently produced an overview of the epidemiological literature on EMF.252

Marino publicly proposed that, in his judgement:

... the portion of the EIS dealing with the health hazards question is erroneous, and grossly misleading and self serving.

The conclusions reached can be sustained only by ignoring and misquoting evidence, and by gratuitously disparaging scientific reports that are adverse to ELCOM's position.253

ELCOM and the New South Wales Government did not take the case lightly. A spokesman for the Department of Minerals and Energy, for instance, proposed:

It doesn’t take much thought to predict what would happen if this court action is successful. There would be claims against every existing powerline in the State.254

ELCOM spared no cost in its legal defence. Some sources have suggested that they invested $4 million plus in legal and expert witness fees.255 They called on eight expert witnesses, two from Australia and six from the US.256 Further, to assist their Australian

252 A. Liboff, Oakland University, Rochester, Michigan.
A. Marino, Professor of Orthopaedic Surgery, University of Louisiana.
V. Delpizzo from the Australian Radiation Laboratories.

253 In Skinner, op.cit., p.18.
See also Cripps, op.cit., p.17.

254 Skinner, op.cit., p.18.

255 In an interview with Transmission Lines Manager for ELCOM, Paul Flannagan, July 3rd, 1991, he refused to divulge exactly how much ELCOM paid. Support for the idea for huge legal costs can be gained though from the article by Richard Macey in the Sydney Morning Herald, June 9th, 1992, p.5. 'Fury at $12 m. legal bill'. For instance, this article suggests in 1990 ELCOM (now Pacific Power) spent $5,083,807; in 1991, $4,747,244; and, in 1989 $2,224,918 on legal bills:

"... a spokesman for the Minister for Planning & Energy said the legal bills were not unreasonable and one-off legal expenses - he also admitted that the Gibbs' Inquiry into the proposed Mt.Piper/Marulan line had been partly to blame."

256 From Australia: M.Repacholi, Chairman of the INIRC of IRPA, Chief Research Scientist, Royal Adelaide Hospital;
T.Sandeman, Physician, Peter MacCallum Hospital, Melbourne, Australia.
M.Silva, Ener-tech Consulting Engineers;
J.Stolwicz, Professor, Yale School of Epidemiology;
legal team, they engaged the services of Washington legal firm, Crowe and Moring which specialises in defending powerline authorities/utilities in EMF cases across the world. A number of the scientists called for ELCOM were seasoned performers in the public domain. For instance, from Australia, the familiar public EMF figure, Michael Repacholi, was called. As far as the US based experts were concerned, a number of them were fresh from various US legal powerline proceedings. Of these experts standing out was Edward Castemson, who could boast a lineage of more than twenty past similar court appearances, stemming back to his battles with Marino in the late 1970's in the New York State Public Service Powerline Inquiry, and Zaner and Bockman who had recently given evidence in a New York powerline proceeding.

ELCOM's strategy during these proceedings was to draw them out, and engage in battle via weight of evidence (quite literally) and superior financial staying power. To these ends, ELCOM submitted a 38-volume, 20,000-odd page submission on EMF and ELCOM's planning policies in relation to it. Close to seven weeks of evidence and cross examination were heard. OPIC only managed to hold on to the services of their Q.C. for the bulk of proceedings courtesy of last minute legal aid.

One can only speculate on the effect of these complex and drawn-out proceedings on the final judgement of Justice Cripps of the Land & Environment Court. It would appear to

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257 R. Bockman, Sloan Kettering Cancer Center; S.K. Zaner, Associate Professor, Boston University School of Medicine; E. Gelman, Chief of Division of Medical Oncology, Georgetown University.

(i) See also Environment Headlines, Environment No.1, a newsheet from the Australian legal group, Allen & Hemsley, November 1990, 'Powerlines, Electromagnetic Fields and Farmers'.

(ii) See also Crowell & Moring's involvement in the New York Marcy to Massena Powerline Dispute in Brodeur, 1989, op.cit.

258 Brodeur, 1989, op.cit.

259 Conversations with William Gilmore during Warren (OPIC) vs ELCOM proceedings. See also Richard Macey, 'ELCOM casts a shadow over Oberon', Sydney Morning Herald, Wednesday, 19th December, 1990, p.4.
be plausible to argue, when looking at his final judgement, that he took refuge in backing up the status quo of the IRPA/WHO guidelines.260

Throughout proceedings and final judgement Justice Cripps explained he was not required to judge the state of EMF science, but rather that it was reasonable for ELCOM to have held the views they did in the EIS.261 Of course, he did, nevertheless, commit another judicial evaluation of the state of EMF science to history. The response of the media and the parties to the case themselves was that Cripps had in fact produced a judgement for the public record on the state of EMF science. Cripps' judgement on EMF science went as follows:

Based on the evidence before me I conclude that among scientists it has not been established that exposure to extremely low frequency electric and magnetic fields can cause cancer on what might be described as a 'cause and effect' basis.262

The outcome of the Oberon case, like many of the prior NIEMR cases as have been noted, was clearly unable to achieve scientific closure on the issue. Justice Cripps certainly adhered to the IRPA guidelines and regulatory status quo with his statement on the limited probabilities of EMF harm. Nevertheless, throughout the proceedings he noted that his main job was not to find on the scientific facts, and his judgement lacked any disparaging remarks directed at OPIC's witnesses. This provided enough space and leverage for doubts and dispute to continue to grow.

For example, as is typical of these adversarial style proceedings, there had been a number of displays of the public deconstruction of science. Standing out in particular were sustained attacks on the credibility of the so-called Graves Report which, as noted, had

260 See Cripps, J. Judgement, op.cit.
261 ibid., p.18.
262 Quoted in Adam Fulton, 'Farmers groups loses court battle against new powerline', *Sydney Morning Herald*, November 1, 1990.
been the subject of the Richmond to Brunswick Line dispute, and had been relied on as an adjunct to the WHO/IRPA health guidelines for Australian power authorities.

Much of the context of the Oberon proceedings were shared by, and came to shape, the Gibbs' Inquiry to which we now turn.

On the 28th May 1990 the NSW State government announced that it would hold an inquiry into community needs and high voltage (132 kv. and above) transmission line development. It was to be chaired by ex-Chief Justice of the Australian High Court, the Right Hon. Sir Harry Gibbs. This announcement was made, quite literally, as the Warren (OPIC) vs ELCOM parties made their final preparations prior to the commencement of the hearing of their case in the NSW Land & Environment Court.

Some journalists announced that the Gibbs' Inquiry was the first of its kind in Australia, for instance, the widely circulated *Bulletin* news magazine reported:

... the Gibbs' Inquiry into high voltage powerlines in New South Wales could have ramifications for all Australians ...

For the first time in Australia, the social, economic and environmental issues associated with high voltage transmission lines will be examined.263

But, as the earlier discussions of the Richmond to Brunswick dispute and Victorian Powerline Review Panel and the Warren vs OPIC proceedings show, the Gibb's Inquiry was only, in a limited sense, the first time in Australia the issues surrounding high voltage powerlines were being examined. These background contextual factors and past

It is worth acknowledging that whilst the Inquiry tackled these broader concerns, the EMF debate became the Inquiry's single most important pre-occupation with 68% of its 177 submissions devoting some, or all, of their consideration to it.
appraisals of the EMF issue became important influences on the way the Gibbs' Inquiry was carried out.

Five major background factors can be identified as to why the Inquiry was announced (the influence of these factors will be discussed in more depth in Chapters 9 & 10.)

First, whilst Brodeur's second NIEMR expose *Currents of Death* had not received a great deal of publicity\(^{264}\) in Australia (unlike in the US), it is fair to note that it contributed to a growing media awareness of the NIEMR issue leading up to the time of the Gibbs' Inquiry. A number of newspaper and television stories on local powerline controversies and the EMF debate appeared.\(^{265}\) There was also a flood (possibly of more relevance to the 'attentive audience') of new quasi-scientific magazine articles and books taking Brodeur's account as their point of departure attempting to publicise the EMF issue.\(^{266}\) In this environment of growing awareness of the EMF debate, it is not

\(^{264}\) One of the few reviews of Brodeur's book in the Australian popular press can be found in *The Independent Monthly*, April 1990, by L.V.Kepert, 'Killing Fields', p.35.

\(^{265}\) For example:

(i) *A Current Affair*, Jana Wendt, Channel 9, Tuesday, 1st May, 1990, touching on the Whalan dispute;
(iii) P. Quidington, 'Plug them in then run for cover', front page, *Saturday Herald*, June 9th, 1990.

\(^{266}\) See for instance:

(ii) *Electronics World plus Wireless World*, February 1990, Special feature, 'Killing Fields':
(a) A.Phillips, pp.96-97, Introduction;
(b) S.Best, pp.98-111, Epidemiological Evidence;
(c) R.Coghill, pp.112-120, Bio-physical Evidence;
(d) A. Phillips, pp.121-124, The Politics;
surprising that the leaking of the draft report of the US EPA on the effects of electromagnetic fields, and the publicity surrounding claims of political pressure on the EPA to reclassify EMF as less of a risk than in the original report, would make front page headlines in a number of major newspapers. This publicity, if nothing else, fuelled further scepticism and active dissent on the part of powerline protest groups and helped give such protests public legitimacy.

Second, a number of these powerline disputes were in sensitive electorates and it is likely that the New South Wales State Government was aware of potential political damage of appearing to be unresponsive to an emerging important issue.

Third, the NSW State Government was beginning to embark on an attempt to restructure the NSW power industry. In fact, across Australia, the dominant styles of electricity industry management were under challenge. As Michael Gill, from the Financial Review, put it:

After a decade of struggle and large scale mismanagement, Australia’s electricity industry is facing what amounts to an identity crisis that is likely to lead to a shake-out. Heavy debt burdens, excess generating capacity and the constant threat of steep price increases are the residue of a decade in which the power engineers’ dreams of ever bigger projects have turned to financial nightmares. And now the economic problems have combined with more powerful arguments for energy conservation and pollution control to challenge the basic thinking of power utility managers.

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267 D. Vincent, 'Wired', Simply Living, Vol.5., No.5., pp.52-55.
269 Barlow, op cit., p.65.
T. Burton, 'Energy authorities may be broken up', Sydney Morning Herald, 19th May, 1990.
See also discussion in Powering the Future, Johnson & Rix (eds.), op.cit.
It could be argued that, as far as the NSW Government was concerned, tackling the EMF issue, whilst also investigating the economics and planning policies of the NSW electricity industry, was like killing 'two birds with the one stone'. This was likely to be true in particular in the case of the Mt. Piper Line which had immense significance for a proposed nation wide electricity grid. There was also talk that with so much invested in the Mt. Piper Power Station, a failure or delay to build the Mt. Piper line could incur costs of up to $1 million per week to State revenue.\(^{272}\)

Fourth, considering that the State government had been compelled indirectly to commit its resources to defending ELCOM in the Mt. Piper dispute, it would be convenient to double-up on this expenditure and appear to be publicly responsive to the more general issues of EMF by calling a public inquiry. This evaluation was put forward by a number of protesters.\(^{273}\)

Finally, there was also speculation that the Gibbs' Inquiry might have been able to serve the purpose of being something of an insurance policy for the NSW State Government if the Oberon farmers case was found against ELCOM, i.e. the Gibbs' Inquiry provided ELCOM with a second chance to argue for the validity of its powerline planning practices.

It is beyond the scope of this thesis to evaluate, in more detail, the possible reasons the Inquiry was called. Nevertheless, it is worth acknowledging that the factors just noted no doubt contributed to the breadth of the Inquiry's terms of reference, and also, as will be discussed in more depth below, that they placed pressures on Gibbs to try to create

\(^{272}\) Macey, 'ELCOM casts a shadow over Oberon', *Sydney Morning Herald*, 19th December, 1990, p.4.

\(^{273}\) Conversations with William Gilmore, September 24th, 1990.
some kind of distance between the proceedings of 'his' Inquiry and its surrounding political landscape.

Moving on from considering these broader political explanations for the holding of the Inquiry, and returning to our major theme, the history of the NIEMR debate, a number of concluding remarks should be made. Whilst standing on its own as an overview of the NIEMR debate, the history provided in Part 1 'Mapping the Terrain' also provides the necessary context for the more detailed explorations of the Gibbs' Inquiry which is to follow in Part III of the thesis.

Two main points are worth flagging for future reference.

First, many of the issues and themes described in 'Mapping the Terrain' make up the raw materials that participants used during the Inquiry. The reader's familiarity with these themes will greatly enhance their understanding of the intricacies of the negotiations of EMF science and policy taking place in the Inquiry, which shall be discussed later.

Second, we have noted in 'Mapping the Terrain' that the Gibbs' Inquiry was not a unique event, but rather yet another attempted quasi-legal administrative solution, punctuating the on-going NIEMR debate which took place in the shadow of a number of similar, and controversial, proceedings such as the Victorian Powerline Review Panel, the Graves Report, and the Warren (OPIC) vs. ELCOM case. This continuity provides an important part of the context which helps explain two themes developed later in the thesis: (i) the way participants negotiated scientific claims, drawing on past proceedings and, in certain respects, treating the Gibbs' Inquiry as part of a larger on-going debate; and (ii) Gibbs' attempt to establish the legitimacy of inquiry by distancing it from its immediate context and the way this shaped the negotiation of the EMF issue, especially in relation to defining appropriate public policy.
Before linking the history of the NIEMR debate in 'Mapping the Terrain' to the specific detailed case study of the Gibbs' Inquiry we shall turn, in Part II, to a review of the various theoretical perspectives provided for analysing the Gibbs' Inquiry by the literature on scientific/technical controversy.