NATURAL RESOURCES JOURNAL

Volume 19
Issue 1 *Symposium on Land Use*

Winter 1979

Power Plant Siting: A Literature Review

Michael S. Hamilton

Recommended Citation
Michael S. Hamilton, *Power Plant Siting: A Literature Review*, 19 Nat. Resources J. 75 (1979).
Available at: https://digitalrepository.unm.edu/nrj/vol19/iss1/5

This Article is brought to you for free and open access by the Law Journals at UNM Digital Repository. It has been accepted for inclusion in Natural Resources Journal by an authorized editor of UNM Digital Repository. For more information, please contact amywinter@unm.edu, lsloane@salud.unm.edu, sarahrk@unm.edu.

www.manaraa.com

POWER PLANT SITING: A LITERATURE REVIEW*

MICHAEL S. HAMILTON**

INTRODUCTION

Regulation of decisions concerning location of large industrial facilities such as electric power generating plants has received special statutory treatment at the state level only since the early 1970's. However, industrial zoning at the local level—with its roots in control of nuisances at common law—was endorsed by the U.S. Supreme Court as a legitimate exercise of the police power in 1926, when the Court upheld the validity of a statutory scheme of zoning districts (including zones for industrial uses) in the landmark decision of *Euclid v. Ambler Co.*[1] More recently, industrial uses have been regulated in accordance with performance standards through special review proceedings (as distinct from location within predetermined districts), and environmental controls[2] have emerged as an important dimension of development planning.

Design and location of nuclear power plants have been subject to federal controls since 1954.[3] But bulk electric power supply[4] facilities were not widely perceived as a locus of conflict between economic development and environmental quality until the early 1960's. Then controversy over siting of the proposed Storm King pumped-storage plant on the Hudson River north of New York City helped to fuel an awakening environmental awareness nationwide.[5] This raising of ecological consciousness contributed, in turn, to increased interest in land use planning and controls.

---

*Portions of the research for this article were supported by the Western Interstate Nuclear Board, the National Power Plant Team, Office of Biological Services, U.S. Fish and Wildlife Service, and the Los Alamos Scientific Laboratory. Responsibility for the content of this article is solely that of the author.

**Colorado Energy Research Institute Fellow (1978-79) and Doctoral Student, Department of Political Science, Colorado State University.

1. 272 U.S. 365 (1926).

2. *e.g.*, Clean Air Act, Pub. L. No. 95-95; 91 Stat. 712 (Aug. 1977); Federal Water Pollution Control Act, 33 U.S.C. §1251 (1975).

3. Atomic Energy Act of 1954, *as amended by* Pub. L. No. 95-217 (Supp. V 1975); 91 Stat. 1567 (27 Dec. 1977); 42 U.S.C. §2011 (1970).

4. Bulk electric power supply generally refers to extra-high voltage generation and transmission facilities but not local distribution facilities.

5. For a recent review of this continuing controversy *see* Tucker, *Environmentalism and the Leisure Class*, 255 HARPER MAGAZINE 49 (1977).

In his treatise on *American Land Planning Law,* Professor Norman Williams, Jr. has defined land use controls as "all those governmental actions which, directly or indirectly, have a substantial impact upon the use of land."[6] Statutory provisions authorizing a state agency to regulate design and location of major industrial facilties clearly fall within these parameters.[7]

State siting statutes, however imperfectly, often condition issuance of construction permits on an assessment of the compatibility of the proposed land use with surrounding uses—the so-called "nuisance criterion"—as well as on the physical, technical and economic suitability of the site for the specific use contemplated. A useful compilation of state siting statutes prepared periodically by the Southern Interstate Nuclear Board reveals that at least 23 states have enacted such controls.[8] Many others exercise control over electric utility siting decisions through public utilities commissions[9] and other administrative mechanisms.[10] While far from a "quiet revolution," such single-purpose statutes nonetheless constitute a significant development in state land use controls.

Compatability and suitability, while not unrelated, pose different questions for analysis. Evaluation of site suitability requires considerable information about physical characteristics of the site (soil stability, seismic activity, etc.) in relation to a range of economic and technical engineering parameters, including choice of generating technology, costs of fuel transportation, proximity to existing transmission facilities, and others.

Assessment of compatibility, on the other hand, involves analysis of site relationships to a larger geographic area. This analysis includes

---

6. N. WILLIAMS, 5 AMERICAN LAND PLANNING LAW §160.03 (1975).

7. For a general overview of land use and energy interfaces, *see* SENATE COMM. ON INTERIOR AND INSULAR AFFAIRS, 94th Cong., 2d Sess., LAND USE AND ENERGY: A STUDY OF INTERRELATIONSHIPS (Comm. Print 1976).

8. SOUTHERN INTERSTATE NUCLEAR BOARD, POWER PLANT SITING IN THE UNITED STATES, viii-x (1976).

9. *Id. See also* SOUTHERN INTERSTATE NUCLEAR BOARD, STATE UTILITY REGULATION: THE CHALLENGE AHEAD (1976); N. WENGERT & R. LAWRENCE, REGIONAL FACTORS IN SITING AND PLANNING ENERGY FACILITIES IN THE ELEVEN WESTERN STATES: A REPORT TO THE WESTERN INTERSTATE NUCLEAR BOARD (1976).

10. The Governor of Utah recently created a unique Interagency Task Force on Power Plant Siting comprised of local, state and federal government officials, representatives of consumers and the environmental community. This group reviews prospective power plant sites and acts in an advisory capacity to the Governor, who must implement a legislatively mandated state energy development policy. *See* UTAH CODE ANN. §§63-9-48, 49, 50 (Repl. 1978); MEETING OF THE UTAH ENERGY CONSERVATION AND DEVELOPMENT COUNCIL (16 August 1977) (typewritten, available from the Utah Energy Office).

considerations which flow not only from suitability criteria, but also from legal and political constraints (environmental controls, public attitudes toward nuclear power and toward transmission towers, for example) which vary widely between potential sites. Such considerations may, in turn, impede economic and technical choices that might otherwise be preferred by industry decision makers. Use compatibility, therefore, emerges as a significant, if not crucial, component of the overall decision on site suitability.

Siting Proceedings: A Richness of Issues

State regulation of industry siting decisions generally entails exercise of quasi-judicial functions by administrative agencies in adversary proceedings. Issues raised in review proceedings vary with choice of technologies preferred and characteristics of particular sites proposed, and frequently reveal a "weakest link" strategy on the part of project opponents—which are today almost invariably in evidence. That is, the most vulnerable aspects of a proposal are identified and challenged, regardless of their bearing on generic questions raised as central issues. For example, design features of a cooling water reservoir may be attacked as unsound, although the primary concern of project opponents is population growth attending construction and operation of a large facility in a rural area.

A seminal work identifying some of the public interest considerations affecting power plant site selection was produced in 1968 under the leadership of S. David Freeman, then Director of Energy Policy Staff in the President's Office of Science and Technology.[11] Since then, the literature on power plant siting has slowly accumulated from diverse sources.[12]

A selection of concerns which are frequently raised in siting proceedings may be readily identified. Competition for water supplies between electric utilities and other industrial, municipal and agricultural users is complicated by instream flow needs for fish and wildlife, for recreational uses and for nonpoint source pollution dilution. This competition is often intense, especially in the semiarid Western states.

Fish entrainment in water intakes, wildlife habitat losses due to long-term commitment of previously undeveloped or agricultural

11. ENERGY POLICY STAFF, U.S. OFFICE OF SCIENCE AND TECHNOLOGY, CONSIDERATIONS AFFECTING STEAM POWER PLANT SITE SELECTION (1968).

12. For an annotated guide to this literature, *see* M. HAMILTON, POWER PLANT SITING (WITH SPECIAL EMPHASIS ON WESTERN STATES), COUNCIL OF PLANNING LIBRARIANS EXCHANGE BIBLIOGRAPHY NO. 1359-60 (1977). A supplement focusing on Eastern states is forthcoming in fall, 1978.

land to industrial uses, and impairment of scenic values by physical plant structures or air pollutant emissions are recurring concerns. Thermal pollution of lakes and rivers, possible weather modification occasioned by use of large-scale evaporative cooling towers or ponds, and fears about unknown health effects of extra-high voltage transmission lines are also raised in siting proceedings by project opponents.

Unresolved—and perhaps unresolvable—questions about radioactive waste disposal and reactor operating safety are now standard fare in nuclear plant licensing hearings. Legitimate concerns about unknown cumulative and synergistic effects of air pollutants emitted by multiple industrial plants in the same airshed remain largely unanswered. Tensions flowing from philosophical differences between managers of investor-owned and publicly-owned utilities, while more often aired in rate setting hearings and antitrust proceedings, may impact siting decisions and are sometimes discussed in this context.[13]

Recently there has been a sharp increase in concern for impacts of rapid growth or rural industrialization attending current patterns of dispersed plant siting in areas remote from large population centers.[14] Widespread utilization of agricultural or "open" zones as a catch-all for industrial uses considered undesirable in urban and suburban areas is increasingly receiving criticism as a practice which forces certain environmental and aesthetic costs and lifestyle changes on a dispersed, numerically inferior population which may be ill-equipped to defend itself from such impositions.

The foregoing is by no means an exhaustive list of issues raised in siting proceedings, but it is illustrative of the richness of subject matter bearing on siting decisions. The literature is broad in coverage, yet it varies substantially in depth. It is multi-disciplinary in nature, drawing an eclectic selection of material from the fields of power systems engineering, biological and environmental sciences, law, economics, geography, and political science—to name but a few.

Various facets of this literature have been reviewed elsewhere and will not be treated extensively here. A truly comprehensive view is

13. M. Hamilton, Intergroup Conflict and Coordination of Planning and Operations in the Electric Power Industry of the Western United States (October, 1977) (unpublished professional paper prepared for the Department of Political Science, Colorado State University).

14. For a selection of references, *see* R. LITTLE & S. LOVEJOY, WESTERN ENERGY DEVELOPMENT AS A TYPE OF RURAL INDUSTRIALIZATION: A PARTIALLY ANNOTATED BIBLIOGRAPHY, COUNCIL OF PLANNING LIBRARIANS EXCHANGE BIBLIOGRAPHY NO. 1298 (1977).

not yet in evidence and is certainly byond the scope of this article. Materials reviewed here have been selected so as to characterize the literature, and it is hoped that omissions (which will no doubt become apparent to those familiar with this issue area) may be ameliorated by recourse to footnoted resources.

ELECTRIC UTILITY PLANNING AND OPERATIONS

The influence of technological change on the electric utility industry in the United States has been pervasive since central station power generation first became commercially feasible in 1882. Increases in generator and transmission capacity gradually moved electric supply beyond the neighborhood level where it began, eventually making possible operation of multi-state networks of bulk power facilities.

Today these facilities are extensively interconnected[15] in three large networks which blanket much of the North American continent. Ownership of generation, transmission and distribution facilities in these networks is divided between investor-owned firms, municipalities, state and federal agencies, and rural electric cooperatives. Investor-owned utilities, most of which are vertically integrated,[16] control nearly 80 percent of total industry generating capacity and more than 90 percent of its thermal generating capacity.[17]

Interconnection and Interdependence

Utility companies plan and operate their facilities singly or in groups known as "power pools."[18] Because the large networks are

15. An interconnection or intertie is a transmission line joining two or more power systems through which power produced by one can be used by the other. 1 FEDERAL POWER COMMISSION, NATIONAL POWER SURVEY 290 (1964).

16. "Vertically integrated" refers to those firms which provide generating, transmitting and distributing services as a single entity or through separate firms controlled by the same holding company. S. BREYER & P. MacAVOY, ENERGY REGULATION BY THE FEDERAL POWER COMMISSION 90 (1974) (hereinafter cited as BREYER & MacAVOY).

17. HUGHES, *Scale Frontiers in Electric Power,* TECHNOLOGICAL CHANGE IN REGULATED INDUSTRIES 44, 53 (W. Capron ed. 1971).

18. A power pool is comprised of two or more electric systems which are interconnected and coordinated to a greater or lesser degree to supply, in the most economical manner, electric power for their combined loads. SUBCOMM. OF THE SENATE COMM. ON INTERIOR AND INSULAR AFFAIRS, 94TH CONG., 2d SESS., NATIONAL POWER GRID SYSTEM STUDY–AN OVERVIEW OF ECONOMICS, REGULATORY, AND ENGINEERING ASPECTS 223 (Comm. Print 1976) (hereinafter cited as NATIONAL GRID STUDY).

organized on a multi-system[19] basis, with each utility comtrolling only a part of the network with which it is interconnected, a high degree of coordination in design of facilities and in operating procedures is needed if such networks are to function at all.[20] Continuous delivery of electric service at the lowest possible cost to the consumer is a complex task requiring minute-to-minute interchanges of electric power between facilities within a system. Firms in a given geographical area are therefore highly interdependent in both the technical and economic aspects of their operations.

Interconnections in Public Policy

Created in 1920 to license hydroelectric developments on interstate streams,[21] Federal Power Commission (FPC—now Federal Energy Regulatory Commission—FERC) jurisdiction was extrended over wholesale sales of electricity in interstate commerce by the Public Utilities Holding Company Act of 1935.[22] The same Act triggered 20 years of "trustbusting" by the Securities Exchange Commission. These antitrust actions were directed only towards what were known as unconscionable business practices, however, and the legitimacy of interconnections was recognized in provisions of the 1935 Act which authorized the FPC to "promote and encourage . . . interconnection and coordination"[23] of electric systems. Subsequently, interconnection agreements continued to be made on the initiative of adjacent power companies, and precursors of contemporary power pools were formed. But efforts of the FPC under this provision prior to 1960 were not impressive.[24]

Coordination

The so-called "coordination problem" has received considerable attention in the literature of public utility regulation since publication by the FPC of a *National Power Survey* in 1964.[25] In this study, the FPC made an ambitious attempt to estimate the need for

19. As used here the term "system" refers to physically connected generation, transmission, distribution and other facilities operated as an integral unit under one control, management or operating supervision. *Id.* at 225.

20. HUGHES, *supra* note 17, at 46-47. *See also,* BREYER & MacAVOY, *supra* note 16, or BREYER & MacAVOY, *The Federal Power Commission and the Coordination Problem in the Electric Power Industry,* 46 S. CAL. L. REV. 661 (1973).

21. 16 U.S.C. §797(e) (1976).

22. 15 U.S.C. §79 (1971).

23. 16 U.S.C. §824a (1974).

24. BREYER & MacAVOY, REGULATION BY THE FPC, *supra* note 16, at 89.

25. NATIONAL POWER SURVEY, *supra* note 15, 3 vols.

increased coordination in the industry, and concluded that closer coordination of planning and operations than then existed was desirable to reduce power production costs to the nation.

Public/Private Ownership

A seminal article by Richard Wirtz in 1969[26] explored tensions between publicly and privately-owned utilities in industry coordination efforts. Proceedings before the FPC under section 202(b) of the Federal Power Act,[27] in which municipal utilities sought to interconnect their facilities with unwilling investor-owned utilities, were analyzed and the value of such interconnections briefly delineated.

Size of Planning Units

Studies done by Stephen Breyer and Paul MacAvoy[28] for the Brookings Institution in the early 1970's provided a critical appraisal of FPC interconnection efforts, while confirming the general conclusions of the 1964 Survey. Breyer and MacAvoy argued with some eloquence that coordination over a wide geographic area: may minimize operating costs and capital expenditures for plant construction; may enhance system stability and recovery capabilities during emergency operating conditions; and may provide opportunities for reducing total construction and enabling the siting of facilities so as to produce the required amount of power with minimum adverse environmental impact.[29] Their work suggests that the number, cost and location of bulk power facilities needed may be influenced significantly by the actual degree of coordination evident in industry planning and operations.

The Brookings studies, as well as the 1964 FPC Survey, were based on an analysis of industry ability to approximate some hypothetical optimum of economic efficiency, emphasizing realization of perceived economies of scale through utilization of largest available generation and transmission technology by individual and group planning units (power pools) as a measure of industry coordination. FPC ineffectiveness was gauged largely by lack of success in stimulating formation of larger planning units.

Breyer and MacAvoy provide an essential overview of electric

26. Wirtz, *Electric-Utility Interconnections: Power to the People,* 21 STAN. L. REV. 1714 (1969).

27. 16 U.S.C. §824a(a) (1974). This provision authorized the FPC to order interconnections on an emergency basis and under stipulated circumstances.

28. BREYER & MacAVOY, REGULATION BY THE FPC, *supra* note 16.

29. *Id.* at 90-93.

power industry development planning and daily operations., and highlight two important historical trends within the industry. These are first, a tendency toward corporate consolidation, which has stimulated much antitrust activity; and second, a proclivity for rapid introduction and utilization of ever larger generation and transmission technology.

True to the bulk of the literature, however, they do not attempt to address trade-offs between economic criteria and considerations affecting environmental quality or continuity of electric service to the consumer—considerations which certainly impact management decision making in selection of sites for new facilities. While generator size may be significant in selection of a rural site over an urban site, this possibility is not adequately explored.

Further, a focus of investor-owned utilities (due to the large percentage of total generating capacity under private control), while convenient for purposes of scale-related economic analysis, seems too narrow. It effectively precludes analysis of significant interactions between publicly and privately-owned electric firms which may frustrate coordination efforts, and it ignores the important role of some federal power agencies in developing interconnections and power pooling efforts.

Federal Power Agencies

In the early 1950's, for instance, bulk power producers in the Western states were organized in four non-interconnected power pool areas. Bureau of Reclamation hydroelectric facilities in one area were operated independently of those in other areas but were interconnected with most non-federal firms in each. Construction of transmission interties (with Congressional authorization) between Bureau facilities in these areas from the mid-1950's to late 1960's effectively interconnected, directly or indirectly, nearly all the bulk electric power facilities in the Western United States.

Planning and operation of an interconnected generation and transmission network of this size had never been undertaken before, and it posed a number of technical problems which could not be dealt with without close inter-firm coordination. Power system engineers in the Bureau played an important leadership role in developing such coordination efforts, consolidating their position in the electric power industry in the process.[30] Yet, evaluation of this influence

30. Whether these activities reflect a response to the Eisenhower "partnership" policies of licensed private hydroelectric development at federal dams (and curtailed federal expenditures for this purpose), or a realization that agency longevity in an era of reduced demand for irrigation projects might be dependent upon development of an alternative mission remains an open question.

remains an unsung story of our time,[31] although the efficacy of such a public role within the industry should be of as much interest to policy makers as FPC ineffectiveness in achieving the same ends.

Northeast Power Failure, 1965

The desirability of increased interdependence which accompanies coordination was dramatically put in question by the Northeast power failure of November 9 and 10, 1965, which left several million people in eight states and parts of Canada without electricity for up to 13 hours.[32] Stunned by such a massive disruption of electric service, consumers across the nation clamored for reassurance, only to be told that it could happen anywhere. Bolstered by the occurrence of this massive blackout—which seemed to confirm their assessment of industry planning and operations—the FPC began some prodigious sword-rattling, which continued for several years. After preliminary investigation into causes of the blackout, the FPC called for "acceleration of the present trend toward . . . stronger interconnections between systems."[33]

Reliability

One response by utility managers to this FPC action was to increase the public visibility of industry concern for electric service "reliability" as a principal objective of power systems planning and operations. A precise definition of "reliability" (if indeed one does exist), is virtually impossible to find in the literature of power system engineering or public utility regulation. It appears to be one of those words everyone uses but no one carefully defines. Definitions of the term, when offered, are generally equivocal and not comparable from source to source.

In common usage, "reliability" clearly concerns maintenance of electric system operating stability so as to avoid prolonged interruption of service to consumers. Yet momentary interruptions are commonplace, though they may go unnoticed by most consumers. The most common method for assessing system reliability is the so-called "loss-of-load probability" method, where the probability of loss of generating capacity due to simultaneous outage of facilities is superimposed on the probability of coincidence of this loss of capacity with heavy electricity demands. The generally accepted

31. *But see,* FOOTE, LARSEN & MADDOX, *Bonneville Power Administration: Northwest Power Broker,* 6 Envt'l Law 831 (1976).

32. FEDERAL POWER COMMISSION, NORTHEAST POWER FAILURE, NOVEMBER 9 AND 10, 1965, at 1-17, 43-45 (1965).

33. *Id.* at 43.

index of "one day in ten years" during which time a utility may not be able to meet expected demand with available capacity similarly "is not based on any full scale study of reliability requirements and customer acceptance, but has more or less come to be accepted as a convenient measure."[34] Further, this index is by no means universally accepted, and interconnected firms may use different indices in adjacent service areas.

Regional Coordinating Councils

Formation of regional and national coordinating organizations were priority actions, recommended in 1967 by the FPC in an important follow-up study, *Prevention of Power Failures,*[35] which focused on industry planning and operations affecting continuity of electric service. Information and recommendations contained in this study formed a basis for controversial legislation requested by the FPC which would have authorized that agency:[36] to establish regional planning entities; to establish minimum reliability standards; to review construction plans for extra-high-voltage transmission lines; and to require interconnections between bulk power suppliers. All told, fifteen similar or identical "reliability" bills were introduced in the 90th Congress, though none were enacted.

The industry responded by setting up its own regional coordinating councils,[37] which now number nine nation-wide. One, the Western Systems Coordinating Council (WSCC), is comprised of utilities serving a single interconnected network in the eleven contiguous Western states and parts of Nebraska, South Dakota, Texas and British Columbia, Canada, with combined generating capacity of approximately 90,000 megawatts.[38] Firms in the Electric Reliability Council of Texas (ERCOT) serve a second network with total generating capacity of nearly 34,400 megawatts, maintaining no

34. N. SAVAGE & L. WOFSY, cited in NATIONAL GRID STUDY, *supra* note 18, at 102, n. 17.

35. FEDERAL POWER COMMISSION, PREVENTION OF POWER FAILURES, 3 vols. (1967).

36. *See* Electric Power Reliability Act of 1967, S. 1934, H.R. 10727 and others, 90th Cong., 1st sess. (1967); H.R. 10729, 90th Cong., 1st sess. (1967).

37. These are sometimes called "regional reliability councils."

38. WESTERN SYSTEMS COORDINATING COUNCIL, WESTERN SYSTEMS COORDINATING COUNCIL TEN-YEAR COORDINATED PLAN SUMMARY: 1976-1985 1 (1976), and NATIONAL ELECTRIC RELIABILITY COUNCIL, 7TH ANNUAL REVIEW OF OVERALL RELIABILITY AND ADEQUACY OF THE NORTH AMERICAN BULK POWER SYSTEMS, App. A3 (1977) (hereinafter cited as NERC, 7TH ANNUAL REVIEW).

interstate interconnections.[39] A third network includes utilities in seven other coordinating councils covering the remainder of the coterminous United States and parts of Canada, with combined generating capacity of approximately 370,000 megawatts.[40] Substantial interconnections are maintained between firms in these seven councils. But the WSCC and ERCOT networks remain virtually isolated from the rest of the nation, with no major interregional interconnections planned.

An umbrella organization, the National Electric Reliability Council (NERC) was created in 1968. While the actual wording of their statements of purpose varies somewhat, it may be fairly stated that the regional organizations share a common purpose with NERC in being established "to augment the reliability and adequacy of the bulk power supply and transmission network of the electric utility industry in North America."[41]

These regional councils annually prepare an update of member construction plans for the next ten years, which is submitted to the FPC.[42] Annual reports of regional councils are published by NERC along with its own and that of the North American Power Systems Interconnection Committee (NAPSIC).[43] NERC also publishes annually an assessment of fossil and nuclear fuel available for electric power generation,[44] and a review of "reliability and adequacy" of bulk power supply systems in North America.[45]

Literature on the role of these regional and national organizations—other than what they publish themselves—is sketchy at best. No in-depth study of the ways in which these organizations may actually influence industry planning has yet been done. Further, outside the Federal Energy Regulatory Commission, a few Congressional committees and the industry itself, there appears to be little recogni-

39. NERC, 7TH ANNUAL REVIEW, *supra* note 38, at App. A3. Whether ERCOT utilities would be able to continue operating in isolation from utilities with interstate interconnections, presumably in avoidance of federal regulatory jurisdiction, was the subject of proceedings pending before the Federal Power Commission, Securities Exchange Commission and Nuclear Regulatory Commission in June, 1977. *PUC Orders Restoration of Interstate Power Grid,* ELECTRICAL WORLD, June 1, 1977, at 28.

40. NERC, 7TH ANNUAL REVIEW, *supra* note 38, App. A3.

41. NATIONAL ELECTRIC RELIABILITY COUNCIL, 1976 ANNUAL REPORT 2 (1977).

42. Pursuant to 18 C.F.R. § § 211, 410(a)-(b) (1972).

43. *See* NERC, 1976 ANNUAL REPORT, *supra* note 41.

44. *See* NATIONAL ELECTRIC RELIABILITY COUNCIL, FOSSIL AND NUCLEAR FUEL FOR ELECTRIC UTILITY GENERATION: REQUIREMENTS AND CONSTRAINTS, 1977-1986 (1977).

45. *See* NERC, 7TH ANNUAL REVIEW, *supra* note 38.

tion that such organizations exist. Their publications are not widely cited and recent interviews with state agency personnel concerned with electric utility planning reveal a lack of familiarity with these organizations, their role in the industry and their publications.

Increasing Scale of Technology

It has been suggested that interconnections may be expected to continue to develop until a single national grid evolves.[46] This assertion presumes a continuation of historical trends toward introduction of ever larger power supply technology and improvement of coordination efforts. Yet precious little scrutiny of policy choices implicit in continued institutional and technological centralization of electric power supply is evident in literature today.

Transition to a decentralized energy supply infrastructure, based on renewable energy resources such as solar power, has recently received much media attention.[47] But the difficulties, trade-offs, and implications for siting decisions inherent in reversing a longstanding trend to the contrary have not yet been discussed in the literature.[48] Although a dialogue is emerging in the news media and before the Congress,[49] much analytical work remains to be done in this area.

Whether continued centralization in electric supply will reflect planning efforts undertaken to best serve the broader public interest or narrower individual interests of the many firms involved, has recently been sharply questioned. Executives of some engineering firms and electric utilities view current industry planning as limited in scope by the needs of particular utilities and fraught with intercompany in-fighting which may frustrate coordination efforts. They suggest that existing practices may be inadequate to accommodate the planning needs of the future, when construction of huge "energy centers" is contemplated.[50]

Energy Centers

Only in recent years has it become technically feasible to build generating plants of 1000 to 5000 megawatts capacity. A new plant

46. NATIONAL GRID STUDY, *supra* note 18, at vi; Nagel, *The National Grid–A Misconception*, 89 PUB. UTIL. FORT. 31 (1972).

47. *See especially*, A. B. LOVINS, SOFT ENERGY PATHS: TOWARD A DURABLE PEACE (1977).

48. For a "first cut" in this area, *see* Hamilton, *Bulk Power Supply Reliability and Proposals for a National Grid: Signposts Pointing Toward What Destination?* 7 POL'Y STUD' J. 96 (1978).

49. ALTERNATIVE LONG RANGE ENERGY STRATEGIES: JOINT HEARINGS BEFORE THE SENATE SELECT COMM. ON SMALL BUSINESS AND THE SENATE COMM. ON INTERIOR AND INSULAR AFFAIRS, 94th Cong., 2d Sess. 94-47 (1977).

50. NATIONAL GRID STUDY, *supra* note 18, at 287-90, 302-03.

of 1,000 megawatts may generate more power than the total used in some of the less populated Western states. It is assumed in the power engineering literature that economies of scale justify increasingly larger plants and may justify energy parks of 10,000 to 20,000 megawatts capacity in the foreseeable future.[51]

Recent growth of a small body of literature—most of it prepared by consultants to federal agencies and national laboratories—concerning colocation of multiple generating units at a single site was stimulated by Section 207 of the Energy Reorganization Act of 1974,[52] which authorized the Nuclear Regulatory Commission (NRC) to perform a national study of "nuclear energy centers" (NEC's).[53] This NRC study, *Nuclear Energy Center Site Survey—1975*,[54] reviewed earlier work and examined the technical feasibility of this concept. While making no recommendations as to specific sites, this effort produced a nationwide "coarse screening" of potential locations for NEC's, and recommended additional study by other federal agencies in cooperation with various state, regional and industrial organizations.

The most recent of these studies, entitled *Preliminary Assessment of Nuclear Energy Centers and Energy Systems Complexes in the Western U.S.*,[55] was prepared by the Western Interstate Energy Board/WINB for Oak Ridge National Laboratory. It briefly reviewed previous studies and systematically examined the eleven contiguous Western states in ten-mile by ten-mile grid cells for potential NEC sites of 6,000, 12,000, and 18,000 megawatts generating capacity. Each cell was evaluated in terms of composite suitability[56] and site-related costs.[57] Zones of highest suitability were identified and displayed on computer-generated maps. Characteristics of selected cells within these zones and eight additional sites nominated by WSCC utilities were described in greater detail. Four of the latter sites

51. *See* Jopling, *Large Capacity Plant Sites: Problems and Opportunities*, 80 POWER ENGINEERING 36 (1976).

52. Act of October 11, 1974, 42 U.S.C. §5847 (1976).

53. NEC's may also include industrial consumers of waste heat or electric power, or nuclear fuel reprocessing and high-level radioactive waste disposal facilities.

54. U.S. NUCLEAR REGULATORY COMMISSION, NUCLEAR ENERGY CENTER SITE SURVEY—1975 (1976).

55. WESTERN INTERSTATE ENERGY BOARD/WINB, PRELIMINARY ASSESSMENT OF NUCLEAR ENERGY CENTERS AND ENERGY SYSTEMS COMPLEXES IN THE WESTERN U.S. (1978).

56. Composite suitability was determined on the basis of a numerical sum of ten weighted factors: protected and restricted lands, population density, airports and corridors, seismic design, electric transmission requirements and cost, cooling system, land form, major transportation access, coal development and thermal application.

57. Site-related costs consisted of additional expenditures required for seismic hardening, long-distance transmission lines and wet/dry cooling systems, where required.

(Hanford, Washington; Boardman, Oregon; Green River, Utah; and Tularosa, New Mexico) fell in zones of highest suitability and were ranked in the top ten percentile overall.

A draft version of this report was recently circulated in the Western states to identify interest in further investigation of eligible sites. Arizona, New Mexico and Utah have expressed such interest.

It is evident that investigations incident to initial planning and decision making phases of site selection for NEC's are being carried out under government auspices, yet the professional literature has been slow to respond with independent critical analysis of the NEC concept.[58] The possibility that recent efforts could evolve into one of the largest public works programs ever devised by man remains virtually unscrutinized.

Regional Perspective

Facilities of such tremendous capacity will create major difficulties in system planning and operation, as well as in provision of government services, and they can only be considered in relation to large service areas which may include parts of several states. Today, few factors in the development of electric power are limited to the boundaries of one state. The basic energy resources—coal, oil, gas, uranium—often originate or must be processed in states other than those in which the electricity generated by their use is consumed. Water for hydropower and steam plant cooling invariably involves interstate,[59] and often international[60] interests. A utility may find it necessary to secure financing and engineering design services in states other than those in which new facilities are constructed, and may contract with construction firms, equipment and material suppliers, and draw on labor pools located in other states.

In spite of obvious multi-state dimensions of bulk power supply and the existence of regional organizations within the electric power industry, there is a conspicuous lack of regional perspective in the literature. Two isolated, yet notable recent exceptions to this statement are evident.

58. A single notable exception is: Bhumralkar & Alich, *Meteorological Effects of Waste Heat Rejection from Power Parks,* 80 POWER ENGINEERING 54 (1976).

59. As exemplified by Upper Colorado River Basin Compact, April 6, 1949, 63 Stat. 31.

60. *See, e.g.,* the Treaty with Mexico on the Colorado River, Feb. 3, 1944, 59 Stat. §1219 (1944) (effective Nov. 8, 1945), concerning the obligation of the U.S. to deliver a certain quantity of water; Treaty with Canada Relations to Cooperative Development of the Water Resources of the Columbia River Basin, Jan. 17, 1961 (1964) 15 U.S.T. 1556, T.I.A.S. No. 5638, obligation of the U.S. to build hydroelectric facilities and market the Canadian share of additional power generated as a result of construction of Canadian water projects.

First, in 1975, Peter Meier (Brookhaven National Laboratory) argued persuasively for recognition of a series of siting issues that may be most appropriately addressed at the multi-state level.[61] Meier maintained that complex interactions between energy policy options preclude a simplistic isolation of siting issues from other energy issues of regional concern.[62] He argued further that, absent articulation of a regional perspective, important policy decisions will be made at inappropriate levels of government, without giving adequate consideration to the interests of the region as a whole.

Meier's conclusions receive some support from a report completed in 1976 at Colorado State University by Professors Norman Wengert and Robert Lawrence.[63] This study surveyed and characterized state siting practices, industry planning and operations, and regional factors affecting siting decisions in the eleven Western states.

Citing the parochial nature of most public utility commission and state siting statutes, Wengert and Lawrence found that, in general, "regional factors are given little weight in actual government decisions, and few institutional or procedural arrangements exist for systematic consideration of regional dimensions of electric facility siting."[64] It seems that citizens, and policy makers in state legislatures, executive departments and regulatory agencies, are poorly informed about how any particular generating facility relates to the interconnected system.

State Siting Controls

Government regulation of power plant siting decisions was the subject of considerable attention in legal periodicals in the period 1970-1973. Environmental issues were at the forefront of national consciousness following enactment of the National Environmental Policy Act of 1969,[65] extensive media coverage of Earth Day, 1970; and during Congressional consideration of strengthening amendments to federal air and water pollution control legislation[66] and con-

61. P. MEIER, ENERGY FACILITY LOCATION: A REGIONAL VIEWPOINT (1975). NTIS No. BNL-20435.

62. These include water supply, capital availability, public or private ownership, generation of power in one state for consumption in another, proximity of nuclear reactors to population centers, and atmospheric dispersion of air pollutant emissions.

63. Wengert & Lawrence, *supra* note 9.

64. *Id.* at I-4.

65. National Environmental Policy Act of 1969, 42 U.S.C. §4321-4347 (Supp. V 1975).

66. Clean Air Act, 42 U.S.C. §7401-7642 (Supp. 1978); Federal Water Pollution Control Act, 33 U.S.C. §1251-1376 (Supp. 1978).

troversy over construction of the Calvert Cliffs nuclear plant on Chesapeake Bay.[67]

Recurring "brownouts" (electric shortages) in several parts of the nation during the summer of 1970 recalled memories of the 1965 Northeast blackout and helped stimulate renewed interest in federal "reliability" and siting legislation. Hearings were held during the 92d Congress on numerous competing proposals for an expanded federal siting authority, none of which were enacted.[68] Perhaps cognizant of lengthy delays in construction of the Calvert Cliffs plant, and fearful of a further extension of federal authority over electric utility decisions, many state legislatures in this period enacted siting controls ostensibly designed to expedite the siting process.

Of the many excellent law review articles published on power plant siting[69] in this period, a lengthy review of the legal framework for siting decisions by Mason Willrich[70] stands out as a cornerstone of the literature. Using the state of Virginia as a model, Willrich developed a picture of the siting approval process prior to creation of a state-level siting authority; considered alternative policy goals for power supply, environmental protection and land use; determined appropriate roles and relationships between participants in siting decisions; and developed a model procedure for state regulation of site selection.

Absent consolidation of state environmental and resource agencies, Willrich argued the merits of an independent siting commission, conceived as an initial step toward a comprehensive state role in land use planning. Arguing with much insight for separation of powers between agencies—to avoid biasing site approvals in terms of a single agency mission—Willrich would leave certification of "need" for new generating and transmission capacity to the state public utilities commission, and he would leave determination of environmental controls to state environmental protection agencies. The siting commission would have primary responsibility for applying specified land use criteria to proposed sites, and, if politically feasible, jurisdiction

67. For authoritative treatment of this siting controversy, *see* Bronstein, *The AEC Decision-Making Process and the Environment: a Case Study of the Calvert Cliffs Nuclear Power Plant,* 1 ECOLOGY L.Q. 689 (1971); Bronstein, *State Regulation of Power Plant Siting,* 3 ENVT'L LAW 273 (1973); *Calvert Cliffs Court Decision: Hearing before the Comm. on Interior and Insular Affairs,* 92d Cong., 1st Sess., ser. 92-14 (2 parts) (1971).

68. *See Powerplant Siting and Environmental Protection, Hearings before a Subcomm. of the House Comm. on Interstate and Foreign Commerce,* 92d Cong., 1st Sess., sers. 92-31, 92-32, 92-33 (1971).

69. For a bibliography of this literature, *see* HAMILTON, *supra* note 12, at 27.

70. Willrich, *Energy-Environment Conflict: Siting Electric Power Facilities,* 58 VA. L. REV. 257 (1972).

over major commercial developments and industrial, transportation and government facilities.

As is the case with the bulk of this literature, Willrich seems to accept electric utility industry figures on the financial cost of construction delays as conclusive evidence that the site approval process should be expedited.[71] But the assumption that such delays are necessarily detrimental (even though costly) has not been tested against the possibility that such an extended amount of time may be desirable to ensure adequate scrutiny of the siting proposal. Many proposals have been modified during siting proceedings, but nowhere is there evidence of research which might show whether or not better decisions have been made as a result of time devoted to more careful review of utility plans.

Another proposal, advanced in 1974 by a Special Committee on Environmental Law of the American Bar Association, urged creation of a single state agency with power to preempt decision making authority of other state and local government entities and jurisdiction over all major industrial facilities, in the context of comprehensive statewide land use planning.[72] Creation of an independent federal agency to consolidate and review federal siting decisions, and joint state-federal environmental evaluations were also recommended by the committee.

Political opposition to state land use controls seems not to have been recognized at this time. There also appears to be no recognition of the practical difficulties of some sparsely populated states in staffing and maintaining such an agency—one which might process only one or two applications over several years.

Coastal Zone Siting

An important contribution which integrates various aspects of environmental law, land use planning, coastal zone management and industrial facilities siting in a coherent text is provided by Michael Baram in his *Environmental Law and the Siting of Facilities.*[73] His discussion of provisions in the Coastal Zone Management Act of 1972 (CZMA) dealing with "national interests" in siting of facilities "necessary to meet requirements which are other than local in nature,"[74] constitutes an alternative approach to combating

71. *Id.* at 270-72.

72. SPECIAL COMMITTEE ON ENVIRONMENTAL LAW, AMERICAN BAR ASSOCIATION, DEVELOPMENT AND THE ENVIRONMENT: LEGAL REFORMS TO FACILITATE INDUSTRIAL SITE SELECTION, 2 (1974).

73. M. BARAM, ENVIRONMENTAL LAW AND THE SITING OF FACILITIES (1976).

74. Coastal Zone Management Act of 1972, 16 U.S.C. §1455(c)(8) (1978).

parochial decision making from that proposed by the ABA, and is particularly lucid.

State administration of federally mandated, funded and approved regulatory programs has developed as a new intergovernmental relations mechanism to be used under federal air and water pollution control statutes, and now under this federal program for state land use planning in a designated coastal zone. Whether such a mechanism could be developed for state-wide land use planning via federal standards and planning assistance for energy facility siting in inland areas remains to be seen, but it is certainly not outside the realm of possibility.

OTHER PERTINENT LITERATURE

Location Analysis

The literature of mathematical location modeling[75] expanded rapidly in the 1960's and found application by Bruce Smith in analysis of investor-owned, coal-fired generating plant sites in 1973.[76] Using a least-cost approach to location analysis, Smith tested and verified the hypothesis that power plants in the Eastern United States were sited relative to fuel sources and service areas so as to minimize total transportation costs. However, the model used did not facilitate analysis of system "reliability" considerations, and insufficient data was obtained to evaluate the role of environmental variables in location decisions. It appears that a more complex model than that used in this study is required for a comprehensive analysis of siting decisions.

Investment Analysis

A more insightful article—in part because the author details its limitations—is Dennis Anderson's review of models used in the bulk electric power supply industry for determining least-cost investments in plant additions.[77] Typical decision variables considered in these models include: choice of generating technology (and the optimum mix of technologies within a system); locations of existing plants (and interconnections giving access to plants owned by other firms);

75. For reviews, *see* ReVelle, Marks & Liebman, *An Analysis of Private and Public Sector Location Models*, 16 MANAGEMENT SCI. 692 (1970); Scott, *Location-Allocation Systems: A Review*, 2 GEOGRAPHICAL ANALYSIS 95 (1970).

76. Smith, *Analysis of the Location of Coal-Fired Power Plants in the Eastern United States*, 49 ECON. GEOGRAPHY 243 (1973).

77. Anderson, *Models for Determining Least-Cost Investments in Electricity Supply*, 3 BELL J. OF ECON. AND MANAGEMENT SCI. 267 (1972).

timing of investments; replacement; and optimum mode of system operation.

While a firm background in economics is required if the reader is to fully comprehend this article, it should be evident to the layman that siting decisions must be based on a sophisticated understanding of complex interactions between economic and technical factors which reach far beyond the physical characteristics of the individual facility under consideration. Significantly, Anderson notes:

> Use of one or more investment models is the first of several stages of the investment decision process. Engineering analysis of solutions follows and generally requires a revision of the solutions. The investment program finally selected must satisfy a number of engineering criteria regarding system stability, short-circuit performance, the control of watts, vars, and voltage, and the reserves and reliability of supply. The search for an investment program which satisfies engineering and economic criteria is an iterative, multi-disciplinary process.[78]

Development planning in the electric power industry must carefully consider effects of new facilities on the existing interconnected system into which they will be integrated when built.

Power Systems Engineering

A view of the technical complexity, and of many as yet unresolved difficulties inherent in planning and operating large electric networks, may be had by reference to the proceedings of a conference sponsored jointly by the Energy Research and Development Administration and the Electric Power Research Institute in 1975.[79] Conference sponsors, cognizant of a "long period of relative neglect which power engineering had suffered in schools of engineering," acted on "a conviction that the rapidly growing complexity and magnitude of systems problems in electric power were rapidly outstripping the capabilities of existing tools of analysis and synthesis,"[80] and brought together a select group of experts to discuss a number of survey papers.

Unresolved technical difficulties in power system operation imply that design constraints may be imposed on future additions to inter-

78. *Id.* at 270.

79. L. FINK & K. CARLSEN, SYSTEMS ENGINEERING FOR POWER: STATUS AND PROSPECTS (1975). For a slightly less technical discussion of contemporary technical difficulties, prepared for the U.S. Bureau of Reclamation, *see* W. KEATING, R. BRANSTETTER & G. McCONE, PLUSES AND MINUSES OF POWER SYSTEM INTERCONNECTION IN THE WESTERN UNITED STATES (1972).

80. *Id.* at iii.

connected systems constraints which may have substantial dimensions in terms of both economic costs and continuity of service. Some constraints may affect site selection for new plant construction, either through technical limitations or via differential impacts on comparative equipment costs between alternative sites.

Conversely, in some instances technology may be available, which a firm may be reluctant to install (due to cost or unfamiliarity), and this may in turn influence a decision between alternate sites. Access to technical engineering design information, and awareness of its impact on decision making may therefore be a significant factor in siting proceedings.

Use of sophisticated computer programs by firms prior to plant construction, to simulate interconnected network performance with various development alternatives, may be taken as an indication of the importance of technical parameters to siting decisions. That such simulation models are generally considered to be proprietary information by investor-owned utilities further impedes access of policy makers to technical understanding of system interrelationships in bulk power supply planning.

Siting Methodologies

The number of methodologies for selection of power plant sites most likely approaches the number of engineering consulting firms and electric utilities in the United States. Most utilize a site screening sequence of constraint mapping or overlay techniques on progressively smaller geographical areas, based on environmental impacts, economic factors and engineering feasibility. Many involve elaborate numerical weighting and ranking of alternatives, and some are computer-assisted.

A brief review of siting methodologies prepared by the Mitre Corporation for the U.S. Geological Survey, *Methodologies for Power Plant Siting,*[81] provides a useful, nontechnical overview of this process for the layman. In addition, Peter Meier includes an equally nontechnical critical review, highlighting the limitations of such site-specific methodologies in his essay discussed above.[82]

COMMENTS AND CONCLUSIONS

With continuing debate over a national energy policy, increasing controversy over the role of nuclear power in our energy future, and

81. MITRE CORP., METHODOLOGIES FOR POWER PLANT SITING (1975). For a more extensive survey, *see* MITRE CORP., RESOURCE AND LAND INVESTIGATION (RALI) PROGRAM: METHODOLOGIES FOR ENVIRONMENTAL ANALYSIS (1974).

82. MEIER, *supra* note 61, at 30.

the occurrence of a second massive blackout in New York City on July 13 and 14, 1977,[83] planning and operations in the bulk electric power industry are taking on new significance. Yet our knowledge about industry decision making appears woefully superficial, and institutional inadequacies in regulation of siting decisions are readily apparent.

Most of the technical literature on power systems planning and operations has been written by engineers and physical scientists, and it has not been translated into terms that are useful to policy makers. The policy implications of technical operations and system interrelationships are not well articulated or understood by decision makers in state government, where most regulation of siting decisions takes place.

The bulk of the literature has been written by legal scholars when addressing regulatory questions. But analysis on which fundamental policy choices between centralized or decentralized energy systems might be based is not yet in evidence. The economics of industry operations have been assessed primarily as they relate to internal business accounting and overall industry efficiency, but they have not been assessed in terms of the external socioeconomic benefits and detriments of individual siting decisions, or in terms of their cumulative impacts on the surrounding economy. Lack of a regional perspective—in either policy or literature—in the face of obvious regional dimensions of existing interconnected systems, is striking.

Precious little has been produced by social scientists on institutional interactions which may determine the outcome of siting decisions. Existing siting policies may be ill-conceived, but the requisite knowledge to improve them significantly has yet to appear in readily usable form in literature.

83. U.S. FEDERAL POWER COMMISSION: BUREAU OF POWER, STAFF REPORT ON JULY 13-14, 1977 ELECTRIC SYSTEM DISTURBANCE ON THE CONSOLIDATED EDISON COMPANY OF NEW YORK, INC. SYSTEM 4-5 (1977).