Chapter 7

Siting, Environmental, and Health Issues Associated With Increased Competition and Expanded Transmission Access

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INTRODUCTION

Increasing competition and opening up the transmission grids raise many public policy issues beyond the technical and institutional feasibility of accommodating these changes. This chapter provides an overview of three of the most significant and potentially contentious of these issues: transmission line siting, environmental impacts, and potential public health effects of power frequency electric and magnetic fields. Because of the clear interconnections with proposed industry changes, Congress asked OTA to include consideration of these issues in its assessment.

Siting

The process of gaining approval for transmission line construction has changed and become more formalized as opportunities have been provided for public involvement and greater scrutiny of potential environmental and social impacts of proposed projects. As the Nation is becoming more and more urbanized, competition for available land to route transmission lines has become more intense and right-of-way costs have increased as higher value lands are taken. It is clear, however, that in order to provide an adequate and reliable power supply new and expanded transmission systems will eventually have to be built whether a competitive future path is taken or not. The challenge for industry and regulators is to create a system that plans for and encourages needed expansion and at the same time accommodates other competing interests while resolving or minimizing conflicts. The siting section of this chapter describes generally how transmission line siting decisions are made by State, local, and Federal agencies and discusses several proposals for improving the siting process.

Environmental Impacts

Decisions over the future structure and composition of the electric power industry in the United States have both direct and indirect environmental impacts. These choices will shape fuel mix, dictate location of impacts, and advance or frustrate the achievement of other environmental and social goals. Transmission line construction, operations, and maintenance also raise direct and indirect impacts on the environment. This section discusses the potential environmental concerns presented in the implementation of OTA's alternative institutional scenarios.

Health Effects

One of the most prominent concerns raised by people living near existing or proposed transmission lines is the potential for adverse health effects from exposure to electric and magnetic fields. Scientists are still investigating whether and to what extent these effects are harmful and long lasting and their possible public health implications.

The health section describes the current state of knowledge on health effects of power frequency fields based on available research. It also discusses some of the policy responses to the implications of these research results,

SITING ELECTRIC TRANSMISSION LINES

Long-distance transmission of electricity has increased significantly in recent years. Transmission capacity in some regions is already strained by high usage. At the same time, the pace of construction of new power lines has fallen. Some analysts point to the many licensing and certification processes required to site new transmission lines as one possible reason for this decrease in new construction.

Gaining approval of specific transmission line projects from State regulatory agencies can be a complicated process, often requiring the filing and review of multiple applications. The involvement of many local governmental agencies, the courts, and Federal and tribal governments further complicates the siting process and can lead to jurisdictional conflicts. The participation of a variety of competing interest groups in the siting process for new transmission lines frequently adds to the time required to complete siting and to the complexity of the process.

Long-range planning efforts by utilities and State agencies tend to focus on power generation issues, leaving long-distance transmission issues understudied. Consequently, decisionmakers are often hampered by inadequate information about transmission needs as they review project applications. Constraints imposed by State utility laws and regulations could also hamper decisionmakers as they review large interstate transmission line proposals. Moreover, the lack of multi-State siting procedures and coordination among Federal and State agencies could further encumber the siting of interstate power lines. However, even without such procedures in place, voluntary cooperation among utilities and State and Federal agencies has resulted in the siting, approval, and construction of multi-State lines. The National Governor's Association Electricity Transmission Task Force survey, conducted in the fall of 1986 (hereafter referred to as the NGA survey), indicated that 73 projects had been approved and 84 requests were pending approval within the previous year. In addition, the survey noted that the majority of projects approved between 1982 and 1987 had been completed.[1]

Proposals to improve the siting process for new transmission lines include developing more information about transmission needs in the long-range planning and application review processes, streamlining and clarifying State regulatory agency review processes, broadening multi-State siting efforts, and increasing public participation. Standardizing and expanding reporting requirements, increasing interagency communication, developing clear and consistent evaluation criteria, and creating new regulatory entities empowered to make final siting decisions could also help achieve these objectives. A number of States have already adopted some of these measures.

This section provides an overview of the transmission line siting process, beginning with the long-range energy planning process through which States and utilities strive to identify future electricity supply requirements. It also explores the impediments to power line construction and discusses the perspectives of interest groups towards transmission facilities. Finally, several proposed options to improve the transmission line siting process are examined.[2]

None of OTA's scenarios, described in chapter 3, affect the process for approving the routing and construction of transmission systems. This process is generally separate from the regulatory decisions concerning certification of need and recovery of transmission system investments through ratemaking.

The Siting Process

Once a need for new power supplies has been identified, specific transmission line projects are designed by utilities, and approval for those projects is sought from State agencies charged with certification and licensing. Project approvals from a variety of local governmental entities are usually required. In addition to these State and local siting requirements, special siting approval for power lines crossing Federal and tribal lands and for multi-State transmission line projects is required.

Capacity Planning

Recognition of the need for new transmission lines usually surfaces through long-range energy planning processes that attempt to predict electricity demand patterns in future years and decades. At least 31 States require electric utilities to file long-range supply and demand plans for their service area.[3] These utility plans discuss, among other issues, anticipated electricity supply and demand, the need for new power generation or transmission facilities, and anticipated nonutility generation capacity. Long-range energy plans generally reflect a 20-year planning horizon, although shorter range planning frameworks of 10 to 15 years are not uncommon. Moreover, utilities are required to submit planning

1"Tr~s~I.~I~~ Line Certification and Siting Procedures and *Energy* Planning Processes: Summary of State Government Responses 10 a Survey By the National Governors' Association Task Force on Electricity Transmission, " prepared by staff members of the Public Utilities Commission of the State of Ohio and of the West Virginia Public Service Commission, OTA contractor report, July 1988, p 4, hereafter "NGA survey."

2Much of the information in this section is drawn from an OTA contractor report, James S. Cannon, "The Siting of EHV Electric Transmission Lines," May 1988.

3National Governor's Association, Committee on Energy and Environment T& Force on Electricity Transmission, *Moving Power: Flexibility for the Future* (Washington, LX: 19 W), ' 'Foreword. "

analyses to support their applications for approval of specific power generation or transmission projects.

In many cases, utility plans are supplemented by energy planning efforts by State government agencies. A recent survey of State electricity regulatory programs by the NGA identified 18 States where public utility commissions prepared independent electricity plans and 12 States where planning was performed by a State energy office or department.[4] However, only a few States, such as California, New Jersey, and New York, require agencies to solicit public comment during the energy planning process and to publish State energy plans at periodic intervals.

According to the National Association of Regulatory Utility Commissioners (NARUC) and NGA, several factors diminish the effectiveness of energy planning processes. First, many State energy regulatory agencies do not have adequate staff either to scrutinize utility long-range plans or to prepare detailed energy forecasts on their own. Thus, planning reports often receive close review by a State agency only when a specific construction project is proposed, which may be years after the need for the project was first identified.

Second, utilities jointly involved in the development of a transmission line submit separate long-range plans, which discuss only those portions of energy projects directly affecting that utility. Most State-mandated, long-range planning programs do not require utilities to coordinate their projects' planning reports. The task of consolidating the individual plans into a comprehensive picture of a State's electric power system often falls to the limited resources of the State agency to which the plans are submitted.

Third, utilities' long-range plans have traditionally focused on generation needs within a particular service area. Issues related to interutility sales and transmission are not necessarily addressed in detail in long-range plans. Thus, NGA's report noted "determinations of transmission requirements are frequently ancillary or iterative to, rather than integral to the determination of need for new generating capacity. '5 Identification of the overall efficiency or the economic benefits potentially obtainable from expansion of the extra-high-voltage transmission line system and increased interutility sales can easily go unrecognized in the planning process.

State Certification and Licensing

Major transmission line construction projects usually require some sort of State certification and/or licensing. Certification normally comes in the form o! the issuance of a "Certificate of Public Convenience and Necessity" (CCN) by a State's public utility commission (PUC). Other State agencies, such as the environmental protection department, may also be involved in the licensing of projects through, for example, their responsibility to issue requisite construction and operating permits. In some States, power project siting boards coordinate State agency responses to transmission line projects as well as serve as decisionmaking entities. (See table 7-l.) A CCN is a prerequisite in many cases for other permits and authorizations, such as the taking by eminent domain of land that is needed for the completion of the project.

Requirements for documentation in support of a CCN application are vague in most States, one of the many sources of uncertainty in the certification process, Applications usually include formal testimony by the utility summarizing the utility's argument for the project. Upon receipt of an application, a case or docket is opened by the PUC, a hearing schedule is established, and potential interveners are notified. lntervenors frequently include other State agencies and utilities, large power users, and public interest groups. The PUC either accepts or rejects interveners' applications and the case usually enters a "discovery" phase during which the various parties collect and study information about the project obtained through depositions and other methods of information exchange.

At the conclusion of the "discovery" phase, the PUC staff and the interveners file their formal testimony, and the utility files a second, or rebuttal, testimony. The case next enters the ''healing" phase during which the witnesses submit to examination and cross examination by attorneys for all parties.

[4] NGA Survey, supra note 1, p. 14.

[5] NGA, supra note 3, p. 16.

Table 7-l-State Certification and Siting Requirements for High-Voltage Transmission Lines

State	Required certification authority	Required siting authority	Agency with final authority for project approval
Alabama	Not required	Not required	NA
Alaska	Not required	Not required	NA
Arizona	Not required	Not required	NA
Arkansas	Puc	Puc	Puc
California	Puc	Puc	Shared with EC
Colorado	—	—	—
Connecticut	—	—	—
Delaware	Not required	DOT (limited)	NA
District of Columbia	Puc	Not required	NA
Florida	Puc	Siting Board	Siting Board
Georgia	Not required	DNR	NA
Hawaii	DNR	PUC/DNR	—
Idaho	Puc	Puc	Puc
Illinois	Icc	Icc	Icc
Indiana	Not required	Not required	NA
Iowa	Utility Division DOC	Utility Division DOC	Utility Division DOC
Kansas	Corporate Commission	Corporate Commission	Corporate Commission
Kentucky	Psc	Psc	Psc
Louisiana	Not required	Not required	NA
Maine	Puc	LURC/BEP	—
Maryland	Psc	Psc	Psc
Massachusetts	PUC/Siting Council	PUC/Siting Council	PUC/Siting Council
Michigan	Not required	Not required	NA
Minnesota	Puc	EOB	—
Mississippi	Psc	Psc	Psc
Missouri	Psc	Psc	Psc
Montana	BNRC	BNRC	BNRC
Nebraska	PSB	Not required	—
Nevada	Psc	PSC/NCNR/NEC	Psc
New Hampshire	Puc	Site Evaluation committee	—
New Jersey	BPU	BPU/DOC/DEP	Energy Facility Review Board
New Mexico	Psc	Not required	NA
New York	Psc	Psc	Psc
North Carolina	Not required	Not required	NA
North Dakota	PSC	Psc	Psc
Ohio	Siting Board	Siting Board	Siting Board
Oklahoma	Not required	Not requmd	NA
Oregon	Siting Council	Siting Council	Siting Council
Pennsylvania	PUC	Puc	Puc
Rhode Island	PUC/Siting Board	PUC/Siting Board	PUC/Siting Board
South Carolina	PSC	Psc	Psc
South Dakota	Not required	Not required	NA
Texas	PUC	Puc	Puc
Utah	PSC	Not required	—
Vermont	PSB	PSB	PSB
Virginia	Corporation Commission	Corporation Commission	Corporation Commission
Washington	Not required	EFSEC (limited)	—
West Virginia	PSC	Psc	—
Wisconsin	PSC	PSC/DNR	Psc
Wyoming	PSC	PSC/DPIJISC	Psc

KEY: BEP=Board of Environmental Protection
BNRC=Board of Natural Resources and Conservation
BPU=Board of Public Utilities
DEP=Department of Environmental Protection
DNR=Department of Natural Resources
DoC=Department of Commerce
DOT. Department of Transportation
DPL=Department of Public Lands
EC= Energy Commission
EFSEC=Energy Factilities Site Evaluation Council
ICC=Illinois Commerce Commission
ISC.industrial Siting Council
LURC=Land Use Regulatory Commission
PSB=Public Service Board
PSC Public Service Commission

SOURCE: Summary of State Government Responses to a survey by the National Governor's Association Task Force on Electricity Transmission (prepared by the starts of the Public Utilities Commission of the State of Ohro and of the West Virginia Public Service Commission), OTA contractor report, July 1988.

Hearings are frequently held before a hearing examiner appointed by the PUC commissioners, although they are sometimes held in front of the commissioners themselves. Most States also require that public meetings be held to solicit public opinion on the project. In some other States public meetings can be called at the discretion of the public service commission.[6]

In instances where a hearing examiner is utilized, he or she prepares a report and a proposed or recommended decision which is reviewed and upheld, rejected, or modified by the PUC commissioners. If the commissioners hear the case, they prepare both the report and render the final judgment. PUC decisions can be appealed to the State court system.

The NGA survey found that the certification process in most States generally takes less than a year, although the process can take years in some complex or controversial cases. None of the States responding to the survey placed a limit on the amount of time a public service commission can take to decide on a CCN application.'

Depending on the State, a utility can proceed to obtain permits from other State agencies needed to construct a transmission line either before, during, or after a CCN is granted. In 11 of 33 States responding to the NGA survey, utilities are not permitted to pursue required permits from other State agencies until a final ruling on a CCN has been rendered.[8] In at least 21 States a joint certification and siting approval process has been instituted that can simplify and expedite State agency permitting issuance. At least eight States have established some sort of a siting board to coordinate and resolve permitting issues.[9]

Even with all required State agency permits in hand, a transmission line cannot be constructed until rights-of-way have been acquired for the land through which the line travels. For some projects, land acquisition for the transmission line corridor cannot be obtained voluntarily by the utility through negotiation with the landowner. Such opposition can result in the abandonment of a project or a costly rerouting unless the utility can invoke eminent domain to acquire the needed property upon payment of a court-approved level of compensation.

In a few States, utilities are granted the power of eminent domain by State law for any transmission line project, but in most the issuance of a CCN is a prerequisite before eminent domain can be exercised. According to the NGA survey, in at least 11 States the issue of whether or not eminent domain powers are granted to a utility is decided as one component of the certification and siting process. At least 20 States require a separate application and decisionmaking process for eminent domain which occurs after siting approval has been obtained. In some States, the power of eminent domain is obtained from a court which considers issuance of a CCN and siting approval as evidence in its decisionmaking process.[11]

Local Permits and Approvals

Special use permits and zoning variances issued by local and county governments are commonly required before construction of a transmission line project can begin. Acquisition of local permits can be an extremely complex and time-consuming undertaking, especially in areas where significant local opposition to a transmission line project exists. A recent case study by the National Coal Council of a 50-mile transmission line project found that over 30 local and county governments had to be individually contacted regarding the project.[12] For a long-distance interstate transmission line project, separate approvals from many local government entities can be required. Each decisionmaking process generally includes an opportunity for appeal through

6 Public Service Commission of West Virginia, "State Survey of Transmission Certification and Siting, and Planning Processes," unpublished summary, Nov. 13, 1987, p. 8. This document provides the preliminary results of the NGA-NARUC survey of State utility and siting commissions.

7 NGA survey, supra note 1, p. 12.

8 Public Service Commission of West Virginia, supra note 6, p. 6.

9 NGA survey, supra note 1, p. 7

10 Ibid., p, 4.

11 NGA, supra note 3, p. 11.

12 National Coal Council, *Interstate Transmission Of Electricity* (Washington, DC: June 1986), p. 33.

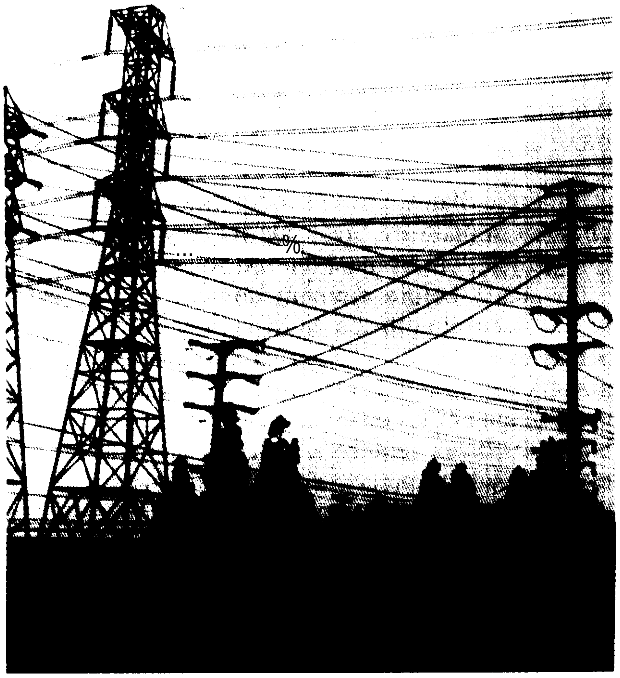

Photo credit: Casazza, *Schultz & Associates, Inc.*

View of multiple transmission lines

the court system in addition to the administrative review process.

As part of their certification and licensing processes, several States permit one agency to override the decisions of other agencies, including local governments. At least 17 States grant such powers,[13] but in at least 12 States, local agencies have the authority to block transmission line projects from being built within their jurisdiction.[14]

Permitting Transmission Lines Across Federal Lands

Long-distance transmission lines often cross lands administered by Federal agencies, especially in the Western United States. In most cases, siting a line on Federal lands requires obtaining a right-of-way from the administering agency in a process separate and distinct from State and local agency actions. Federal land permitting frequently involves three steps: an environmental review, a land-use planning process, and review of a specific right-of-way application.

Under section 102(2)(c) of the National Environmental Policy Act of 1969 (NEPA), an Environmental Impact Statement (EIS) must be prepared prior to any major Federal action significantly affecting the quality of the human environment. Most major transmission line projects that cross long stretches of Federal lands are considered major actions and fall under the EIS requirement.

The EIS process begins with a preliminary analysis to determine how extensive an environmental review is required by NEPA for a particular project. A "finding of no significant impact" can permit a project approval process to continue without more analysis under NEPA. If minor impacts are anticipated, an abbreviated environmental assessment is deemed adequate.

For projects with significant potential impacts, a full EIS is required to be prepared by the agency administering the land affected by the transmission line. When the lands are administered by more than one Federal agency, a lead agency is selected, but all agencies participate in and are bound by the results of the EIS. For example, for the 1984 EIS analyzing the 345-kilovolt (kV) line between the San Juan Generating Station in New Mexico and Rifle, Colorado, the Rural Electrification Administration acted as the lead agency and the U.S. Forest Service (USFS), the Bureau of Land Management (BLM), and the Western Area Power Administration served as cooperating agencies.[15]

Separate from the NEPA process, several Federal agencies, notably BLM and USFS, are responsible for providing comprehensive land-use plans for the lands under their jurisdiction and to identify areas suitable for the construction of transmission lines. Land-use plans, called Resource Management Plans, for public domain lands under control of BLM are

[13] NGA survey, supra note 1, p. 7.

[14] NGA, supra note 3, p. 10.

[15] Rural Electrification Administration, *Rifle to San Juan 345 kV Transmission Line and Associated Facilities Final Environmental Impact Statement* (Washington, DC: March 1984), p 1.

required under the Federal and Policy and Management Act of 1976.[16] Similarly, National Forest land-use plans are required under the National Forest Management Act of 1976. Utility corridors are frequently discussed in Regional Guides, which are prepared for each of the USFS's 10 regions and in the Land and Resource Management Plans for each National Forest. Identification of potential utility line corridors is an important part of these land-use plans because only projects sited along corridors identified as suitable for transmission lines can be approved.

Many land-use plans, such as the recently released Farmington Resource Management Plan for the BLM administered lands in the San Juan Basin in New Mexico, employ a "window" approach to planning for transmission lines, which seeks to identify general areas where power lines might be needed and more specific areas where a conflicting land use would preempt transmission line construction. This approach provides significantly more flexibility in later line siting efforts than would exist if only specific corridor paths were approved at the land-use planning stage.

Apart from NEPA and land-use planning processes, approval of the use of Federal lands for a specific transmission line is still required from the administering Federal agency. Depending on the type of transmission line project and the categories of Federal lands involved, a number of Federal agency permits might be required. For example, the BLM issues a right-of-way permit across public lands and the USFS issues an authorizing document for a line to cross a National Forest. For lines crossing an international boundary, a permit must be obtained from the Department of Energy as the implementing agency of a 1953 Presidential Executive Order on international electricity transactions. The Department of Defense can deny a permit if it interferes with a major military installation or if it is deemed to interfere with national security. The Federal Highway Administration (FHA) must approve corridor paths along interstate highways, which is currently only done as an exception to FHA policy. The U.S. Army Corps of Engineers must issue permits for lines crossing interstate navigable waterways. The Federal Energy Regulatory Commission (FERC) must approve transmission line projects associated with Federal hydroelectric facilities.

Permitting Transmission Lines Across Tribal Lands

Approval of transmission line corridors across tribal lands must be obtained from the governing tribal council or other tribal ruling body for the affected Indian lands. There is no Federal requirement for land-use planning on tribal lands, nor are there standardized procedures for applying for a right-of-way across tribal lands. Reporting requirements and the decisionmaking process employed to rule on the application vary among different tribal governments and can change markedly over time.

Utility companies cannot exercise the power of eminent domain on tribal lands even though they may have received overall approval of transmission line projects by Federal or State agencies. In eight States, tribal governments are consulted as part of the State process for transmission line certification and licensing even if tribal lands are not involved.[18]

Transmission line siting on tribal lands has proven to be very difficult in some instances, even when only sparsely populated lands are involved. For example, proposed transmission line rights-of-way from the San Juan power plant in New Mexico across the Navajo Nation, where the transmission system can be linked to the electricity demand centers in the Far West, have been debated by the Navajo Tribal Council for decades and remain a very controversial topic with no clear resolution in site.

Regardless of the decisionmaking procedure used by the tribal government, any action taken by a tribal government must also be approved by the U.S. Bureau of Indian Affairs (B IA) as the Federal trustee for tribal lands. (B IA, however, does not exercise its authority over all categories of Indian lands, e.g., allotment lands.) Because BIA approval of a permit for a large transmission line project is often ruled to be a major Federal action under NEPA, an EIS can

[16]Title V sets out Federal land requirements, including the shared use of rights-of-way, where possible.

[17]National Regulatory Research Institute, Non-f *technical Impediments to Power Transfers* (Columbus, OH: 1987), p. 161,

[18]Public Service Commission of West Virginia, supra note 6, p. 1.

be required for projects on tribal lands. For example, BIA has acted as the lead agency for the EIS for the proposed Ole power line in New Mexico because several proposed routes could affect Pueblo Indian lands or sacred sites within a National Forest.

Multi-State Siting Efforts

Certification and siting of transmission lines are generally the responsibility of State regulatory agencies. For a long-distance interstate power line project, regulatory agencies in each State independently review the portion of the project within their jurisdiction. Denial of a CCN in any one State can lead to the abandonment of an entire interstate project,

An interstate transmission line project which distributes costs and benefits in many States presents a difficult problem for State regulatory agencies as they assess the overall need for the project in relation to the traditional State-specific criteria for certification. Only a few programs have been undertaken to date to bring regulatory agencies together during the planning or permitting of an interstate power line. Communication among States most frequently occurs on an informal basis through associations of State agencies such as NARUC. Other examples include the Western Interstate Energy Board and the Western Conference of Public Service Commissioners, which in 1987 established a joint Committee on Regional Electric Power Cooperation; the National Governors Association, which has formed a Committee on Energy and Environment Task Force on Electricity Transmission; and the New England Governors' Conference, which has formed an interstate agency Power Planning Committee. Occasionally regulators from other States will be invited to observe or participate in a planning or certification process taking place in another State. Sometimes a State agency will take the initiative to intervene in a regulatory proceeding in another State.

The Federal Government currently plays only a small role in transmission line certification issues for interstate or interutility projects. Under the Federal Power Act, FERC has the authority to set the wholesale rates that utilities may charge for bulk or economy sales and wheeling. Although FERC decisions are critical in determining the overall economic viability of a long-distance power line project, it does little to assist in power line siting.

Utility companies have done the most to foster interutility planning for reliability purposes, which includes identifying the need for new long-distance transmission capacity. One institution that performs this function as part of its mandate is the North American Electric Reliability Council (NERC).

Power pools and coordination agreements among utility companies provide another forum for joint utility planning and transmission line project development. For example, both the New England Power Pool and the Pennsylvania-New Jersey-Maryland Interconnection engage in joint utility planning activities. Moreover, ad hoc interutility agreements that deal with potential transmission and reliability problems occur frequently among utility companies.[19]

With one exception, multi-State utility and State agency programs regarding long-distance transactions are voluntary. The one mandated interstate electricity planning agency—the Northwest Power Planning Council (NPPC)-was established and is guided by Federal legislation.[20] Washington, Oregon, Idaho, and Montana are the member States of NPPC, which was created by the Pacific Northwest Electric Power and Conservation Act of 1980. The Council prepares long-range electricity demand forecasts for the region and develops power supply plans capable of meeting that demand.[21]

Impediments to Transmission Line Siting

Institutional, regulatory, and legal elements of the transmission line siting process can delay extra high voltage (EHV) power line projects by adding to their completion time and cost and by contributing to the uncertainty that the required approvals will be obtained. Three potential sources of impediments are discussed in this section: 1) power line approval

[19] National Regulatory Research Institute, supra note 17, p. 96.

[20] NGA, supra note 3, p. 18. Pacific Northwest Electric Power Planning and Conservation Act of 1980, Public Law 96-S01, 94 Stat. 2697, Dec. 5, 1980, 16 U.S.C. 839.

[21] Northwest Power Planning Council, *Western Electricity s/@ Briefing Paper: Interregional* Transac/ions, Portland, Oregon, Dec. 28, 1987, " Preface."

procedures; 2) jurisdictional complexities among agencies required to give approval to a project; and 3) the lack of multi-State coordination.

Obstacles to Transmission Line Approval

As noted earlier, State-mandated utility planning processes tend to have a strong focus on the need for new power plants and frequently do not analyze in depth the potential for increased long-distance interutility transmission to facilitate interutility sales as a supply option. The inherent uncertainties involved in interutility power sales, especially from another State or from Canada, often result in a low ranking of this option in long-range plans. Another shortcoming of the long-range planning process is that utilities jointly involved in development of transmission lines are not required to discuss components of the project either owned by other utilities or located out of state. State agency staff are left with the job of thoroughly scrutinizing and consolidating the project plans. The same shortcomings may often apply to long-range electricity plans produced by State regulatory agencies.

The lack of attention given to long-distance transmission projects and interutility sales during the long-range planning process contrasts sharply to the attention these issues draw in the world of actual electricity sales contracts and transmission line project development. Moreover, when the time comes for decisions about specific projects and contracts, limited analysis from past planning efforts is available.

State laws regarding the obligations of utilities and utility regulators alike often create obstacles to long-distance transmission line projects. State utility franchise laws generally place the greatest obligation on a utility to provide reliable service within its service area. This obligation provides a disincentive for a utility to consider a project such as building a power plant or transmission line which may have as its goal supplying electricity to customers of another utility.

State regulatory agency transmission line siting criteria reflect the same specificity with regard to service areas that guide most utility company actions. In assessing need for a transmission line, State public service commissions generally examine first the benefits that may accrue to the customers of the utility proposing to build the line. These benefits are then balanced against the anticipated costs of the project, including impacts on the environment, the lifestyles of affected residents, and other public interest considerations,

A difficult analytical dilemma is frequently encountered by State regulatory agencies facing an application for a long-distance transmission line project. Often the only direct benefit to the customers living in the service area through which a transmission line passes is improved reliability of electricity supply, which is impossible to quantify. The quantifiable benefits of low-cost electricity often accrue to customers living in other service areas or States outside of the agencies' jurisdictions or the scope of the application. On the other hand, local costs are obvious and quantifiable, including lifestyle and economic disruption, and aesthetic, environmental, and recreational impacts.

Balancing costs and benefits is a complicated process for State regulatory agencies, especially in some States. Wisconsin, for example, has laws which require that local or statewide benefits outweigh local costs as a condition of power line approval. Many State regulatory agencies have responded by developing conservative ''prudence" or public interest criteria against which to judge the merits of utility projects under review. These public interest criteria have on occasion been criticized as ''highly parochial attitudes" that dampen the enthusiasm for utilities to undertake long-distance transmission line projects.[23]

Another problem utility company applicants face is that power line approval criteria can differ among agencies within a State and especially when agencies are located in different States. As a result, power companies often must file multiple applications in support of a transmission line project. Moreover, the information in each application must be tailored to fit the evaluation criteria of the agency to which it is submitted.

[22] Ibid, p. 90.

[23] National Coal Council, supra note 12, p 2

Unless one agency is empowered to veto a contrary decision by another agency, a utility applicant faces several ''show-stopper" regulatory review processes. An adverse decision in any one arena in any State can force the abandonment of the entire project. Furthermore, criteria used by a single agency can change, even during the process of review of one project.

A final consideration is that very few siting procedures contain any deadlines for decisionmaking. Thus, it becomes impossible to predict with confidence when a power line project approval or denial will be forthcoming. Even when deadlines are established, they usually affect only one component of the decisionmaking process, not the entire process. For example, schedules set for regulatory agency actions are completely distinct from schedules set by courts to address judicial challenges to regulatory agency actions. Scheduling problems encountered by transmission line projects have led NGA to conclude that the lack of a definitive time table for the regulatory decisions appears to be one of the biggest causes for delay .24 (See table 7-2.)

Table 7-2-Most Important Factors Affecting Timely Consideration

Most important factors(s) promoting timely considerations:
Statutory time frame
Single agency
Ease of process
Discretionary hearings
Joint review
Information requirements
Formal planning process
Limited siting authority
Most important factor(s) hindering timely considerations:
Reviews/opposition/issues
Environmental constraints
Incomplete information
Lack of resources
Duplication of effort
Cumbersome process
Lack of deadlines
Court involvement
Other agencies involved
None

SOURCE: Summary of State Government Response to a survey by the National Governors' Association Task Force on Electricity Transmission (prepared by the staffs of the Public Utilities Commission of the State of Ohio and of the west Virginia Public Service Commission), OTA contractor report, July 1986.

Jurisdictional Complexities

A labyrinth of regulatory agency requirements faces the sponsors of long-distance transmission line projects, Coordination among Federal, State, and local agencies is frequently poor, and jurisdictional boundaries are often vague, leading sometimes to mismatches, overlaps, and gaps in agency responsibilities and to interagency conflicts.

Federal and tribal land administering agencies have permitting powers that exist separate from State regulatory agency approval procedures. Decisions by these agencies affect the viability of a transmission line project regardless of State agency actions. Federal and State jurisdictions mesh somewhat more closely between FERC, which sets wholesale power and wheeling rates upon which interutility sales depend, and State public utility commissions, which usually grant required project licenses. However, according to the National Regulatory Research Institute (NRRI), "there is virtually no coordination between the two entities in regard to these activities."[25]

Depending on the State, several State regulatory agencies can be involved in the permitting process for a large transmission line project. Although many States have established either a siting board or appointed a lead agency to coordinate the State review process, guiding an application through the regulatory apparatus can be a difficult and time-consuming task. Joint agency permitting processes remain the exception, not the rule, and because consideration of some permits is often contingent on issuance of others, agency approvals must sometimes be sought sequentially rather than simultaneously.

Participation of a multitude of local municipalities and county governments in permitting a long-distance transmission line represents another layer of jurisdictional complexity. Even in States where local decisions can be overruled by a State siting agency, local government actions are still important to the overall siting process, especially where strong local opposition makes a State agency leery of vetoing local government actions.

[24] NGA, supra note 3, p. 23.

[25] National Regulatory Research Institute, supra note 17, p. 169.

Added to this intricate network of regulatory agency interactions is the court system. Judicial review of regulatory agency actions is a legal right of opponents to most agency decisions, Thus, depending on the agency and the decision involved, Federal, State, and local courts frequently enter the transmission line approval process and can create lengthy tangents from the regulatory agency review process.

Lack of Multi-State Coordination

Variations in transmission line approval processes among States coupled with the lack of coordination in decisionmaking and interstate information exchange can create major obstacles to long-distance power line projects. Even where there is some fledgling effort at interstate coordination, no one State agency is necessarily bound to implement a decision made as a result of multi-State planning efforts.

Coordination between State agencies and FERC is also inadequate. The current practice of independent actions by FERC and by State regulatory agencies has moved the NRRI to conclude that .'the Federal-State regulatory dichotomy can be considered to be an important institutional impediment to the movement of bulk power between utilities. "[26]

One problem that can result from the lack of coordination between FERC and State agencies is that State public utility commissions, as they make their cost/benefit analyses, cannot necessarily obtain needed information from FERC. Another potential problem is that State regulatory decisions with regard to interutility power projects can be affected by future FERC rulings that the agencies cannot anticipate and over which they have no control.

Interest Group Perspectives

A number of interest groups frequently interact during the siting of a transmission line. These groups include utility companies, government regulators, landowners, consumers, environmental organizations, and energy system advocates. Although the positions of these groups are molded by the individual circumstances surrounding each project, a number of perspectives are commonly associated with each group. It is the clash between these perspectives during the siting process that frequently leads to the conflicts that impede transmission line siting.

Utility Companies

At least 35 utilities in the United States now have formal public participation programs to assist in the planning of utility project...[27] Nearly all utilities include public participation at some point in their decisionmaking regarding transmission lines.

Nonetheless, it is common for utility companies to feel that criticism of transmission line projects comes from amateurs who cannot possibly understand the economic and technical intricacies of the electric utility industry. In many respects, utilities do know more, if not best, and in adversarial environments resentment can build. Moreover, State franchise laws and historical utility standard operating practices tend to promote conservative, risk-averse attitudes on the part of many utility companies. On occasion, these attitudes can reinforce skepticism towards suggestions originating outside utility company circles, especially ideas regarding complex projects such as transmission line construction.

Government Regulators

State and Federal Government regulatory agencies respond first and foremost to the statutory mandates under which they operate. For State public utility commissions this usually means careful implementation of prudence and cost/benefit balancing concepts in transmission line siting reviews. For an environmental protection department this translates to assurance that transmission line applicants will comply with a wide range of construction and operating requirements.

A narrow perspective could develop among individual regulatory agencies with each agency focusing on its mandated responsibilities. This perspective does not necessarily foster free information exchange, cooperation, and compromise among decisionmaking authorities and also may hinder the development of a rationale for collaboration *among*

[26] Ibid, p. 47.

[27] Westview Special Studies in Natural Resource Management, Dennis W, Ducsik (ed.), *Public Involvement in Energy Facility Planning The Electric Utility Experience* (Boulder, CO: Westview Press, 1986), p. 5.

agencies that could expedite and facilitate transmission line siting approval.

Landowners and Affected Populations

People who live, work, or play under or near a proposed transmission line corridor are often the most vocal interest group during the siting process. Their concerns can take many forms. If they live directly beneath the proposed path of the power line, they might be opposed to moving or they might fear that they will be inadequately compensated for the loss of their homes. These same concerns are typical if businesses, such as farm or ranch operations, are situated along a line's path. Public health concerns are also commonly encountered among people who live near an EHV transmission line.

Local opposition to a transmission line can also occur if the line is perceived to threaten noneconomic values attached to the land. Thus, for example, some Native American groups have opposed transmission lines crossing lands they hold sacred. And, subtle lifestyle disruptions caused by transmission lines, such as aesthetic degradations, can foster controversy about a project. Noneconomic concerns can cause an affected population to view as unfair the distribution of the economic costs and benefits of a transmission line project if they believe they will absorb a disproportionate share of the costs while the benefits are more widely dispersed or accrue to others altogether.

These concerns can often be addressed through careful route selection for a proposed line, extensive impact mitigation programs, and increased compensation to the affected population. Nevertheless, the perspective of the local population can solidify into nonnegotiable opposition, typified by the slogan "not in my backyard. "

Ratepayer Consumer Groups

The electricity ratepayer is usually concerned chiefly with the cost of electricity at the point of end use and, to a lesser extent, with long-term reliability of supply. Under the current conditions of excess power generation capacity in many parts of the country, these concerns frequently are reflected in support of increased competition in the electric utility industry, more interutility sales, and wider interutility connections to facilitate long-distance transfer of cheap electricity. In some instances, however, concern over the cost of a transmission line project or over the future availability, cost, and reliability of supply can outweigh these protransmission expansion sentiments, leading some ratepayer organizations to oppose such projects.

Environmental Organizations

Environmental groups often take strong exception to the potentially adverse impacts of long-distance transmission lines on the visual and physical environment, wildlife, human health, and traditional lifestyles. In many instances where proposed transmission lines cross inhabited areas, the concerns of environmental groups reflect those of local landowners, particularly with regard to public health issues and the disruption of traditional lifestyles, and sacred sites.

Alternatively, environmental groups can oppose transmission line projects because they conflict with land use objectives distinct from those held by the affected population, thereby placing them in conflict with the landowners on these issues. This situation often occurs for transmission line projects proposed to cross sparsely populated lands such as National Forests and other public lands managed by the Federal Government. Rerouting and impact mitigation measures can sometimes, but not always, resolve satisfactorily many of these environmental concerns.

Energy Systems Advocates

A number of organizations promote a particular energy policy objective or technology. For example, ''soft path" energy advocates believe that a combination of energy programs to promote conservation and decentralized power supply systems provides the best approach to long-term energy security in this country. [28] Similarly, trade organizations exist to promote individual energy technologies, including decentralized systems, conservation, and "hard path'* coal and nuclear generating technologies.

In some instances promotion of long-distance electricity transmission and interutility power sales can be contrary to the objectives of energy systems advocates. For example, in the late 1970s, Citizens

[28] Amory Lovins, *Soft Energy Paths* (Cambridge, MA: Ballinger Publishing Co., 1977), p. 18.

for a Better Environment opposed on technology grounds the expansion of long-distance transmission capacity to California from the Northwest partially because of a concern that the capacity would be used as a justification for the proposed construction of several large nuclear plants in Washington State.

Another example is the National Coal Association's opposition to the construction of a transmission line from Quebec, Canada to an existing utility line owned by Central Maine Power Company. The Association feared the project would promote the importation and use of hydroelectric power to the detriment of coal-fired power plants.[29]

Options To Improve Transmission Line Siting

The approval of transmission line projects by regulatory agencies is a routine, although often difficult procedure. According to the NGA survey, State regulatory agencies approved 515 transmission line projects between 1976 and 1986, while denying approval for only 18. More than two-thirds of the projects approved during 1981 to 1986 have been completed.[30] The survey did not distinguish among the types of lines involved.

The success rate of power line siting notwithstanding, impediments to siting continue to draw fire from interest groups and a number of recommendations for ways to improve the siting process now enjoy considerable support in some circles. Several proposed recommendations are presented as policy options in this section.

Expanding the Planning Process

Inadequacies in the long-range planning process, especially with regard to transmission line planning, could be reduced in a number of ways. Simply providing more resources to the agencies involved in planning could help produce more comprehensive and insightful plans. Transmission line and interutility power sales issues could receive a higher priority in the planning process. The scope of planning efforts, including those submitted by individual utility companies, could be broadened to include regional and interstate electricity issues. Some entities that are frequently exempted from *planning* requirements, such as municipal-owned utilities and power cooperatives, could be required to participate more in the planning process.

Greater integration of planning efforts and transmission line project development could also enhance the usefulness of planning. More relevant and accurate long-range electricity plans should be of greater usefulness in determining overall project costs and benefits during the regulatory review process of specific transmission line projects. As noted by the NGA, "planning on a multi-State or regional basis can help identify even larger sources of savings from improved coordination of generation and transmission capacity development."[31]

Improved planning should help utilities anticipate land requirements for transmission line corridors farther in advance and with greater certainty of actual future need. The NGA and others have suggested that several transmission line corridors be pre-approved as part of the planning process. Creation of "resource banks" of approved corridors could provide "a bridge between the planning and transmission line certification processes to reduce the lead time for final approval" of transmission line projects, the NGA believes.[32] On the other hand, it can be argued that preelection of multiple corridors, some of which will never be used for transmission lines, can needlessly involve and upset people, lead to unnecessary changes in patterns of land use and value, and add significantly to the cost of planning.[33]

Streamlining the Regulatory Approval Process

Simplifying and shortening the process for obtaining certification and license approvals for a transmission line project from State and local regulatory agencies has undoubtedly been for years the single largest target of reformers of the siting process. Frustration with the difficulties inherent in the current system has, in part, prompted the Electric

[29] *Coal Week,* Sept. 8, 1987, p. 8.

[30] Public Service Commission of West Virginia, supra note 6, p. 8.

[31] NGA, supra note 3, p. 18.

[32] Ibid, p. 25.

[33] National Regulatory Research Institute, supra note 17, p. 156.

Power Research Institute to develop a handbook for utilities to use as they weave through the regulatory labyrinth.[34]

One of the most frequently made suggestions is that the State siting process be coordinated by a single agency or by a Siting Board composed of members of several agencies. About 12 States have already taken this step, although the circumstances when the Boards become involved and the extent of power vanes considerably.[35] This move toward ‘‘one-stop” shopping for licenses and permits has in fact expedited the siting process in many cases, but provides no guarantee that the controversy surrounding a transmission line project can be resolved. Nonetheless, the NGA has concluded that “consolidation of the approval process within a single agency (even if that agency must work with other agencies) appears to improve the predictability and certainty of the regulatory process and may increase the speed with which the State acts on project proposals. "[36]

Endowing siting agencies or boards with the power to overrule decisions made by other regulatory agencies and local governments is another suggestion commony offered to speed government review of transmission line project applications. Many States currently do authorize preemption of decisionmaking authority by some agencies, resulting, in some instances, in faster siting of transmission lines. But delays can still occur in part because of a reluctance to assert veto authority. Thus, endowing an agency with veto power may save little time and effort in the review process, but it does create a greater degree of certainty over the final outcome.

Establishment of clear criteria against which a transmission line application can be measured could also help simplify the siting process. Some States, including Florida and Montana, have established specific siting criteria, such a.. minimum corridor widths for power lines, based on generic issues, such as public health concerns. Greater definitiveness and specificity in siting criteria can ease the information requirements for the applying utilities and help focus the review process.

Finally, many critics of transmission line siting procedures call for the institution of firm deadlines in decisionmaking. The NGA has noted that ‘‘of those (impediments) involving State regulation, lack of a definitive time table for the regulatory process appears to be one of the biggest causes of delay. ”[37] On the other hand, the price tag for forcing decisions within tight schedules can be inadequate review and analysis of the issues involved. Moreover, structuring a penalty for an agency for missing a deadline poses difficulties and, as a result, deadline schemes usually act more to pressure rather than coerce agencies to act on utility applications for transmission line projects.

Involvement of Multi-State, Federal, or Independent Agencies

A final group of policy options are tailored especially for application in the siting of 1ong-distance transmission lines that involve several States.

Increased Federal Government involvement in the siting of interstate transmission lines has been suggested as a policy option by several organizations. The National Coal Council, for example, has been very supportive of this option and has recommended that the Secretary of Energy intervene in siting cases that have interstate or regional implica-Ttions.[38]

Increasing the powers of the FERC could provide another method of bolstering the Federal role in interstate transmission line siting. FERC or another Federal agency could affect siting indirectly by creating ‘‘model” siting procedures or transmission line application review criteria which could help standardize procedures used by State regulatory agencies.

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34 EPRI, Electrical Systems Division, ‘‘A Stream] ined Procedure for Obtaining Regulatory Approval for New Transmission Lines, ” contractor report prepared by Westinghouse Electric Corp. (EL-1404, RP-TBS79-733), December 1982.

35 NGA, supra note 3, pp. 28-30.

36 Ibid, p. lo.

37 Ibid, p. 23.

38 National Coal Council, supra note 12, attached letter to Secretary Herrington.

Expanding the Northwest Power Planning Council concept to other regions could offer another avenue to increase Federal and multi-State involvement in transmission line siting. Alternatively, congressionally approved siting ‘‘compacts” of States through which a transmission line is proposed to pass could create ad hoc multi-State decisionmaking bodies with broad siting powers. It should be noted, however, that there have been no clear examples of one State blocking the construction of an interstate transmission line.

Informal Federal-State transmission line siting dispute resolution boards could provide forums where clashing interest groups can come to discuss and possibly resolve their differences. More dramatically, some have suggested that the Federal Government or some independent dispute resolution organization, such as the American Arbitration Society, could be empowered to make decisions on issues about which regulatory agencies in different States disagreed.[39] But, the need for such a Federal role is not clear.

Enhanced Public Participation

Most utilities and State and Federal regulatory agencies have established extensive public participation programs which include participation in the review of transmission line projects, These programs seek to provide early disclosure of information and to solicit public input into the designing of utility projects. Citizen review, evaluation, advisory, and participation committees are commonly formed to help shape transmission line projects. Moreover, individual interest groups can make their opinions known through public comments, formal interventions, and legal appeal processes which occur at a number of points under most siting procedures.

Development of new models for public participation specifically geared to the circumstances commonly encountered during transmission line siting is an ongoing process which, if effective, could alleviate some impediments to siting. Toward that goal, the Edison Electric Institute convened a task force on public participation in 1982 and subsequently sponsored a lengthy study of the issue.

Conclusions

The complexities involved in the siting of large transmission line projects are significant, especially with regard to multi-State projects designed to promote interutility power sales. Nevertheless, the simple fact is that most power line projects are successfully sited in a timely fashion, if not to the satisfaction of all the interest groups participating in the decisionmaking processes. Even in the face of increased demand for new transmission capacity anticipated by electric utility industry restructuring proposals, current siting procedures are probably adequate, although inefficient.

A number of impediments to transmission line siting can be clearly identified, although sound recommendations to remove those impediments are not so obvious. A dearth of information about future transmission needs and a lack of communication among regulatory agencies appear to encourage confusion in siting processes. Conflicting regulatory agency priorities, objectives, and jurisdictions can add Byzantine elements to siting processes. Multiple decisionmaking procedures within overall siting procedures permit interest groups to pick the decisionmaking arena of their choice in which to express their views or to repeat the same concerns before different audiences recognizing that a single success can achieve their objective.

Many proposals to alter siting procedures could have negative as well as positive effects in practice, sometimes leading to solutions which create conditions as bad or worse than the problems they are designed to correct. For example, creation of “one-Stop” siting entities with final decisionmaking authority can greatly simplify and expedite siting, but it can also undercut public participation, information dissemination, and the exercise of statutory responsibilities by other regulatory agencies. Bolstering long-range transmission planning can provide more useful analytical information for decisionmakers, but collection of this information can add time and costs to siting processes and identify new uncertainties and information needs.

Most of the proposals to address the impediments to transmission line siting discussed in this section are being tested to a greater or lesser degree in

[39] National Regulatory Research Institute, supra note 17, p. 159.

specific States or regions of the country. Perhaps the most prudent advice is to encourage the continuation and expansion of these efforts to improve siting procedures. Greater attention to the implementation of innovations to traditional siting protocols under virtual "test" conditions coupled with redoubled efforts to share the resulting experiences and insights could produce significant improvements to siting processes over time without undercutting along the way what appears to be a basically sound process.

ENVIRONMENTAL EFFECTS OF INCREASED COMPETITION IN THE ELECTRIC POWER INDUSTRY

The electric utility industry faces perhaps the broadest array of environmental issues of any industry in the Nation and has for many years. Because electric utilities are so pervasive in the life of the United States. and because their facilities are often so large, the industry has been at the cutting edge of environmental disputes and a leader in developing environmental control and monitoring technology.

As the industry's structure changes, either through evolution or by conscious public policy, there is no reason to believe that environmental issues will recede into the background. Indeed, it is likely that environmental concerns over generation, transmission, and distribution activities will continue to be a major element in the industry's structural dynamics under any future scenario.[40]

Generation

The major environmental impacts of electric power generation can be divided according to fuel cycle issues and combustion issues. Changes in electric power industry regulation and the structure of bulk power markets could have demonstrable impacts in these areas, and moreover, these are 1ikely to vary in different regions of the country .[41]

Fuel-cycle issues include the impacts of extracting, processing, and transporting fuels and disposing of their wastes. The primary fuels for power generation are coal, oil, gas, uranium, and waste materials. Major concerns include the impacts on competing land uses, air and water pollution, and hazardous waste disposal. Renewable energy sources such as hydropower, wind, solar, and biomass each have their own set of environmental impacts.

Combustion issues include not only the direct impacts of generation or combustion, but also the mix of electric utility generation—the size, type, fuel, and location of generating plants. Burning fossil fuels raises a whole series of air quality issues, including control of emissions of SO_2, NO_x, CO_2, and other hazardous pollutants. Nuclear generation, of course, has a long and familiar list of environmental and public health disputes, including routine air and water emissions, reactor safety, emergency planning, and the consumptive use of water.

There is fairly widespread belief that reliance on competitive bidding for new electric power supplies could, depending on the details of the bidding process, cause a shift in the size of new plants and in fuel choices. If small supply increments, lower short-term costs, and shorter lead time projects are favored, it is likely that more oil and gas generators will be built. However, developing coal technologies—particularly atmospheric fluidized bed and integrated, combined-cycle coal gasification-that are targeted at smaller, modular units could eventually be competitive for cogeneration and utility applications. Under other bidding structures, larger plants with perhaps lower long-term costs might be able to compete more effectively.

Size and fuel choices can be important environmentally. Until quite recently, air pollution regulations subjected smaller boilers (i.e., less than 67 megawatts) to much more lenient sulfur dioxide standards than large boilers. But as a result of a lawsuit brought by the Natural Resources Defense Council and settled late in 1987, the 1.2 pounds per million Btu SO_2 standard and 90 percent emissions reduction rule will apply to all fossil-fueled boilers above about 27 megawatts.[42] And EPA is on a

40 Much of the in formation in this section is drawn from an OTA contractor report, Kennedy P. Maize, "Environmental Effects of Increased Competition in the Electric Power Industry, " May 1988.

41 See also the discussion m ch. 6.

42 While 27 megawatts is rather large for a ~a~.fired combustion turbine or combined-cycle project, it is on the smaller side for coal -fired boilers.

schedule to apply the 1.2 standard to even smaller coal-fired plants by 1989.[43]

Transmission and Distribution

Transmission and distribution have their own set of environmental issues. While these issues haven't received the national attention accorded air quality and waste Tdisposal, they have often been just as intense and fractious at the local level as the more traditional environmental disputes. Transmission issues may become a greater part of the environmental debate in the future, as utilities change their spending patterns away from building plant and toward moving power.

Transmission and to a lesser extent distribution are intimately tied into local land use and zoning, and disputes often take place in the institutional forums created for dealing with local problems, such as city, county, and State zoning boards, boards of zoning appeals, and the like. Other venues for land use disputes over transmission and distribution can occur before State bodies that must license or permit a facility, in an eminent domain proceeding, or in State courts.[44] If Federal lands are crossed, Federal land management agencies will be involved. Landowners who will see power lines cross their property, particularly in urban or suburban areas but also in rural areas, often believe the line will lower the value of their property.[45] Consequently, the disputes can be very bitter and intense.

Because power lines can extend for long distances, are often highly visible, and frequently pass through populated areas, the siting process can be a time-consuming, politically fractious, and frustrating experience for the utility, regulators, and local citizens. The economic impacts of siting decisions on affected landowners can be direct and costly.[%] After the project has been sited and permitted, there can also be environmental disputes related to the impacts of construction, including issues such as erosion and sediment control, soil compaction, destruction of forests, and the like.[47]

Once a power line is built and operating, a different set of impacts comes into play, although these issues likely will have been raised earlier during the siting and permitting processes. These include visual impact, impacts on bird life,[48] audible noise,[49] corona effects,[50] and, an area that has generated a lot of attention of late, the effects of electrical and magnetic fields on wildlife, livestock, and human health.[51] Another environmental issue related to existing power lines is the use of pesticides and herbicides to clear rights-of-way.

Visual impacts play a major role in transmission line disputes, in part because the visual presence of the lines often becomes a symbol of its total presence. Figure 7-1 shows the dimensions of typical 345-kV transmission line towers. The utility industry has attempted to design less visible structures. although that can drive up costs. Some analysts have suggested that the presence of a visible line is ''a negative feedback mechanism" that could serve to slow growth of electrical use, by symboliz-

43 Telephone interview with David Hawkins, NRDC, Jan. 7, 1988. Plants with a capacity factor of less than 30 percent and plants burning very low sulfur 011 are exempted from the percentage reduction requirements. See also, American Public Power Association, ''Small power plants now must meet pollution standards, '*American Public Power Weekly,* Jan. 11, *1988.*

44See *the discussion* of the siting process elsewhere in this chapter.

45Robert R. Thompson and William E. Phillips, "Agricultural Land Value Changes From Electric Transmission Lines: Implications for Compensation," *Right of Way,* December 1985, pp. 24-27.

46See, for example, the remarks of Richard Disbrow, President, American Electric Power Service Corp., OTA workshop, Sept. 28, 1987.

47 For a ~@ discussion of the environmental impacts of powerlines, see Federal Colstrip Transmission Corridor Study Project Team, "Developing Numerical Values to Estimate Potential Environmental Impact of Power Transmission Corridors," Bonneville Power Administration, November 1978, Appendix.

48Rene Males, *EPRI Journal,* March 1980, p. 49.

49John A. Molina et al., ''Modification of Transmission Line Audible Noise Spectra to Reduce Environmental Impact, " *IEEE Transactions on Power Apparatus and Systems, vol.* PAS-l(K), No. 4, April 1981.

50Air ionized by the high electric fields at the surface of the conductor creates the corona phenomena.

51For a discussion of the evolution of environmental concerns about power lines, see William E. Feero, "The Evolution of Electromagnetic Effects Issues, " paper presented at the international Utility Symposium on Health Effects of Electric and Magnetic Fields, Sept. 16-19, 1986, Toronto, Canada.

ing to consumers the costs associated with electricity use.[52]

Existing power lines can have an adverse impact on bird populations, including protected species such as the golden eagle, which use poles as perches for hunting and are often electrocuted by contact with lines. There is also some evidence that overhead lines may increase avian mortality from collisions and changes in behavior, although not much data on this problem has been accumulated.[53]

The physical presence of power lines is associated with what are sometimes referred to as "nuisance" effects that are annoying or unpleasant to those living or working around them. Corona discharges from power lines create audible noise and interfere with radio and television frequencies. Corona discharge is largely a function of weather, posing greater problems in rain or fog.[54] Corona noise is typically both low-frequency hums and buzzes, and random, high-frequency hisses and crackling. Studies suggest that the high-frequency component is more objectionable to listeners .55

Another product of corona discharge is ozone, a powerful oxidant that can affect living tissue. Ozone is similar to ionizing radiation, in that it causes tissues to breakdown and undergo chemical change. It can irritate eyes, lungs, and circulatory systems of animals, including humans, and increase susceptibility to infection and chronic disease through stress. It can also cause direct damage to vegetation.

Power lines may also have a more subtle impact on health. A number of studies have demonstrated effects on cells, animals, and humans from exposure to extremely low-frequency fields such as those generated by power lines and household appliances. The electric utility industry is devoting a greater share of its research dollars to this emerging field, trying to pin down the mechanisms that are at work, and determine what steps can be taken to prevent damage if it is occurnng.[56]

Finally, maintenance and vegetation management can have environmental impacts with existing transmission lines. Utilities generally want to establish a shrubland environment under their power lines, because shrublands last far longer than grasslands, once undesirable trees are removed. Since the 1940s, utilities have applied chemical herbicides to control vegetation. Information is lacking on the effects of chemical herbicide treatment beyond the initial brownout that results.[57]

Scenarios of Change in the Electric Utility Industry

Structural changes in the electric power industry could have different environmental consequences. These impacts are difficult to discern in light of the speculative nature of the proposals. Despite the inability to pin down the impacts with precision, it is possible to describe how OTA's five scenarios (see ch. 3) might affect the environment.

Scenario 1: Reaffirming the Regulatory Compact

As with all the scenarios, scenario 1 presents both environmental problems and opportunities. The environmental advantages flow from the fact that scenario 1 is well understood. As essentially the status quo with slight modifications, the first scenario presents issues that have been faced in the past and relies on institutional arrangements that have been developed over the past 20 years. With this scenario, most environmental issues are known.

The concept of "rolling prudence" has some potential environmental benefits. It might prove easier to cancel some projects earlier in the construction process, before such enormous amounts of capital have been sunk in a project that cancellation becomes politically difficult. Prudence is a doctrine

[52] Thomas W. Smith et al., *Transmission Lines: Environmental and Public Policy* Consideration, Institute for Environmental Studies, University of Wisconsin-Madison, June 1977, p. 44.

53 Males, supra note Q& Of course large birds also can have minor, but harmful impacts on transmission lines. EPRI, "A Joint Utility Investigation of Unexplained Transmission Line Outages, " (EL-5735) Final Report, May 1988, Palo Alto, CA.

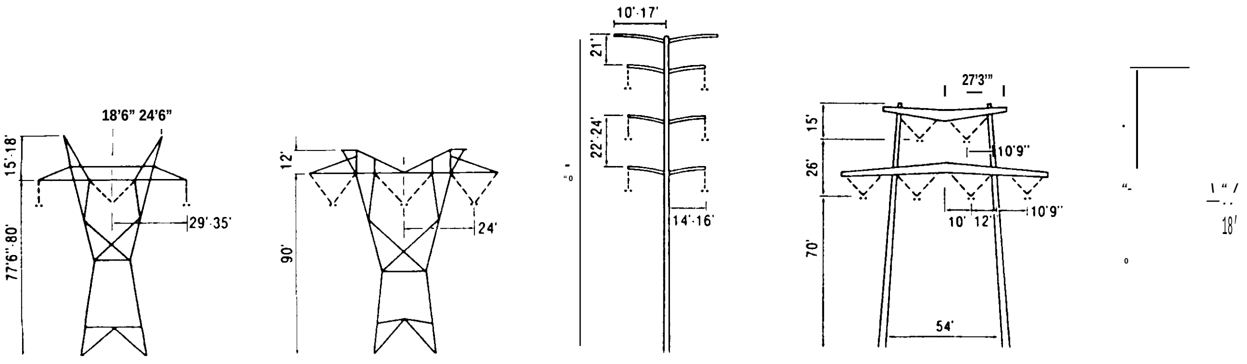
[54] Smith et al., supra note 52, p. 39.

[55] Molina et al., supra nOte 49, p. 2122.

[56] "EMF: The Debate on Health Effects, " *EPRI Journal*, vol. 12, No. 7, October/November]987, pp. 4-15. See also, Mart H. Malakoff, "Electronic Smog," Not *Man Apart*, March-April 1988, pp. 10-11.

[57] Smith et al., supra note 52, p. 32.

Figure 7-1-Dimensions of Typical 345-kV Transmission Lines



SOURCE: Office of Twhnology Assessment adapted from Electric Power Research Institute, *Transmission Line Reference Book: 345 kV and Above*, 2d ed. (Palo Alto. CA: Research Reports Center, 1982).

that utility commissions have rediscovered recently and applied with various effect. However, the findings of imprudence necessarily come too late to prevent expenditures which should never have been made.

Utilities complain that post-construction prudence determinations subject them to too much financial risk, and there is merit in that complaint. But many regulators, consumer groups, and environmentalists are also critical of the current system because it allowed construction to continue on a number of nuclear and coal plants that later proved to be imprudent because of their extreme costs or excess capacity. Carefully designed, periodic prudence reviews could provide an institutional mechanism to prevent unneeded, socially costly, and environmentally damaging plants from being built.

The periodic reviews might also be a way to factor in technological advances made during the course of plant construction. Under the current system, once a plant design is finished, it can be difficult to persuade the utility to alter it voluntarily to incorporate advances in pollution control technology. Reviews during the process might provide a way to update the plant plans and apply the best available technology. State assurances of recovery of prudent expenditures would offer additional incentives.

Scenario 1 is not without environmental problems, but those problems are largely similar to those under the status quo.

The down side to scenario 1 and the status quo, from an environmental standpoint, is the incentive it gives to the continued operation of some of the oldest and dirtiest coal-burning power facilities, which are among the primary targets of acid rain cleanup proposals. For example, Cleveland Electric Illuminating's Eastlake plant has a State emission limit of 5.64 pounds per million Btu and the Avon plant has a 4.65 pound limit, in contrast, the new source performance standard is 1.2 pounds. Other older plants around the country have even higher emissions 1imits under State Implementation Plans.[58]

The 1970 Clean Air Act (as amended in 1977) was premised on the belief that most older plants would be replaced after their 30-year book lifetime. Consequently, the act relies on the new source performance standards for its regulatory bite, rather than on pressing for improved environmental performance of existing plants.

The economic landscape in the years since Congress passed the Clean Air Act has favored keeping existing plants on line and avoiding building new ones. This was driven partly by the costs of pollution control on new plants, but more directly by unusually high interest rates of the 1970s, coupled with declining and unpredictable load growth, Power plant life-extension and geriatric programs have become a major focus of savvy utilities, and some experts believe that it may be possible to keep old

[58]Figures are from an interview with Centerior Energy's environmental department by Kennedy Maize, OTA contractor, Apr. 18, 1988.

plants in service almost indefinitely .[59] Under the Clean Air Act, if the cost of a life-extension program exceeds 50 percent of a "comparable new facility," the plant may be subject to New Source Performance Standards (NSPS). According to the Electric Power Research Institute: ''This regulation has not yet been tested, and utilities are unsure whether the 50 percent trigger refers only to a one-time capital expenditure or to aggregated refurbishment costs over several years. "[60]

The status quo offers a strong incentive for utilities to keep the oldest, and often dirtiest, plants on line as long as possible. In extending the life of existing plants, the utility avoids siting disputes, heavy capital requirements, prudence reviews, and major disallowances. By contrast, some of the other scenarios might encourage utilities to close the facilities if they can get power cheaper from QFs or independent producers, can raise capital relatively inexpensively, or can avoid the need for prudence reviews and rate basing entirely by building a deregulated plant.

Scenario 2: Expanding Transmission Access in the Existing Institutional Structure

From an environmental perspective, this scenario could have some favorable and some troubling consequences. On the positive side, it would be possible to build environmental considerations into the public interest standard for wheeling orders. For example, it might further environmental goals to wheel in power from remote sites to avoid burning coal or oil in an urban environment. Increased wheeling could lead to construction of fewer base-load plants and a more flexible electric supply system, better able to accommodate advanced renewable technologies such as photovoltaics. Greater wheeling and stronger interconnected transmission grids could avoid situations such as today's power surplus in the South and Midwest while the Northeast faces potential power shortages.[61]

Scenario 2 also has potentially negative environmental consequences. If expanding transmission access is successful, presumably more transmission capacity will be constructed. Utilities would have to plan for third-party transmission in their system planning of power lines. The result likely would be plans for more transmission lines, with concomitant disputes over siting and construction. Some utilities might see transmission as a new business opportunity and build transmission marketing into their plans. Siting, building, and operating electricity transmission has both well-understood and frontier environmental problems, ranging from land use to public health issues associated with extremely low-frequency fields.

Access to transmission services and expanded competition might also encourage unneeded plant construction, both by independent power producers (IPPs) and QFs. If electric utilities see selling transmission services as a business opportunity, rival utilities might get into price wars attempting to lure generators into their grids. That could lead to construction of plants beyond what would occur simply to supply the PURPA market if transmission continued to be closely guarded.

The availability of wheeling and expanded QF eligibility could cause a shift in the generation mix. It is not known how this change might affect the nature and distribution of environmental impacts of power generation. Based on early experience among QFs, it has often been presumed that QFs and IPPs would rely heavily on gas-fired combustion turbines, with perhaps some combined-cycle generation as well, but initial results of State competitive solicitations somewhat belie this presumption. See box 7-A: Bidding in Massachusetts: A Glimpse of the Future'? While natural gas is the cleanest burning fossil fuel, it is not entirely devoid of pollutants. In nonattainment areas, increased local generation could lead to further tension and disputes over pollution offsets and lowest achievable emission rates (LAER). In attainment areas, increased genera-

[59] ''Longer Life for Fossil Fuel Plants," *EPRI Journal, vol. 12, No.* 5, July/August 1987, pp. 21-27.

[60] Ibid, p. 26. Also, the plant could be subject to NSPS if the emission rate of any of the criteria pollutants is increased as a result of the life-extension program.

[61] See New England Governors' Conference, "A Plan for Meeting New England's Electric Needs," December 1986. For a powerful critique of this view see New England Energy Policy Council, "Power to Spare: A Plan for Increasing New England's Competitiveness Through Energy Efficiency." July 1987.

Box 7-A—Bidding in Massachusetts: A Glimpse of the Future?

The Commonwealth of Massachusetts has been one of the pioneers in implementing a bidding scheme for allocating generation under PURPA. The State's department of public utilities issued its first set of competitive bidding regulations in late 1986, and the first contracts have been awarded. The State and its utilities are now working on a second round of bidding, with somewhat changed circumstances.[1]

The bidding process begins with supply and demand plans for each utility filed with the state's Facility Siting Council. Based on its plan, the utility forecasts what its next supply addition will be. If, for example, the utility were to conclude that the next plant addition it would build to meet projected demand would be a 200-megawatt, combined-cycle facility, then the utility would attempt to solicit 200 megawatts of supply from QFs. to avoid that new facility.

Massachusetts regulations stipulate how to calculate costs of the new generating capacity, including system fuel costs and capital costs. That determination, which is the equivalent to the avoided cost, becomes the ceiling price for the bidding process or the maximum bid that the utility will accept from QFs.

The Massachusetts program uses a standard contract, developed by the Department of Public Utilities (DPU), against which the suppliers are to bid. The utility can include "nonPrice" elements in its solicitation and bid-evaluation process. This is where the utility can build in environmental constraints, or other special conditions such as reliability, dispatchability, fuel diversity, preferred locations, and the like. The standard contract provides a baseline, but the final contract does allow for negotiation as long as DPU is able to exercise oversight.

The current bid system does not include provisions for conservation and load management. That thorny issue, along with the issue of how to treat non-QF facilities, is currently the focus of another regulatory proceeding, underway at DPU.

It is important to note that Massachusetts already requires wheeling within the State, on the basis of an open, published tariff. If a QF in the western part of the State wins an award from Boston Edison, State regulations require the intervening utilities to wheel the power.

The Experience To Date

Boston Edison Co. was the first utility to complete the full cycle, from initial solicitation with the company expecting to have contracts for 344 MW of power from nine separate projects (see table 7-3). Boston Edison originally sought only 200 MW, but received bids for 1,860 MW. The levelized ceiling price for the bid was 8.7 cents per kWh, and the successful bids tendered at between 6 and 6.5 cents. The first eight low bidders came in at a total of 144 MW, but the ninth bidder offered 200 MW. After some negotiations among the parties, Massachusetts DPU concluded that Boston Edison could go forward with the nine bidders. Later, even though several projects dropped out, contracts were signed for a total of 416 MW.[2]

To prevent a repetition of California's early experience with its Standard Offer No. 4, where as many as a third of the bidders turned out to be speculative projects that likely never would have been built, Massachusetts' regulations require that the QF put up a $15 per kW deposit as earnest money at the contract signing.

From an environmental standpoint, the winning projects do not support assumptions that bidding will necessarily result in a better fuel mix or greater environmental protection than conventional avoided cost determinations.

First, the 200-MW coal-fired facility belies the widely shared expectation that gas would be the preferred fuel for QFs and IPPs. It is also important to note that the original bid for the 200-MW atmospheric fluidized bed facility proposed a site in East Boston, a small, highly urbanized area, Subsequently, the project developers decided that perhaps an inner-city site wasn 't such a good idea and proposed two alternative sites for the project. As of November 1988, the plant remained unsited.

Some 35 MW are to come from waste-to-energy plants. The Clean Harbors project would bum hazardous wastes in a rotary kiln, raise steam, and sell power to Boston Edison, but whether the project will ever be licensed

[1] Much of this information is based on interviews by OTA contractor Kennedy Maize with Henry Yoshimura of the Massachusetts Department of Public Utilities and with John Whippen, manager of energy resource planning and forecasting, Boston Edison Co.

[2] "NEES Pulls 4 Winning Projects out of Boston Edison Solicitation," *Electric Utility Week, Nov. 21, 1988,* p.19.

Continued on next page

Continued from previous page

is clearly a legitimate question. The Webster mass burn facility is already running into the predictable siting disputes, which threaten to derail or delay the project. It's future is also clouded because the developers have filed for reorganization under protection of the bankruptcy court. The Wheelabrator project is one of several proposals to burn construction wastes or "urban woods. " Construction wastes would appear to offer a higher quality fuel stream than conventional mixed trash. It might also be a cleaner waste stream, although one could postulate some environmental problems with construction trash, particularly with air emissions and ash toxicity from burning lumber treated to resist termites. Another problem could be associated with the amount of gypsum wallboard in the waste stream. Burning gypsum could cause serious sulfur dioxide problems. It too remains unsited,

There is an interesting irony in the four cogeneration projects offered by the New England Electric System (NEES). While NEES has been among the utilities that have been pushing the FERC to embark on an all sources bidding scheme,[3] the Company has been less enamored of bidding for QF power at home. NEES argued in the Massachusetts proceeding that it could get more and cheaper power by negotiated contract rather than open bidding. The DPU gave the company an exemption from its bidding procedures in return for NEES agreements on more stringent wheeling procedures and to a provision that the company must demonstrate that it obtains more power for less money by negotiations. Thus DPU and other utility oftlcials were surprised when NEES was a major bidder for the Boston Edison contract. NEES subsequently dropped its four winning project because of siting difficulties.

The technological mix that resulted from the first Boston Edison Request for Proposal (RFP) was probably a result of bonus points the company awarded in the nonprice section for fuel diversity. ''We had established certain objectives we wanted to pursue " in the first RFP, said a Boston Edison official, "that included the promotion of fuel diversity."[4]

Boston Edison plans to revise its RFP over the next few months, to match an updated resource plan and will then file RFP No. 2 with DPU. While the new RFP will be "philosophically" the same, it will be less price intensive, and push several nonprice issues.

Anticipating regulatory changes,[5] Boston Edison likely will push environmental performance by providing target pollutant levels, with a bonus for commitments by bidders to exceed those targets, The RFP, for example, might specify a 1.2 pounds per million Btu standard for SO_2 emission, and give a bonus for a commitment to exceed by 110 percent.

Boston Edison is also pondering how to build conservation and load management bids into RFP, probably by targeting specific loads the utility wants to reduce. Utility planners hope to have some version of a negawatt bidding system in place.

Other Massachusetts utilities are not as far down the bidding road as Boston Edison. The DPU has approved the following supply additions, and ceiling prices, for the participating utilities:

Cambridge Electric Light Co: 33 MW -7.33 cents per kWh
Commonwealth Electric: 76 MW -6.52 cents per kWh
Eastern Edison: 30 MW -6.86 cents per kWh
Fitchberg Gas& Electric: 11.7 MW -7.69 cents per kWh
Nantucket Electric: 3.6 MW -7.8 cents *per* kWh
Western Massachusetts Elec.: 40 MW -5.8 cents per kWh

Clearly, capacity bidding in Massachusetts has not proceeded far enough yet to make any firm conclusions about how it is working from an environmental standpoint. However, the first Boston Edison bids had some troubling aspects because of the unexpected presence of a large coal-fired plant and the proliferation of waste-to-energy projects. The second round of bids, driven by tough new pollution rules, could be better. It will be worth watching what goes on in Massachusetts as a harbinger of what might occur as a result of the FERC bidding initiative.

[3] Bill Rankin, ''FERC Competitive Bidding Plan Splits The Utility Industry," *Energy Daily, vol.* 15, No. 171, Sept. 9, 1987, p. 1.

[4] Whippen, supra note 1.

[5] Massachusetts in 1985 passed an acid rain control law that will require substantial sulfur dioxide emission reductions by 1%15. The law requires an average emission rate of all utilities m the State of less than 1.2 pounds of SO_2 per million Btu. New England Power, the NEES generating subsidiary expects that it will have to reduce emissions from its Massachusetts facilities by as much as 46,000 tons per year, New England Power Fact Sheet, "'Using Natural Gas at New England Power Company's Brayton Point State to Meet Massachusetts Acid Ram Law Requirements," Jan. 18, 1988.

Table 7-3-Boston Edison Company-Winning Bidders-RFP No. 1

Project	Size	Technology
FHN Energy (w/ Dominion Resources)	200 MW	Coal-AFB
Clean Harbors	2.5 MW	Hazardous waste
Bellingham	68 MW	Gas-combined cycle
NEES-cogen	3.3 MW	Combustion turbine
NEES-cogen	3.3 MW	Combustion turbine
NEES-cogen	24.5 MW	Gas-combined cycle
NEES-cogen	10 MW	Gas-combined cycle
Webster Resource	7.4 MW	Trash-mass burn
Wheelabrator Energy System	25 MW	Construction debris (aka "urban woods")
Total	344 MW	

NOTE: More recent developments have cast even greater undertainty over the results of the first round bidding. According to *Electric Utility Week*, NEES dropped its four winning projects because of siting difficulties and two projects, including the large coal plant and the urban woods project, remain unsited. Even so, contracts have been signed for a total of 416 MW. (*Electric Utility Week*, Nov. 21, 1988, p. 19.)

tion would consume some of the PSD increments available for other kinds of industrial development.

Greater access to transmission could stimulate the development of trash-to-energy projects by creating a broader market for their power. That could lead to even greater contention over waste-to-energy projects at the local and national level.[62]

Greater access to transmission could also slow individual utility conservation and load management programs and complicate the analysis that goes into conservation and load management planning. It might become necessary to create regional conservation and load management institutions, such as the power pools and NERC, to match conservation and load management planning with regional transmission and generation planning. This is what has happened in the Pacific Northwest as a result of the 1981 Northwest Power Planning Act.

Scenario 3: Competition for New Bulk Power Supplies

From an environmental standpoint, there is probably more known about scenario 3 than some of the others, because more thought and effort has gone into it at both the Federal and State level. At least seven States have implemented bidding systems of some some sort.[63] FERC has commissioned two environmental studies in connection with its notices of proposed rulemaking (NOPRs) on competitive bidding and independent power producers. An environmental report done for FERC by Oak Ridge National Laboratory before release of NOPRs identified potentially significant environmental impacts from the proposals, particularly increased use of coal in four States, New York, New Jersey, Virginia, and California.[64] As a result, FERC agreed to prepare a full nationwide Environmental Impact Statement as part of its rulemaking.

Scenario 3 offers some potential environmental benefits, chiefly the prospect of more rapid replacement of the older plants with new plants, which are likely to be less polluting. The scenario implicitly assumes that 'new" power will eventually drive out ''old" because new, "competitively priced" generation will be cheaper and because old plants will be phased out on some actuarial basis. But if the guaranteed rate of return to the old plants, particularly those that are fully depreciated, exceeds the return on investment available in the competitive market, those assumptions may not hold, and old plants may continue to be a problem.

@see Neil Seidman, "Garbage In, Garbage Out," *Nor Man Apart,* November-December 1986, pp. 10-1 I, for an environmental critique of mass bum projects. The Institute for Local Self Reliance has a study of transmission and wasle-to-energy projects currently underway.

63Colorado, Maine, Massachusetts, New Jersey, New York, Texas, and Virginia.

64" Environmental Report: Regulations Governing Bidding Programs" (Docket No. RM88-5-000) and "Regulations Governing Independent power Producers (Docket No. RM88-4-000)," Oak Ridge National Laboratory, March 1988.

One environmental issue will be whether and how to treat plant geriatric work in the context of bidding. If a utility is required to bid the added supply associated with a particular life-extension project, it starts with an asset owned by the ratepayers. Even if fully depreciated, the plant would still have a market value. If the market value of the plant isn't factored into the bid price, the utility could reap a windfall profit from the life extension, a further incentive to keep old plants on line. This is similar to the problem posed by a deregulation scheme that allows a utility to spin off its existing plant into a deregulated subsidiary and then bid the power from that plant against new construction in the power auction. In both cases, it is necessary to factor in the value of the existing asset in order to avoid subsidizing older, presumably dirtier, plants.

Two other environmental issues are particularly, pertinent to the concepts of all source bidding to supply utilities with power. The first is how to factor environmental considerations into the bidding process, and the second is how to square the bidding schemes (a supply-side issue with conservation and load management demand-side issues). The second issue may prove to be the most difficult to deal with, although not insurmountable.

In the States that have addressed the bidding schemes so far, environmental issues generally have been treated as 'nonprice" factors.[65] Other nonprice factors include such things as reliability, dispatchability, and fuel diversity. The difficulty with the nonprice factors is that they introduce an element of subjectivity to the selection of the winning bidder, and take away from the auction aspects of the bidding process. That means there will continue to be a need for regulatory review to make sure that the subjective judgments of the utility don't adversely bias the decisions. It is also possible that nonprice factors will be given less emphasis than the more easily quantifiable price elements in the bids.

In ca..es where there is a larger policy issue—such as, for some, fuel diversity—the bidding process might have to be altered somewhat to reflect this. In New York, for example, Long Lake Energy Company, a hydro developer, suggested that, in view of the public policy in favor of developing renewable sources of energy, the State require separate requests for proposals for renewable projects during the bidding. Otherwise, the company said, a capital-intensive project such as hydro might not be competitive on a price-only basis.[66]

One of the major considerations in any competitive scenario is the desire to establish a level playing field for all competitors. From an environmental perspective, an important consideration will be whether all the players—utilities, IPPs, and QFs—are required to meet the same high environmental standards.[67]

Building environmental concerns into a bidding process as a subjective factor at least provides a conceptual way to make sure that awards are environmentally sound. But including conservation and load management raises far more difficult issues. So far, States have approached the problem in different ways.

In New York, the State PSC adopted a staff proposal to require utilities to establish bidding auctions for demand-side management.[68] An administrative law judge earlier had rejected the State PSC staff proposal for "negawatt bidding," in which a purveyor of conservation and load management could bid measures to reduce the utility's consumption by the proposed supply increment, and ruled that demand-side management not be included in the same bidding process with supply auctions.[69] The judge cited the imperfect equivalence of demand reductions and supply additions and the potential loss of utility revenues. In Maine, demand-side

[65] See testimony of Robert J. Keegan, Commissioner, Massachusetts Department of Public Utilities, before the Senate Energy and Natural Resources Committee, Feb. 4, 1988, p. 8.

[66] ALJ Frank s, Robinson, Case 29409, *Recommended Decision on Bidding, Avoided Cost Bidding, and Open Wheeling*, p. 65.

[67] In its brief to the New York Public Service Commission on that State's bidding rulemaking, Orange & Rockland *Utilities* argued that ' 'to hold utilities to higher environmental standards would provide IPPs with an unfair and possibly deceptive economic advantage: customers could be receiving an ostensible benefit in their utility bills. with a hidden cost to the State's environment. " Robinson, supra note 66, p. 66.

[68] New York State Public Service Commission, Case 29409, Opinion No. 88-15, mimeo, pp. 21-22.

[69] Robinson, supra note 66, p. 53.

options were allowed to compete to provide needed increments of electricity supply .70

FERC's proposed rule on bidding under PURPA does not provide for bidding of conservation and load management. Economist Paul Joskow of the Massachusetts Institute of Technology has argued that FERC is correct to avoid the negawatt issue. Including demand-side options in the FERC proposal, Joskow told a congressional subcommittee, "could result in higher electricity rates, inequitable electricity rates, windfall profits for some conservation suppliers, and incentives for inefficient conservation investments. " But Ralph Cavanagh of the Natural Resources Defense Council told the same committee that omitting demand-side options from the rulemaking would ''exclude from power supply competitions the least expensive resources available to modern electricity systems. "[71]

Despite the objections, demand-side bidding is a powerful idea for stimulating energy conservation in a market-oriented industry structure. More analytic work, and perhaps some practical experiments, are needed to test whether the barriers that critics raise are real or fiction. Some suggest that negawatt bidding can work by targeting specific loads for reductions, such as motor efficiency, lighting, or buildings.

Scenario 4: All Source Competition for All Bulk Power Supplies With Generation Segregated From Transmission and Distribution Services

Both scenario 4 and scenario 5 are considerably further from the status quo than any of the predecessors. Consequently, trying to divine their environmental impacts is a speculative enterprise at best. Nevertheless, several environmental questions present themselves with this full-fledged revolution in the electric utility industry: the older plant problem, how to build in environmental analysis, and the problem of demand-side management.

Scenario 4 could present the most powerful incentives yet to continue using older, dirtier plants. If existing plants and life-extension projects can be bid to supply generation on the same basis as other sources, utilities will doubtless argue that since their older plants are fully (or nearly) depreciated, they are the low-cost bidders, ignoring the market value *that* the plant possesses. The result is a powerful subsidy for the fully amortized plant, even if a considerable amount is spent in life extension. (There is a similar problem in scenario 3.) This incentive could frustrate long-standing environmental goals, embodied in statutes such as the Clean Air Act and the Clean Water Act, of replacing aging, more polluting plants with new, less polluting industrial plants.

One method of reducing the potential competitive advantages of older plants is to structure the transition to scenario 4 so that the market value of the existing plant and equipment gets recognized in the market price of power from those plants. After all, one can make a powerful argument that it is the public, in the form of the ratepayers, who own the plant, since they paid for it.

One way to deal with this problem would be to force newly segregated generating companies to bid against others for ownership of the generating plants of its integrated utility predecessor. Another alternative would credit or debit the utility's rate base for any difference between the net book value of the asset and its sale price. The new owner would do the geriatric work and use the refurbished unit to enter the market.[72]

This scenario also faces the familiar problem of how to factor environmental analysis into the competitive process. Again, this is related to the larger problem of older plants with less sophisticated pollution control devices that likely would have a cost advantage in bidding. A new plant, for example, would have to obtain site approval and a host of permits that would not burden the existing plant.

A new plant sited in a nonattainment area would have to go over the costly LAER (lowest achievable emission rate) hurdle, obtain pollution offsets, and

70 Maine Public Utilities Commissioner David Moskovitz would deal with the imperfect equivalence problem by tying a utility's rate of return to relative reductions in the average bills paid by residential customers, and to reductions in electricity use per square foot by commercial customers. Thus, the lost revenues from conservation would be offset by higher returns on the remaining business. Aviva Freudman, "Moskovitz's Modest Proposal: Reward Utilities for Reducing Customers' Bills," *Energy Daily, vol.* 16, No. 72, Apr. 15, 1988, p. 1.

71 Dennis Wamsted, ''Negawatts or Negafood? A Demand-Side Dichotomy, " *Energy Daily*, vol. 16, No. 63, Apr. 4, 1988, p. 1.

72 Robinson, supra note 66, p. 55.

the like. In an attainment area, the new plant would have to go through the PSD process. An existing plant competing against those new plants could avoid any of those costs, as well as the high capital costs of scrubbers, bag houses, precipitators, and the like. It will require considerable regulatory ingenuity to figure out how to put the existing plant and new plants on an environmentally level playing field in this scenario.

Finally, there is the conundrum of how to carry on conservation and demand-side management in an economic environment that is almost completely supply side. In a nonintegrated market, with generation separated from transmission and distribution. it is not very clear just who will worry about conservation and reducing demand. The distribution companies or "discos" will be less concerned, because they no longer face the risks of construction which have driven much industry concern about demand management. Potentially, discos will make money only if they sell power and pass through the costs of purchased power. If the equivalence between demand reduction and supply addition is imperfect in scenario 3, it is even less so in scenario 4. Clearly, the interest of the generating company (genco) will be to generate and sell megawatts. The scenario might also reduce pressure on State regulators to push for conservation and demand management if their retail ratesetting influence over wholesale transactions is curtailed.

Scenario 5: Common Carrier Transmission Services in a Disaggregate, Market-Oriented, Electric Power Industry

In addition to the environmental issues raised with regard to scenario 4, scenario 5 has some unique environmental problem areas. The knotty issue of conservation and load management becomes even more intractable in a conventional sense. With transmission companies (transcos) now in the market, making their money from selling transportation services, another force has been removed from the conservation and load management equation and added to the supply ledger. Now only the regulated distribution utility—probably serving a captive and bypassed residential and small commercial market—will have any incentive to push demand-side measures. And as long as the disco can buy power cheap enough to make a reasonable rate of return on sales, all incentive for conservation and load management disappears.

Scenario 5 also raises the specter of reduced maintenance of power generating equipment. In the rush to compete, particularly if the competition seriously drives down prices and profit margins, generating companies may decided to cut costs by skimping on maintenance. This can have disastrous environmental and health consequences. In this regard, the electric utility industry could come to resemble the deregulated U.S. airline industry, where the need to pay careful attention to costs has increased pressures on the maintenance decision-making process.[73]

This issue is not present in prior scenarios, because in each case, some strong institutional entity remains with a vested interest in reliability and maintenance. Even in scenario 4, the integrated transmission-distribution companies have a need for high reliability standards.

But in scenario 5, the only entity with an overriding interest in reliability appears to be the distribution company. For both the genco and the transco, reliability becomes solely an economic issue. Freed from its obligation to serve, if it makes more economic sense to walk away from a market than to continue to sell to it (as a result, for example, of a poorly structured fuel supply contract or a contract for transmission services that turns out to be uneconomic), the genco probably will walk. If the transco has an obligation to provide transmission service, the company might meet that obligation grudgingly.

There also is fear that the disco could become a weak market player, bypassed by its biggest customers and left serving only a market that is economically fragmented but politically very powerful (i.e., a market that uses its political power to keep rates low). In those circumstances, the disco may not have enough clout to insist that its suppliers maintain their plants even under adverse economic conditions.

[73] U.S. Congress, Office of Technology Assessment, &@ *Skies for Tomorrow: Aviation Safety in a Competitive Environment,* OTA-SET-381 (Washington, DC: U.S. Government Printing Office, July 1988), p. 108.

Finally, the sort of industry structure envisioned in scenario 5 could result in a construction boom for new transmission with an associated increase in local siting battles,

Conclusions

Change is a given in the electric utility industry, and most observers would agree on the general direction of that change: toward greater competition in the generation sector and away from the traditional pattern of the vertically integrated electric utility. But as those changes appear, it will be important to keep an eye on the environmental impacts of the changed circumstances and conditions in the industry.

Neither expanded competition or increased transmission access is inherently incompatible with national environmental objectives. Nor are arty of the scenarios inherently preferable on environmental grounds—at least, given our current level of understanding. However, as each scenario diverges further from the status quo than its predecessor, assessing environmental consequences become increasingly difficult and problematic.

In all cases, environmental concerns will be an important consideration in the policymaking that will accompany the changes *in* the electric utility industry. The OTA scenarios and other proposals would have their most direct environmental effects by affecting fuel choices and the generation mix, potentially frustrating achievement of anti-pollution goals and reducing incentives for development of some renewable energy technologies. Implementation of consemation and load management programs could be complicated and/or stalled by competitive markets that focus only on supply-side options, An increased demand for transmission services could lead to more transmission line construction and aggravate some already difficult disputes over transmission line siting. Based on OTA's preliminary review, there is little evidence that would support blanket assertions that major structural or regulatory changes in the electric power industry would be environmentally neutral or benign.

HEALTH EFFECTS OF POWER FREQUENCY FIELDS

For about two decades, there has been some concern about the health effects of electric and magnetic fields produced by electric power systems. Recent studies have only intensified this concern. One study in particular, the New York State Power Lines Report generated headlines in newspapers all over the world, focusing attention on the health effects associated with living next to power lines. Whatever the future direction of the electric power industry, these concerns are likely to persist.[74]

The first evidence that electric and magnetic power frequency fields might have a direct effect on human health appeared in 1972 when Soviet investigators reported that workers in Soviet extra high voltage (EHV) switchyards suffered from a number of ailments, such as appetite loss, fatigue, headaches, insomnia, and reduced sexual drive. While the Soviet research proved to have a number of flaws, it served to stimulate public concern.

In the United States, most of the health effects concerns have focused on fields generated by power lines. In several States, health effects have become a central issue in transmission line siting hearings. By the end of December 1987, there were about 144,386 miles of transmission line (230 kV and above) in the United States[75] and thousands of miles more under construction or being planned by utilities.

For many years, the scientific consensus was that power frequency fields could pose no threat to human health. Unlike x-rays that break chemical bonds by ionization, or microwaves that heat things up, power frequency fields are not powerful enough to break chemical bonds in human cells or cause significant tissue heating. Despite the low energy level of power frequency fields, laboratory research over the last 15 years has shown that even power frequency fields of low intensity (or strength) can disrupt certain processes at the cellular level.

[74] Much of the information in this section is drawn from an OTA contractor report, by Indira Nair, M. Granger Morgan, and H. Keith Florig, Carnegie-Mellon University, Department of Engineering and Public Policy, "Power-Frequency Electric and Magnetic Fields—Exposure, Effects, Research, and Regulation," Jan. 16, 1989.

[75] NERC, *1988 Electricity Supply and Demand for 1988 -1997,* October 1988, p. 63.

The research results are complex and often inconclusive. There have been many experiments that have found no difference between biological systems that have been exposed to fields and those that have not. But the growing number of positive findings have now clearly demonstrated that under certain circumstances, even relatively weak fields can produce changes at the cell level. Moreover, the number and consistency of positive findings has resulted in better experimental design and improved control of the experimental process.

As recently as a few years ago, scientists were making categorical statements that on the basis of all available evidence there are no health hazards from human exposure to power frequency fields. It is still not possible to demonstrate that such effects do exist, and it is important to remember that they may not. However, the emerging evidence no longer allows one to categorically assert that there are no risks.

If fields do turn out to be a health risk, it is unlikely that high-voltage transmission lines are the only sources of concern. Power frequency fields are also produced by distribution lines, household wiring, appliances, and lighting fixtures. These non-transmission sources are much more common than transmission lines and could play a far greater role in any public health problem.

There is, of course, no difference in the biological effects of exposure to power frequency fields under any of the scenarios discussed in chapter 3 or elsewhere in the report. Expansion of transmission systems in a manner that exposes more humans to potential hazards from electric and magnetic fields could occur under any scenario.

Sources and Nature of Electric and Magnetic Fields

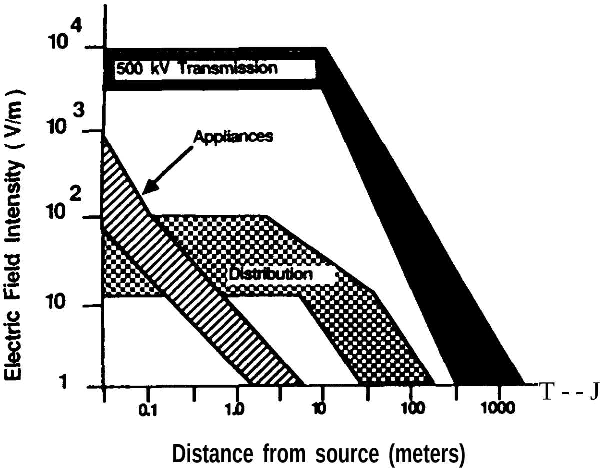
People are exposed daily to electric and magnetic fields. In fact, electric and magnetic fields arise from many natural sources. Processes in the atmosphere produce large static electric fields at the surface of the Earth, thunder clouds produce lightning, and the Earth's core produces a magnetic field which makes navigation by compass possible. Electric and magnetic fields are also produced by high-voltage transmission lines, low-voltage distribution lines, building wiring, electric appliances, and light fixtures. This section focuses on the fields created by power lines.

Power lines carry electric currents that alternate at a frequency of 60 cycles per second (60 Hz). That is, the current changes direction 60 times per second. The alternating current produces electric and magnetic fields around the power lines. These electric and magnetic fields, which oscillate at the same frequency as the electricity in the lines, are called power frequency fields. Power frequency electric and magnetic fields are ''extremely low frequency" (ELF) fields. Other common electric and magnetic fields produced by radio and television broadcasting stations, for example, have higher frequencies than power frequency fields.

The term *"electric field"* is merely a description of the electric force that a charged object is capable of exerting on other charges in its vicinity. The intensity of the electric field is proportional to the magnitude of its force. The electric fields of power lines, wall wiring, and appliances are produced by electrical charges that are ''pumped'* onto the wires by electrical generators. Similarly, *"magnetic field"* is the term used to describe the magnetic force. The magnitude of the magnetic fields around a current-carrying wire is proportional to the amount of current. Both electric and magnetic fields have magnitude and direction. The electric field is measured in volts per meter (V/m) and the magnetic field in ampere per meter, gauss, or tesla.

Unlike ionizing and microwave radiation, which are forms of energy that travel distances from the source, ELF fields diminish rapidly with distance away from the source. Figures 7-2 and 7-3 show the intensity-distance relationship for fields produced by EHV transmission lines. Fields produced by power lines are strongest right under the conductors. The magnetic fields around many appliances are stronger than those under either a transmission or distribution line. However, magnetic fields produced by appliances typically fall off faster with distance than do fields from other sources. This is because appliances are less extended in space than are long power lines.

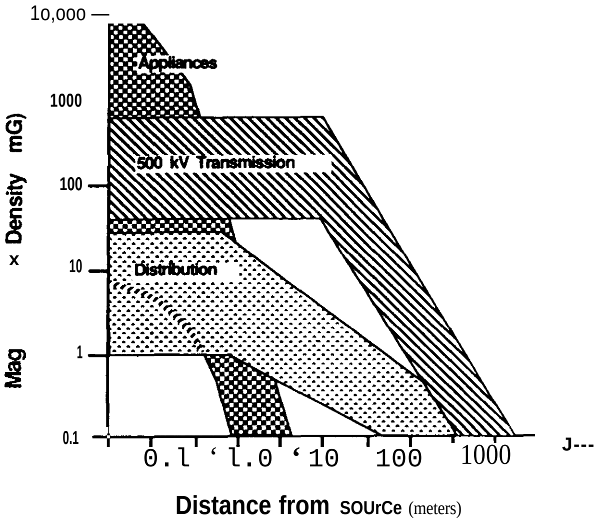
Figure 7-2—Electric Field Intensity at Ground Level v. Horizontal Distance From Three Common Sources of Power Frequency Electric Fields



Bands represent variation across individual sources in each group.

SOURCE: Adapted from H.K. Florg, 1. Nair, and M.G. Morgan, Briefing *Paper 1* Sources *and Dosimetry of power Frequency Fields,* Technical Report, prepared for the Florida Department of Environmental Regulation under DER Contract SP1 17, March 1987.

Figure 7-3-Magnetic Field Intensity at Ground level v. Horizontal Distance From Three Common Sources of Power Frequency Magnetic Fields



Bands represent variation across individual sources in each group.

SOURCE: Adapted from H.K. Florig, 1. Nair, and M.G. Morgan, *Briefing Paper 1: Sources and Dosimetry of Power-Frequency Fields*, Technical Report, prepared for the Florida Department of Environmental Regulation under DER Contract SP1 17, March 1987.

Shielding

Buildings and other large structures, fences, and vegetation can provide appreciable shielding from electric fields. Houses, for instance, diminish electric fields from nearby power lines by about 90 percent.[76] Also, electric fields can virtually be eliminated by grounded shield wires or screens in direct contact with the earth. Buried power lines produce almost no electric fields above ground.

Unlike electric fields, magnetic fields easily pass through most objects, including buildings, earth, and people. Houses, trees, and most other objects do not provide appreciable shielding from magnetic fields. Only structures containing large amounts of ferrous or special metals can shield magnetic fields.

Some have suggested that in the future, superconducting materials could be used to reduce exposures to power frequency fields.[77] In theory, superconducting materials could be used to carry large quantities of power a.. direct current thus avoiding the magnetic fields caused by rapidly alternating current. But they would not eliminate all magnetic fields-a static magnetic field would remain around the superconducting line because all currents produce a magnetic field in their vicinity. Moreover, use of superconductors could be prohibitively expensive or unnecessary for this purpose.

How We Are Exposed To Power Frequency Fields

The human body contains free electric charges, largely in ion-rich fluids such as blood and lymph. (There are also charges, although not entirely free, on cell membranes.) The electric charges, within the body, move in response to forces exerted by charges and currents on appliances and nearby power lines. The processes that produce these movements, or

[76] H.K. Florig, "Population Exposure to Power-Frequency Fields—Concepts, Components, and Control," Ph.D. Thesis, Department of Engineering and Public Policy, Carnegie-Mellon University, 1986.

[77] *Superconductivity Flash Report.* "Do Overhead Transmission Line Health Risks Help SC," p. 8.

body currents, are called *electric* and ***magnetic induction.***

Electric Induction—In electric induction, charges on a power line or appliance attractor repel the body's free charges. Since body fluids are such good conductors of electricity, charges in the body move to the surface under the influence of this electric force. For example, a positively charged overhead transmission line induces negative charges to flow to the surface of the upper part of the body. Because power line charges alternate from positive to negative many times each second, the charges induced on the body surface alternate as well. Negative charges induced on the upper part of the body one instant flow into the lower part of the body the next instant. Therefore, power-frequency electric fields induce currents in the body as well as charges on its surface. Figure 7-4 shows electric and magnetic field strengths observed in common exposure settings.

Magnetic Induction-Magnetic fields are interrelated with electric fields. As noted earlier, alternating current produces magnetic fields which oscillate with the current. The changing or alternating magnetic fields, in turn, produce electric fields, which exert forces on the electrical charges contained in the body. This process is called magnetic induction. The currents induced in the body by magnetic fields are greatest near the periphery of the body and smallest at the center of the body. Because magnetic fields have only recently become a human health concern, data on the detailed distribution of magnetically induced currents in humans and animals are quite sparse compared to the information available on electric induction.

The magnitude of surface charges and internal body currents induced by power-frequency fields depends on many factors. These include the magnitude of the charges and currents in the source, the distance of the body from the source, the presence of other objects that might shield or concentrate the field, and body posture, shape, and orientation. Consequently, induced surface charges and currents are very different for different animals.

Contact Currents-In addition to electric and magnetic induction, humans are exposed to contact currents. Contact currents are the currents that flow into the body when physical contact is made between the body and a conducting object carrying an induced voltage. Examples of contact current exposure include contacts with the handle of a refrigerator and with vehicles parked under a transmission line. Contact currents often produce high current densities in the tissue near the point of contact. Although contact currents result in some of the most intense exposures, they are also among the briefest, usually lasting only as long as it takes to open the door of a car or refrigerator.

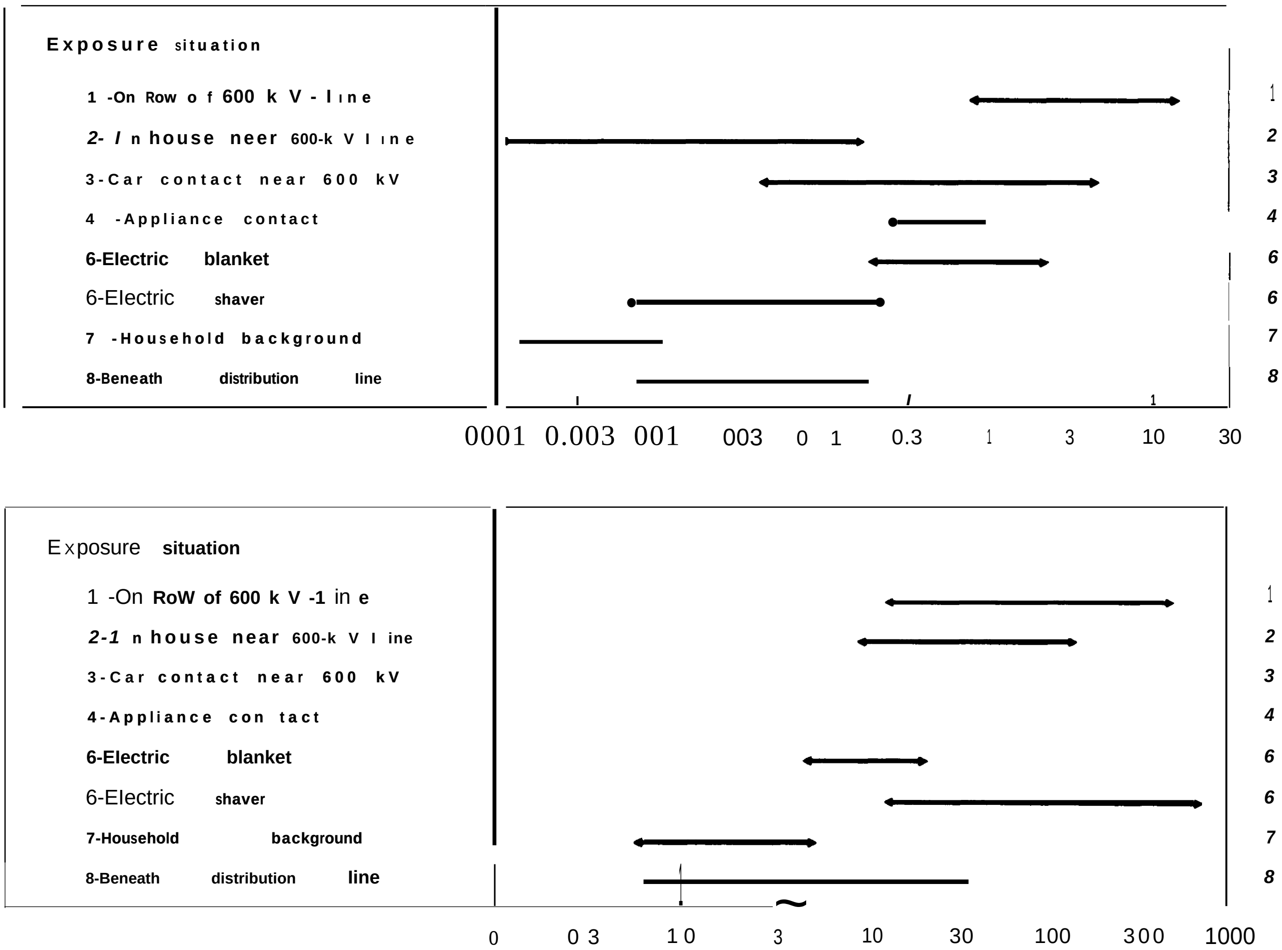
If a person touches a vehicle parked under a power line, the body provides a path to the ground through which the charge induced on the vehicle by the power line's electric field can flow. The magnitude of the contact current depends on a number of factors: local field intensity, the size and shape of the contacted object, and how well-grounded the contacted object and the person are. The largest contact currents are drawn by well-grounded persons who touch large metal objects that are well-insulated from the ground. Most common contact currents are imperceptible. Under the right circumstances, however, contact currents can be annoying or even painful. To protect the public from life-threatening contact currents, the American National Standards Institute (ANSI) has recommended that overhead lines be designed so that contact currents from even very large vehicles do not exceed 5 milliamps.[78] (One milliamp is equal to one-thousandth of an amp.) There is some concern that the ANSI limit is too high because 5 milliamps is still above the "let-go" threshold for some children. The "let-go" threshold is the current above which a person loses voluntary muscle control and cannot "let go" of a gripped contact.

Exposure Parameters

While it is possible to measure fields and induced currents to which people are exposed, scientists do not know which, if any, aspect of the field can have an impact on human health. For example, scientists do not know whether to be concerned about field strength, change in field strength overtime, currents induced in the body, exposure duration, or some other variable. For most known potential hazards,

[78] American National Standards Institute, *National Electrical Safety Codes*, 1977.

Figure 7-4--Compariaon of Ranges of Electric and Magnetic Fields From Common Power Frequency Sources



SOURCE: OTA adapted from Indira Nair, M. Granger Morgan, and H. Keith Florig, Power Frequency Electric and Magnetic Fields—Effects, Research and Regulation, OTA contractor report, Carnegie-Mellon University, Department Of Engineering and Public Policy, final report, Jan. 16, 1969.

such as chemicals, one can safely assume that if some of the agent is bad, more of it is worse. This may not be the case with power frequency fields. Biological experimental evidence about power frequency fields suggests that the "more-is-worse" assumption cannot always be justified.

Some suggested measures of the bioeffects of power frequency fields include:

- Frequency and intensity "windows"-biological effects are noted in specific narrow ranges of field intensity and frequency.
- Time thresholds—biological effects are observed only after several weeks of exposures.
- Time "windows"—biological effects are noted after long- and short-duration exposure periods. In some studies of cells and tissues, the effect is not observed immediately after exposure. Rather, there appears to be a window in time in which biochemical perturbation occurs.
- Field threshold—biological effects appear only when field strength exceeds some threshold value.

Together these different measures of dose suggest that one cannot make the assumption that dose is proportional to field strength or to time spent in the field.

Comparing Human Exposures From Different Sources

Because scientists do not know what measure is relevant in determining biological effect, comparisons cannot be made on the basis of relative contributions to effective dose. Comparisons among sources can be based only on those physical quantities that are amenable to measurement or theoretical estimates. These include electric quantities, such as induced surface charge and internal currents, exposure duration, frequency of exposure, and number of people exposed. Although the electric quantities may not relate in any simple way to a public health impact of a given source, scientists can use them to get some idea of how similar or different people's exposures from various sources are.

Current Scientific Evidence on Biological Effects of Power Frequency Fields

Most of what we know today about the effects of exposure to power frequency fields comes from three types of studies or experiments:

1. Laboratory experiments that use animal or human tissues or cell cultures exposed to fields. These experiments are termed "in vitro" (in glass).
2. Laboratory and field experiments that use animals exposed to fields. These experiments are termed 6.in vivo" (in live state) experiments.
3. Epidemiological studies that observe the effects of field exposures on human populations at work (occupational studies) or at home (residential studies).

Cell-Level Experiments

A considerable body of evidence has emerged that points to the cell membrane (the membrane enveloping the cell) as the primary site of interaction between ELF fields and the cell.[79] The cell's membrane serves as the boundary and maintains the structural integrity of the cell. It is also responsible for transmitting information arriving at its surface to the cell interior so that appropriate life processes can take place. The cell membrane is a highly selective filter that maintains an unequal concentration of ions (charged atoms) on either side and allows nutrients to enter and waste products to leave the cell.

The ELF experiments on the cellular level concentrated on how some of the specific processes governed by the membrane change as a result of exposure. Some of the changes noted in the experiments include the modulation of calcium ion flows; interference with DNA (deoxyribonucleic acid) synthesis and RNA (ribonucleic acid) transcription; interaction with the response of normal cells to hormones and neurotransmitters; and interaction with the biochemical kinetics of cancer cells.

The phenomenon most studied on the cellular level is the flow of calcium ions across the cell membrane when exposed to 60 Hz fields. Calcium is present in the membrane structure and is released when triggered by an appropriate signal. Calcium flow regulates physiological processes such as muscle contraction, egg fertilization, and cell division. The quantity and the rate of calcium ion transport are important in this regulation. When information in the form of an electrical or chemical impulse arrives at the cell membrane, the membrane binding and the permeability of calcium are altered and calcium is released. The subsequent flow of calcium across the membrane transfers information to the interior of the cell. In addition to regulating physiological processes, calcium flows activate certain enzymes called protein kinases, which are found on the surface of nerve cells. When activated by the calcium changes, these enzymes cause actions on other cell surface proteins that are important in cell adhesion during development and growth. The unusual behavior of calcium flow from cell membranes in brain tissue in vitro was the first clear, reproducible effect of ELF fields observed in biological tissue.

Recent research has demonstrated unequivocally that under certain circumstances, the membranes of cells are sensitive to externally imposed low-

[79] W.R. Adey, "Electromagnetic Fields, Cell Membrane Amplification, and Cancer Promotion," paper presented at the National Council on Radiation Protection and Measurements Annual Meeting, National Academy of Sciences, Washington, DC', 1986.

frequency electromagnetic fields, even when the fields' intensity is much weaker than the cell membrane's natural fields.[80] Consequently, processes that are governed by the cell membrane, such as a cell's capacity to recognize other cells, may be candidates for disruption by field exposure.

Also, ELF experiments have focused on chromosomal damage and interference with DNA synthesis and RNA transcription. DNA and RNA are the primary biomolecules in the cell. Nuclear DNA carries the genetic code while the extranuclear RNA transcribes the DNA command codes into proteins for the physiological functioning of the cell. Well-studied cancer-initiating agents, such as ionizing radiation and chemicals, cause direct damage to DNA by mutations. As noted earlier, ELF fields do not have enough energy to break bonds or otherwise disrupt the structure of DNA. However, research has shown that exposure to fields may interfere with the transcription patterns of RNA, resulting in the production of structurally changed proteins. Protein synthesis is a very complicated process, and experiments yield no simple interpretation about potential ELF effects on the organism.

Several experiments have studied the effects of ELF fields on endocrine tissue. From these experiments, it is impossible to draw any inference about the effects of fields on the endocrine system in a human or animal, other than to say that fields do exert an action on endocrine tissue and endocrine processes in vitro, and these effects, too, show windows.

Also, ELF experiments on interaction with the immune response of cells showed that field exposure had no significant effects on immunological functions of normal or specifically immunized cells. However, fields may affect cells already stimulated by mutagens (agents that provoke an immune response).

Several experiments have examined the effect of ELF fields on cancer cells. One of the hypotheses developed is that fields promote cancer formation or cancer growth rather than initiate cancer. The fact *that* ELF fields have not been known to cause alterations in DNA structure, as discussed earlier, is consistent with the observation that ELF fields do not initiate cancer. However, it should be noted that any potential relationship between field intensity and the degree of promotion may be highly complex.

It is important to remember that even when effects are demonstrated consistently on the cellular level in laboratory experiments, it is difficult to predict whether and how they will affect the whole organism. Processes in the cell are integrated through complex mechanisms in the animal. When a cellular process is perturbed by an external agent, such as an ELF field, other processes may compensate for the perturbation so that there is no overall disturbance to the organism.

Another problem in deducing possible health concerns from cell-level effects has been the lack of a theoretical model to explain and understand these potential effects. Although great strides have been made in recent years, cell membrane biology is still in its infancy. Until recently, there was not enough understanding to even advance hypotheses about the potential mechanisms by which ELF fields may disturb healthy cell and organ functions. Hypotheses are now being advanced but are still at a speculative stage. Several decades of carefully designed experiments may be necessary before all the current pieces of evidence fall into place in a coherent framework.

Moreover, many of the lessons learned from environmental hazards, such as chemical agents (PCB, vinyl chloride, benzene, etc.), or physical agents (asbestos, ionizing radiation, etc.), cannot be applied to ELF fields. The cell-level effects produced by ELF fields are complex and dependent on a number of factors, such as frequency and field strength, time pattern of exposure to the field, and direction of the applied field. The effects also may depend upon whether the field is a simple alternating field or a pulsed field. Because of these complex dependencies, ELF fields appear to be an agent for which there is currently no known analog.

A summary of the results of a number of cell level experiments is shown in table 7-4.

[80] W.R. Adey, "Tissue Interactions with Nonionizing Electromagnetic Fields," *Physiological Reviews, vol. 61,* pp. 435-514, 1981; Testimony presented to the U.S. House of Representatives, Subcommittee on Water and Power Resources, "Health Effects of Transmission Lines," Oct. 6, 1987; W.R. Adey and A.F. Lawrence (eds.), *Nonlinear Electrodynamics in Biological Systems (New* York, NY: Plenum Press, 1984).

Whole Animal Experiments

In addition to cell-level studies, whole animal experiments have been conducted. Animal systems have been examined under a range of electric and magnetic field intensities and for varied exposures and durations. The experiments involved many different subjects, including rats, mice, miniature swine, cows, guinea pigs, and chicken eggs.

Historically, animal experiments focused on general effects rather than on formulating and testing hypotheses. Very early experiments were riddled with problems of poor experimental design, leading to artifacts in results. Moreover, animal studies with statistically sufficient numbers are very expensive and time-consuming. In the past 15 years, the quality of health effects experiments has improved but has not yet reached the hypothesis testing stage. Epidemiological studies have focused on a search for cancer as the primary effect because of historical observation rather than because cancer is the most likely effect.

Whole animal and human experiments are reviewed under these categories of effects:

1. General effects, such as detection, avoidance, and behavior responses; development and learning of animals; and moods of humans.
2. Effects on externally measured physical parameters, such as growth, birthweight, respiration, heartbeat rate, and temperature rhythms.
3. Effects on specific biochemical such as hormones that are responsible for maintenance, regulation, and control of general physiological and psychological functions; for response to environmental stressors; for growth and development; and, for triggering special responses such as sexual function, and fetal and newborn nourishment.
4. Effects on circadian rhythms of animals and humans,
5. Epidemiology of cancer, particularly leukemia and brain cancer.

Table 7-4--A Summary of Results of Cellular level Experiments: Effects and Possible Significance

Experiment	Effects noted	Possible significance
Calcium efflux from cell membrane (6 experiments)	Efflux is dramatically changed The change occurs only at some frequency and intensity values, but not at others.	Significance is not clear but points up the possibility that effects of fields may not be such that "higher field intensity is worse than lower."
Chromosomal damage (3 experiments)	No chromosomal damage detectable.	Does not cause the damage that usually initiates cancer.
DNA synthesis rate (1 experiment)	Rate change at low magnetic field.	Extremely low AC magnetic fields as small as the Earth's natural DC field may affect cell process rates.
RNA transcription (1 experiment)	New proteins made by the cell. Rate of transcription altered.	Fields may alter rates of primary cell processes.
Cell response modifications: Response to: A: hormones (1 experiment)	Modifications in adrenal and bone tissue response to hormones.	Public health significance not clear. Adrenal response shows intensity windows. Bone tissue experiment points to membrane as site pf action
B: Neurotransmitters (1 experiment)	Phase shifts in the periodicity of secretion rhythms.	If true in humans, could have implication for psychological disorders, such as chronic depression
C: Immune system (5 experiments)	Not clear that there are significant effects except in special cases.	Implications not clear.

SOURCE: L Nair et al., Department of Engineering and Public Policy, Carnegie Mellon University, OTA contractor report, "Power-Frequency Electric and Magnetic Fields: Exposure, Effects, Research, and Regulation," Jan. 16, 1989.

A summary of the results of whole animal and human experiments follows.

Detection, Behavior, Learning, and Avoidance Responses in Animals—No general conclusions could be gleaned from the experiments on general effects except to note that there are central nervous system effects which may be windowed even in the whole animal.

Reproduction, Growth, and Development— Reproduction, growth, and development studies measure a wide range of factors, such as reproductive behavior, prenatal viability; alterations in physical parameters, gross malformations, and central nervous system development. Most of the studies attempting to examine developmental effects of ELF field exposure have concluded that no overt defects and malformations resulted from the exposure. However, some studies have seen subtle effects and the possibility of the existence of an effect remains an open question.

Several studies have examined the effects of 60 Hz fields on bone growth and repair. Overall, these studies showed that high-intensity electric fields do not appear to have a strong effect on bone growth and repair in rodents.

Central Nervous System Effects—Animal studies have indicated that ELF-central nervous system interactions are very complex. Interactions may vary with the background static fields present, the time of day, and exposure duration. Studies have found that developing nervous systems may be particularly susceptible, and effects may be latent, manifested only in specific situations or later in time. Also, findings show that ELF fields are specific with respect to regions of brain tissue affected. Whether these findings have public health implications remains unclear.

Blood and Immune System Chemistry-The experiments conducted on blood and immune system chemistry imply that there is no general or overall immune system performance changes or short-term endocrine system changes induced by exposure to electric fields of a rather high intensity over a duration of several months.

Circadian Systems of Animals and Humans—The circadian timing system serves to synchronize various physiological and biochemical processes that have a daily cycle. Many aspects of the biology of circadian and other timing systems are not yet well understood. But, the last two decades have brought considerable understanding of some of the elements of the system. ELF experiments on the effects of electric and magnetic fields on circadian systems of man, primates, and lower animals indicate a definite effect on the periodicity of physiological functioning. It is not clear, however, whether such effects are deleterious or even long-lasting. Dyssynchrony of the circadian system has been associated with physiological and psychological disorders. These disorders include altered sensitivity to drugs and toxins and internal conflicts between the timing of physiological processes of sleep, and psychiatric disorders, including chronic depression.

Epidemiological Studies

Epidemiological studies have focused on the association between exposure to ELF fields and cancer in children and/or occupational cancer, These studies have received the most attention in terms of the public health consequences of exposure to ELF fields. Because ELF fields are not known to cause chromosomal damage, cancer promotion, as opposed to initiation, is most often cited as the role ELF fields play in carcinogenesis. However, no experiment or theory clearly proves that ELF fields promote cancer or growth enhancement.

Exposure to ELF fields was first linked to cancer by Wertheimer and Leeper in 1979. The authors estimated the comparative magnitude of the magnetic field in the home by the surrogate measure of wiring configurations. This landmark epidemiological study noted an association between childhood cancer and homes that were classified as located near “high current configuration” distribution lines that were likely to produce stronger than average magnetic fields. In 1982, the cancer association issue resurfaced again-this time in the workplace. The New England Journal of Medicine published an article on the effects of occupational exposure to 60 Hz fields. The article noted that power station operators had 2.5 times the death rate from leukemia. In addition, recent epidemiological studies have begun to examine the incidence of certain cancers to magnetic fields in the household environment. These studies have created a growing need to understand the various sources of magnetic fields in the home, which include not only appliances and house wiring, but also ground currents in plumbing, gas lines, and steel girders.[81] The latest and by far the most thorough study was funded by the New York State Power Lines Project.

Childhood Cancer—Five completed epidemiological studies have addressed the question of association between exposure to ELF fields and childhood cancer. Three of the five studies found positive results. (See table 7-5.)

The latest study, the New York State Power Lines Project, expanded on the 1979 Wertheimer and Leeper study, which involved children from the Denver area. Both wire coding and actual measurement of fields in homes were used to characterize the residential field environment. An analysis of the total childhood cancers occurring in the Denver area was also done and showed that Denver children share the same overall risk as those in the National Cancer Institute Surveillance, Epidemiology, and End Results (SEER) Program. The study also assessed other measures of potential field exposures, such as electric heat and hot water use, the use of heating pads and electric blankets by children and pregnant women, and the total number of electric appliances in the house. The general findings of the study follow:

- A 30-percent increase in risk (odds ratio= 1.31) for all cancers was observed at high magnetic fields (2.50+ milliGauss). The odds ratio did not systematically increase or decrease with field magnitudes, i.e., higher field ranges did not always give a higher cancer risk.
- Cancer subgroups were analyzed under the categories: leukemia, lymphoma, brain tumors, soft tumors, and ''other cancers. " All the categories except leukemia showed odds ratios of 1.3 to 1.6 at high (2.5 mG+) field exposures only. Leukemia showed an odds ratio of 2.11 for the highest field class and 1.23 for the 1.00 to 2.49-mG field range.
- The risk of cancer was not associated with magnetic field values at residence of birth.
- Higher electric fields did not show higher risk of cancer.
- Results on the relationship of childhood cancer to use of appliances, electric blankets, heated water beds, and electric heat are mixed but suggestive of a few trends. Electric blanket and isolette exposures were associated with increased risk of all cancers, especially of the brain and soft tissue, for isolette exposure.

Residential Exposure and Adult Cancer—Three studies have examined the association between adult cancer and exposure to ELF fields from nonoccupational sources. Wertheimer and Leeper were the first to report an association between adult cancers and residential wiring configurations. Four categories of wiring configurations were used to characterize residences in which subjects had lived for periods from 3 to 10 years prior to the diagnosis of cancer. The researchers found an association between cancers of the nervous system, uterus, and breast with a systematically increasing risk for higher current configurations.

The latest study carried out under the New York State Power Lines Project found no association between acute nonlymphocytic leukemia and residential wiring configuration and residential field exposure. The studies do not provide enough evidence that residential field exposure increases the risk of cancer.

Occupational Exposure and Adult Cance+ About 20 studies have examined the association between cancer, particularly leukemia and brain cancer, and occupational exposure to ELF fields. Studies have been done using electrical worker populations or ham radio operators in the United States, England, Sweden, and New Zealand. The results of all studies taken together indicate a small positive association or no association.

Leukemia--Occupational studies of the association of ELF exposure and leukemia show that electrical equipment assemblers and aluminum workers have the highest relative risk of all “electrical” occupations. Uncertainties about the relative risk of these two occupations, however, do exist. For example, job classifications do not clearly indicate actual occupational exposure to fields, and the studies did not take into consideration confounding

[81] D.A. Savitz, *Case Control Study of Childhood Cancer and Exposure to Electromagnetic Fields*. Technical Report to the New York State power Lines Project (Albany, NY: Health Research, Inc., 1987).

Table 7-5-Methodology and Results of Epidemiologic Studies of Childhood Cancer and Electromagnetic Field Exposure

	Wertheimer & Leeper (1979)	Fulton et al. (1980)	Myers et al. (1985)	Tomenius (1986)
Geographic source	Colorado	Rhode Island	Yorkshire (England) Health District	Stockholm County
Case group:				
Time period	Deceased 1950-73	onset 1964-78	Diagnosed 1970-79	Registered 1958-73
Diseases	All cancers	Leukemia	All cancers	All tumors
Age range	0 to 18	o to 20	0 to 14	O to 18
Size	344 (491 dwellings)	119 (200 dwellings)	376	716 (1,172 dwellings)
Other criteria	Colorado birth certificates; resided in Denver area, 1946-73	Identified at Rhode Island Hospital; residences up to years before diagnosis		Born and diagnosed in Stockholm County
Control *group:*				
Source	Birth certificates	Birth certificates	Birth certificates	Birth certificates
Matching	Year of birth; some by county	Year of birth	Time of birth, near case's birth address	Age, sex, and church district
Size	344 (472 dwellings)	240 (240 dwellings)	501	716 (1,015 dwellings)
Other criteria 1.	Subsets formed based on residence information	Only birth addresses considered	Only birth addresses considered	Birth and "diagnosis" address in Stockholm
Exposure:				
Definition	Wiring configurations (wire type, gauge, number, proximity to home)	Estimated exposure from Colorado measurements, divided into quartiles	Calculated magnetic fields from overhead lines	Electrical construction within 150 miles, including 200-kV lines; SO-HZ magnetic fields near door
Range	Up to 35 mG	NA	0.002 to 16.8 mG	0.004 to 19 mG
Potential confounders	Age of onset; sex; urban-suburban residence; socioeconomic class; maternal age; birth order; traffic density	Year of birth; father's socioeconomic level; age of onset	Age	Age, sex, church district
Results:	Positive association between high-current configurations and cancer; dose-response gradient; consistent across cancers	No association observed between imputed exposure and leukemia	No consistent tendency for higher exposures among cases	More electrical construction within 150 miles of case homes; more case homes

SOURCE. 1. Nair et al , Department of Engineering and Public Policy Carnegie Mellon University, OTA contractor report, "Power frequency Electric and Magnetic Fields Exposure, Effect, Research, and Regulation," Jan 16, 1989.

variables and household and other exposures. Studies show that the third highest relative risk group-telegraph, radio, and radar operators, consistently exhibit increased risk. The largest set of data is available for this group.

Collectively, the studies do not provide sufficient evidence that work-related exposures to power-frequency electric and magnetic fields increases the risk of leukemia or brain cancer. However, there is sufficient evidence to warrant more detailed and finely focused research on this question.

Brain and Central Nervous System Tumor-The association between brain and central nervous system tumors and ELF field exposure related to occupation has been examined in a number of studies, some of which are general cancer studies. Brain cancer in adults is rare (1 percent of all cancer incidence; 5 in 100,000 risk), peaking at about 60 years of age. In comparison, brain cancer is the second highest risk cancer for children between O to 8 years of age.

The small number of occurrences of brain cancers in adults poses a data problem in establishing causal association. Also, the brain is a favored site for metastasis.[82] Therefore, cases counted as Primary brain cancer may actually be secondaries spreading from a different organ where the cancer actually initiated.

In addition to the data problem mentioned above, the studies used occupational classification-based data to estimate exposure. Data are classified by job titles or general occupation codes, such as "electrical occupations. " The problem arises when a general occupation code includes workers who are no more exposed to ELF fields than the average individual. For example, in some cases "electrical occupations " include electrical and telecommunications engineers. Even electricians often work with circuits turned off so that their exposures may not be significantly higher than those not in the electrical field.

Major Programs and Funding Levels for Health Effects Research

Over the years, funding for research on the effects of power frequency fields has fluctuated. Current levels of support are only modest. Over the past decade, the Department of Energy (DOE) has been the chief source of Federal funding. DOE's fiscal year 1988 budget for ELF research was $2.2 million, a substantial decrease from a high of $4.7 million in fiscal year 1985. The proposed budget for fiscal year 1989 is higher at $3.0 million.[83] The Bonneville Power Authority (BPA), a Federal power marketing agency, also has supported research. In the past decade, BPA has provided about $200,000 per year, primarily for environmental and livestock studies. A history of the research funding provided by the six largest programs is shown in figure 7-5.

The U.S. Navy played an important and early role in research on the effects of exposure to ELF electric and magnetic fields. In 1968, the Navy proposed to build an ELF submarine communications facility in northern Wisconsin that would have covered many thousands of square miles. In response to concerns raised by people in Wisconsin and to comply with the recently enacted National Environmental Policy Act, the Navy launched a large laboratory research program that examined the effects of ELF exposures on many animal and plant species.[84] Between 1969 and 1977, the Navy funded about 8 million dollars' worth of research. It now has two operating ELF transmitting facilities, one in Wisconsin and one in Michigan. The Navy has continued to sponsor ecological field studies in the vicinity of these transmitters. Navy funding for this program is currently about $2 million per year.[85]

At one time, several laboratories of the Environmental Protection Agency (EPA) had small research programs involved in both exposure and effects-related studies. Because of recent budgetary pressures, EPA's work on ELF fields has essentially stopped.[86]

82 Metastasis refers to secondary growth of cancer that spreads from a primary site.

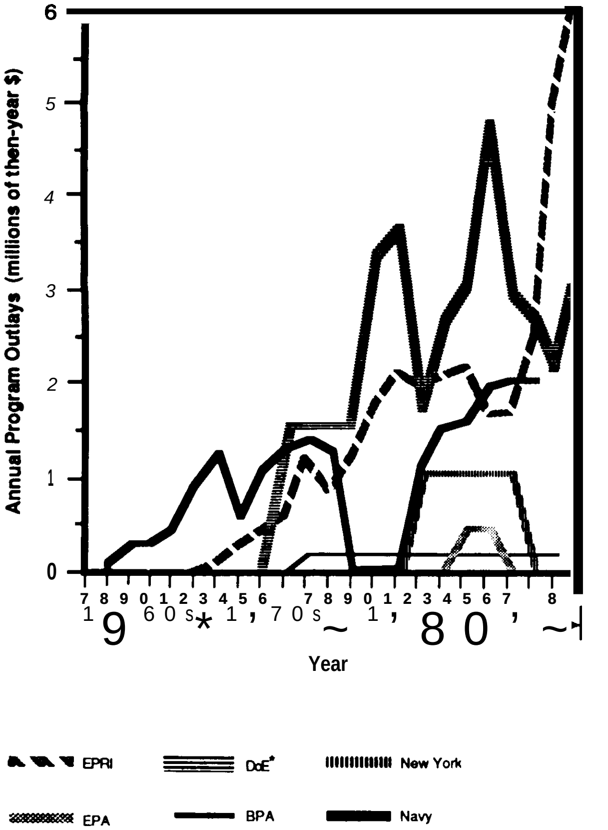
83 I. Gyuk, U.S. Department of Energy, Washington, DC, personal communication, Nov. 22, 1988.

84 T.C. Rozzell, "Biological Research for Extremely Low Frequency Communications Systems," *Biologic and Clinical Effects of Low-Frequency Magnetic and Electric Fields* (Springfield, IL: Charles C. Thomas, 1974), ch. 7, pp. 91-97.

85 M.M. Abromavage, ITT Research Institute, personal communication, October 1987.

86 Bioelectromagnetics Society, "Bioclearomagnctics Funding Survey, " *Bioelectromagnetics Society Newsletter,* May/June 1986.

Figure 7-5-History of Funding for ELF Bioeffects Studies in the United States From 1986 to the Present



SOURCES: M.M. Abromavage, Engineering Advisor, IIT Research Institite, Washington, DC, personal communication, October 1987; Bioelectromagnetics Society, Bioelectromagnetics Funding Survey, *Bioelectromagnetics Society Newsletter* (68), May/June 1986; 1. Gyuk, US Department of Energy, Washington, DC, personal communication, December 1988; "DOE EMF Bioeffects Budget Set at $3 Million," Microwave *News* 8(5):8, September/October 1988; and S. Sussman, Manager, Non-Ionizing Radiation Subprogram, Environment Division, Electric Power Research Institite, Palo Alto, CA, personal communication, December 1988.

State agencies have also funded research. From 1982 to 1986, the State of New York operated a $5 million research project on field effects. The project—the New York State Power Lines Project-was administered by the New York Department of Public Health, with money provided largely by the State's electric utilities. Another useful but smaller State-funded program is the Maryland Power Plant Siting Program, which has supported database development and dosimetric studies at the Johns Hopkins Applied Physics Laboratory. In addition, the California Public Utilities Commission with assistance from the Department of Health Services (DHS) is currently reviewing and summarizing electric and magnetic fields research and related biological theories. DHS expects a report to be issued in September 1989. After the report is released and data gaps identified, DHS will launch a 3-year, $2-million electric and magnetic fields research program, which will be funded by a one-time utility tax.[87]

In addition to Federal and State Governments' support, the electric utility industry has been involved in supporting research on ELF fields effects. Utility support began as early as 1962 when the American Electric Power Company (AEP) funded two small-scale studies at Johns Hopkins University. One study focused on EHV lineworkers and the other on mice exposed to strong electric fields. AEP, several years earlier, had become the first U.S. utility to build an EHV transmission line. Several other utilities, most notably Southern California Edison, have initiated fields research programs. Together, utility sources have provided about $3 million in funding over the last decade.

The Electric Power Research Institute (EPRI), the utility industry's research arm, has spent $15 million on such research over the past decade and has increased its support annually. EPRI's 1989 budget targets about $5.5 million on electric and magnetic fields research.[88] The Institute is currently sponsoring ELF research on statistical studies of human disease patterns, measurements of actual human exposure, and laboratory studies on animals and cells.[89]

International Programs

Many nations have active fields research programs. These include Sweden, West Germany, United Kingdom, Canada, Japan, Italy, France, Finland, and Norway.

[87] Personal communication with Dr. Raymond Neutra, Chief Epidemiological Studies Section, California Department Of Health Services, Mar. 14, 1989.

[88] Dr. Robert Black, EPRI, personal communication, Nov. 30, 1988.

[89] *EPRI 1987 Annual Report*, "Technological Innovations: Window to Economic Prosperity," p. 16.

Sweden's research program has a budget of $1.9 million (11 million krona). Health officials have already embarked on a large-scale epidemiological study of people who have developed certain types of cancer and who lived within 300 meters of a 220- or 400-kV power line for at least 1 year between 1960 and 1983. Funding is provided primarily by Sweden's State Power Board and Sweden's National Institute of Occupational Health. Studies have focused on epidemiology, exposure assessment, and cancer induction and promotion.[90]

In the past decade, the United Kingdom has spent about $6 million investigating the biological effects from its high-voltage overhead transmission grid. After a decline in funding over the past few years, Britain's Central Electricity Generating Board (CEGB) now plans to double its research budget. This increase in funding was prompted by findings of the New York State Power Lines project. British scientists expect to spend about $2 million this year. The CEGB plans to measure the domestic exposure of every child who has contracted cancer in Britain in the past year or two. British research will use a range of new instrumentation that will permit precise measurement of electric and magnetic exposure and will deal with a domestic technology that differs significantly from the United States system. Where the United Kingdom differs from the United States is that far more of the local distribution system is buried instead of dangling from poles. Underground cables are twisted together in a way that tends to cancel out their fields. In addition to dose measurements, CEGB scientists will commission medical surveys from university statisticians to correlate with the measurements.[91]

The West Germans are currently funding a half-dozen projects that include animal teratology experiments, in vitro studies, and measurements of human exposure. Financial support is provided by both public and private sources.

Canadian utilities, Ontario Hydro and Hydro Quebec, have been actively involved in exposure-related research for some time and have recently begun an animal cancer study. They also have active programs in high-voltage DC field and ion effects. Japanese utilities have underwritten a number of studies of electric field dosimetry over the last few years and funded a study at Southwest Research Institute on the effects of electric fields on baboon behavior. Italy's programs are entirely utility funded and include electric field studies with chickens and rodents,

Strategies for Research

At the same time as scientific developments have prompted many to conclude that the issue of possible 60 Hz health risks should be taken seriously, there has been a marked decrease in the level of Federal funding for ELF effects research. The reductions in funding do not, however, appear to be a deliberate effort to reduce fields research but rather a byproduct of efforts to limit the level of overall Federal expenditures.

While current research is sufficient to raise serious concerns about ELF field health effects, it is not sufficient to provide satisfactory answers or to point the way to action. Without adequate research on which to base answers, the vigorous public debate on ELF health effects, and in some instances intervention and litigation, could go on for many years and have costs significantly greater than the costs of the needed research.

Beyond the issue of funding levels, several research management issues need to be examined when addressing the potential health effects of ELF fields. An overall ELF research program should include a balanced mix of cell-level, whole animal, and epidemiological studies. No one study is likely to lead to the kind of complete understanding that is necessary to make informed judgments about risk assessment and management. While epidemiological studies may be able to establish an association between health impacts and humans, cell and animal studies would have to demonstrate the mechanisms, and other features, of the effects. The identification of dose-response mechanisms is essential for the development of effective risk management strategies.

Also, there is a danger of becoming too focused on cancer promotion as a single health effect of

[90] *Technology Review,* "Power Lines and Cancer: The Evidence Is Growing," October 1987.
[91] David Fishlock, "Britain Will Double Its Budget for Research Into Electromagnetic Fields," *Energy Daily, vol. 16, No. 61,* Mar. 30, 1988, p. 3.

concern. The breadth of cell-level and animal experiments suggest that other public health effects deserve some attention.

Furthermore, little attention has been given to field exposures that result from sources other than high-voltage transmission lines. As noted earlier, fields from distribution lines, building wiring, and appliances could be primary sources of public health effects. It will be important for legislators, regulators, and others to address the issue as one of field exposure rather than as a problem of high-voltage transmission lines. Otherwise, enormous attention may be devoted to one, possibly minor, source of public exposure while ignoring other, possibly major, sources of public exposure. A systematic characterization of the entire low-frequency field environment to which people are exposed in normal modem life would be useful to this end.

Finally, little or no research has been done on exploring techniques for reducing or eliminating 60 Hz field exposures. Preliminary work conducted by Carnegie-Mellon University suggests that in many cases solutions may be possible at economically reasonable levels. For example, a low-field electric blanket might be designed by using concentric conductors in the heating elements, by using twisted pair heating elements, or by using heating fluid. A series of carefully conducted studies designed to explore the technical and economic feasibility of reducing field exposure, is needed.

ELF Exposure and Regulatory Activity

In recent years, States have experienced increasing pressure to take regulatory action to protect citizens against the possible hazards posed by power frequency fields. Major transmission line projects in New York, Montana, and Florida, for example, have encountered considerable public opposition based in part on concerns over possible health effects. In several instances citizens have carried these disputes into the courts. In response to these pressures, States have taken a number of approaches to regulate exposures to electric and magnetic fields.

By January 1989, seven States had already set limits on the intensity of electric fields around power lines. A brief summary of the existing field limits is shown in table 7-6.

Officials in Florida have adopted standards to limit the amount of both electric and magnetic fields that new power lines generate. Florida is the first State to restrict magnetic fields around transmission lines. The final maximum edge of right-of-way magnetic field strength limits for new transmission lines are 200 mG for 500-kV lines, 250 mG for double-circuit 500-kV lines, and 150 mG for 230-kV and smaller lines.[92]

Starting in July 1988, Ohio utilities applying for approval of a new transmission line must first submit calculations of electromagnetic field strength of the proposed line. Predicted field strengths must be made for the edge of the right-of-way for the line and at the fence line for substations. However, according to the Ohio Power Siting Board, not much will be done with the calculations until a national consensus is formed.[93]

To date, most of the pressures are directed toward the control of transmission lines. It is likely that similar pressures will increase for distribution lines—at least for those lines that are visible. On the other hand, pressures to control fields associated with building wiring and appliances are likely to increase more slowly.

Legislators and regulators have been dealing with known or suspected health risks from environmental agents for decades. However, data on exposure to ELF fields is even more complex and uncertain than evidence compiled for other hazards such as toxic chemicals and ionizing radiation. Because of the complexity of the interactions between power frequency fields and living cells, conventional legislative and regulatory strategies that focus on setting ‘‘safe” or “acceptable” exposure thresholds may not lead to effective results for the possible risks. The experimental evidence that finds a windowing of observable effects and the presence of effects at very low-field strengths makes reliance on conventional threshold approaches probably inappropriate and unsupportable by available scientific data.

92 ‘‘Florida Environmental Regulators Set New Electromagnetic Field Limits, ” *Electric Utility Week,* Jan, 30, 1989, pp. 1-3.

93 ‘‘For New Lines, Ohio Utilities Told to Submit Data on Field Strengths, ” *Electric Utility Week,* May 23, 1988, pp. 19-20.

Table 7-State Regulations That Limit Field Strengths on Transmission Line Rights-of-Way (RoW)

State	Field limit
Montana	1 kV/m at edge of RoW in residential areas
Minnesota	8 kV/m maximum in RoW
New Jersey	3 kV/m at edge of RoW
New York	1.6 kV/m at edge of RoW
North DakOta	9 kV/m maximum in RoW
Oregon	9 kV/m maximum in RoW
	10 kV/m maximum for 500-kV lines
	2 kV/m maximum for 500-kV lines at edge of RoW
	8 kV/m maximum for 230-kV and smaller lines in RoW
	2 kV/m maximum for 230-kV and smaller lines at edge of RoW
Florida	200 mG for 500-kV lines at edge of RoW
	250 mG for double circuit 500-kV lines at edge of RoW
	150 mG for 230-kV and smaller lines at edae of RoW

SOURCE: 1. Nair et al., Department of Engineering and Public Policy, Carnegie Mellon University, OTA contractor report, "Power-frequency Electric and Magnetic Fields: Exposure, Effects, Research, and Regulation, Jan. 16, 1989.

Three important limits need to be considered in policy choices. First and foremost, it has not been conclusively proven that ELF fields do pose a health hazard. Second, it is possible that no straightforward dose-response relationship exists between the degree of exposure and the level of harm, thus reducing the effectiveness of traditional standards approaches to risk management. Finally, there are many potential sources of ELF exposure and transmission and distribution lines may not in fact pose the greatest threats. In the future, better scientific understanding may clearly demonstrate the existence of adverse public health effects from ELF field exposure from transmission and distribution lines and suggest specific risk management strategies. But, for now, we have to operate with admittedly imperfect response strategies. Possible policy responses include the following:

- Deferring regulatory action while continuing and expanding research to resolve scientific uncertainties.
- Establishing public information programs.
- Adopting a field strength-limit approach to transmission line fields by setting an arbitrary ‘‘acceptable level of exposure even though not fully supported by scientific evidence.
- Adopting a “similarity” based approach to transmission line fields designed to make people’s exposures to transmission line fields as ‘‘similar” as possible to the exposures from all the other fields common in our daily lives.
- Adopting a “prudent avoidance” strategy by taking reasonable steps at modest costs to keep people out of fields in the siting and re-routing of transmission and distribution lines and by redesigning electrical systems to reduce fields.