Chapter 1

Introduction and Summary

CONTENTS

Boxes

Figure

Tables

Introduction and Summary

INTRODUCTION

The electric utility industry is facing unprecedented changes. Problems of the past and uncertainties in the future are prompting an examination of alternative ways to manage the Nation's electric power systems. A major focus of this search is competition—revising the regulation that has controlled most aspects of electric utilities to make better use of market forces. However, competition itself raises a host of questions: how can it best be applied to the electric utility industry? what has to be done to make the electric system work under these arrangements? how would reliability and costs compare to the present system? can the transmission network handle increased transfers of bulk power? This assessment explores the technical requirements for introducing greater competition into the operation and planning of the electric power industry, with particular emphasis on reliability and operation of the transmission network.

Competition is not a single concept. It can be applied in different ways that have quite different implications. This assessment considers two major mechanisms: competition among generators to supply electric power; and expanding access to the transmission network for wheeling of bulk power from seller to buyer. Competitive generation can be introduced without providing access to transmission, but it is likely that any significant move toward competition would include some degree of both.

Background

For nearly a century, regulated utilities have provided most electric power in the United States. These utilities generate or buy the power needed in their assigned service areas and deliver it to their customers via long-distance transmission and local distribution networks. They also plan for future growth and build needed facilities. Regulators review costs and set the rates utilities charge customers. Until the early seventies, this system appeared to work well: the supply of electricity was reliable, and each new plant contributed to lower costs.

The energy crisis of 1973 and subsequent economic problems brought rapid and painful change to the electric utility industry. Fuel prices and construction costs of new power plants, particularly nuclear, rose dramatically during this period due to a combination of factors—the OPEC oil embargo, increased environmental and safety requirements, high interest rates, intentional construction stretchouts due to lack of need, and poor management in some cases.

Higher fuel and capital costs meant higher electricity costs, and utilities sought substantial rate increases. Customers responded by using less electricity, a reaction that most utilities underestimated at first. In addition, some consumer uses, such as major residential appliances, started approaching saturation. Many large industrial users of electricity, such as aluminum and bulk chemicals, experienced declines in domestic production due to foreign competition. In addition, some manufacturing companies and other large electricity users found they could save money by generating their own power, usually in conjunction with the production of process steam (cogeneration), further depressing demand for utility power. Growth rates of overall national demand plummeted from 7 percent per year to less than 2.5 percent by 1980 (with considerable regional variation). Reductions in construction programs lagged the drop in demand, and many utilities developed considerable excess capacity.

As utility costs of production increased, State regulatory commissions scrutinized utility expenditures much more closely, especially the huge construction cost escalations for nuclear plants.

In some cases, regulators determined that plants were unnecessarily expensive or that the generating capacity was not needed and did not allow the utility to charge customers for the entire cost.

Perhaps the most critical legacy of the 1970s is ***uncertainty*** in electricity demand growth. After 1972, not only did the average annual demand growth rate drop to less than a third of that of the previous decade, but the year-to-year changes became less predictable as well. Users of electricity often are able to switch rapidly to other energy forms or improve the efficiency of their use. However, rapid demand growth continues in some sectors, such as space conditioning for commercial buildings, industrial process heat, and electronic office equipment. As growth has become less predictable, utility planning has become more complex.

The last 15 years have been difficult for many utilities, several having come close to bankruptcy, and have greatly raised costs for their customers. Since about 1983, however, most problems seemed to have waned. The cost of producing electricity has leveled out (and even declined in some areas) as fuel prices dropped and costly construction programs were phased out. Demand has risen, and surplus capacity has been utilized.

Despite a substantial return toward financial health, some problems have left permanent changes. The trend toward large, capital-intensive power plants seems to have ended, at least for the time being, for a variety of reasons including uncertainty over future demand and concern over potential cost disallowances by State regulatory commissions.

The Public Utility Regulatory Policies Act of 1978 (PURPA) has also had a major industry impact. Among other things, PURPA was intended to encourage construction of nonutility, generating units by requiring utilities to purchase power produced by qualified facilities (QFs).[1] Despite a slow start due to economic uncertainties and legal challenges, the number of QFs has grown rapidly. Many cogeneration and alternative energy facilities appearing since 1978 have been a result of PURPA. The Act has also inspired a growing interest in independently owned, but otherwise conventional power stations, which would sell their output to utilities or even directly to other customers, perhaps using a utility's transmission system for the delivery.

Several States have already initiated procedures to further promote nonutility generation, sometimes with the active encouragement of their utilities. Utilities in need of new generating capacity can request proposals in a competitive bidding process and then contract with other utilities, cogenerators, or independent power producers (IPPs). In 1988 the Federal Energy Regulatory Commission (FERC) proposed changes to regulations to promote competition in bidding and independent power production.[2]

Cost differentials between utilities are also fostering change. Some utilities are able to sell excess power at low prices. Other utilities have taken advantage of such opportunities for many years. Large industrial consumers and municipal electric distribution agencies in high cost areas also are seeking to purchase lower cost electricity directly from distant utilities. Such efforts often conflict with interests of the local utility, which doesn't want to lose customers

[1] PURPA encourages alternative energy and high efficiency cogeneration through special regulatory treatment. Power from QFs must be purchased by the local utility at a price not to exceed the cost that the utility would have incurred to generate the same powe These limits have been set administratively by State utility commissions, and there has&n considerable controversy over whether avoided costs have been set at levels too high, encouraging too many QFs at consumer expense, or too low, discouraging innovative development. FERC has proposed a rule approving the use of competitive bidding as a means of determining avoided costs under State *regulatory programs.*

[2] Notices of Proposed Rulemaking: Docket No, RM88-4, Regulations Governing Independent Power Rockers; Docket No. RM88-5, Regulations Governing Bidding Programs; Docket No. RM88-6, Administrative Determination of Full Avoided Costs, Sales of Power to Qualifying Facilities, and Interconnection Facilities; Mar. 16, 1988.

and may refuse to supply transmission services, or wheeling, for power produced by other parties.

Change is also occurring in other countries. In particular, the British Government is introducing competition into its generation and transmission system through a radical privatization of its presently government-owned monopoly. This situation is quite different, but it may well provide some useful lessons for the United states.

Future Concerns

All these factors suggest that change is inevitable for the electric utility industry. However, there are many different views on what the appropriate changes should be. To a large extent, partisans of each perspective in the debate are motivated by self-interest. The stakes are large for many of the players. From the perspective of those trying to maximize benefits for the Nation as a whole, the issues are more ambiguous.

The primary argument advanced for policymakers to take some action, whether involving competition or another approach, is that the present institutional and regulatory structure seems unlikely to produce the lowest possible costs for consumers. Some people believe that the problems are too systemic to be addressed by adjustments in the existing regulatory approach: that utilities lack sufficient incentive or ability to control construction costs and operate as economically as possible. Prior to the disallowances of recent years, costs and savings generally were simply passed on to customers, with little reward to the utility for excellent performance or penalty for inefficiency. According to these arguments, competition could help ensure that the lowest cost facilities are built and operated efficiently, and that customers would always have access to the lowest cost power available, no matter who generated it.

Others believe that the problems of the past were one-time events, not likely to be repeated, and that the present regulatory structure can be adjusted to handle any future problems. In fact, some holders of this perspective believe that no competition should be introduced; that unique characteristics of the electric system mean that competition is likely to raise costs and lower reliability.

One of the key elements of the debate is over new construction to meet future needs. Some observers are concerned that under the present regulatory environment utilities will jeopardize future reliability and cost control by failing to construct needed facilities or building only plants with the lowest possible capital cost, such as oil- or gas-fired turbines, which often have high operating costs. Others are concerned that capital minimization is exactly the choice that most competitive generators would select. If new generating plants rely primarily on gas-or oil-fired turbines, and if the prices of those fuels rise sharply as they have several times in the past, electricity could become significantly more expensive. Under some conditions, large coal or nuclear plants could still produce the lowest cost power.[3] Policymakers may wish to consider revisions to regulations so that utilities can confident] y build whatever facilities are deemed least expensive overall for their customers, or encourage competitive entities to build these facilities. However, the choice of fuels for future generating stations and their national energy and environmental policy ramifications are beyond the scope of this study.

[3]Nuclear and coal plants have low fuel costs compared to gas- and oil-fired plants. If their capital costs are not too high, the fuel cost advantage can result in lower overall cost per kilowatthour. At the moment, this is probably generally not the case. Oil and gas prices are not much higher than coal though gas prices are climbing. Future competitiveness for nuclear and coal will depend on holding capital costs down as well as *renewed* increases in oil and gas prices. Despite the spectacular capital cost increases in the seventies, this appears possible. Some of the factors driving those increases were peculiar to the times (20 percent interest rates and construction delays due to plummeting demand). Others were one-time increases that would not continue pushing prices up (strengthening inadequate safety and environmental controls). Thus it should not be assumed that the experience of the *pm* is necessarily indicative of the future.

Another concern is that increased competition will be hindered by existing laws and regulations. Pressure for more competition is increasing and some elements are already being introduced. If Congress chooses to encourage competition, legislation and oversight of regulation is likely to be necessary to allow full implementation.

It is also of concern that change could occur too rapidly. If competition is implemented with little testing and analysis, the economics and reliability of the system could be threatened. Therefore, policymakers may have to guide the process of change to ensure that it follows constructive channels.

A MORE COMPETITIVE ELECTRIC POWER INDUSTRY

Interutility sales have long comprised a form of competition in generation as utilities with excess capacity competed to sell power to those that needed additional power. Typically these interutility transactions benefited all parties and encouraged efficient operation.

Measures to increase competition can range from minor changes in regulatory standards and bulk power procurement practices to a major reorganization of the industry: separating generation, transmission, and distribution into separate companies. The efforts by several States to expand market opportunities for utilities to procure new supplies of power is one form of competitive generation.[4]

Expanded access to the transmission system would increase competition by permitting (when possible) generating companies to deliver power to customers other than the local utility. The widened market increases opportunities available to independents and also to utilities with excess power to sell.

Competitive generation and transmission access can be combined. In the extreme, generating companies or any entrepreneur could build a power plant and sell output to any retail or wholesale customer at a mutually agreed on price, much as the natural gas industry operates. Purchases by a regulated distribution company might still be subject to regulatory review, but generating company costs and operations would be increasingly subject to market discipline. Under such conditions, transmission companies could even act as common carriers, available to any party wishing to arrange delivery of bulk power.

Increased competition, of whatever form and degree, is likely to have significant implications for consumers as well as for existing utilities and new entities in the industry. The following sections summarize arguments for and against competition as it might affect consumers of electric power. Major uncertainties behind these arguments are also identified.

Suggested Advantages to Competition

Some proponents of increased competition in the electric utility industry suggest that it will ensure the lowest possible costs for customers. They believe it would provide incentives for utilities and other generators to improve the operating efficiency of existing plants and control capital costs of future plants. Large differences in construction and operating costs of similar plants indicate that considerable savings are possible if competition can motivate or replace the more poorly performing utilities.

Expanding the ranks of generating companies could reveal attractive opportunities not available to utilities. Entrepreneurial generators might also be able to use lower cost financing techniques (e.g., greater use of debt relative to equity than is normal utility practice). Competitive generators could prove more innovative be-

[4] California, Colorado, Connecticut, Maine, Massachusetts, and New York have formally adopted utility bidding programs for new power supplies. Another 17 States are implementing or considering such a step. Virginia has implemented bidding without a formal program.

cause, unlike utilities, they get to keep the reward if a gamble pays off.

Some risk would also be shifted from utilities and their rate payers to competitive generators. For instance, if costs did get out of control on a construction project, the cost of power could still be fixed by contract terms.

Transmission access might also reduce regional cost differentials by increasing bulk purchases by higher cost utilities from lower cost suppliers with excess capacity. Bulk power sales over long distances may forestall expensive new construction in regions that are growing rapidly while providing economic benefits in regions that have considerable excess capacity.

Proponents also point to precedents in the deregulation of other industries, such as natural gas pipelines, airlines, trucking, and telecommunications.

Suggested Disadvantages to Competition

In some ways, the present system works well. Utilities determine the need for power, the most economical choice to produce and deliver it, and how to ensure its reliability. This integrated approach enables utilities to optimize the entire system. Even if competitive generators can operate more economically than utilities, long-term system economics also depend on how well individual components work together. Not only are many individual utilities vertically integrated, but close coordination among utilities enables them to share generation and transmission to minimize costs and improve reliability. While some utility performance has been less than ideal, **separating a system's mutually dependent areas of decisionmaking may introduce a different kind of inefficiency that could be costlier than that intended to be addressed by competition.**

Opponents also note that many problems (such as overbuilding and construction cost overruns) that have led to interest in competition can be (or already have been) addressed within the present institutional/regulatory structure. The threat of disallowances for imprudent investments is a powerful incentive to control costs, and there is no inherent reason why utilities could not use the same financing techniques as nonutility generators. In addition, risks to consumers are not necessarily lessened when utilities buy instead of build, because the utilities will have to sign long-term contracts for purchased power. If the utility guesses wrong on its power needs, a contract could, depending on its terms, prove as inflexible as a construction program.

The present industry also supports research and development, for example, at the Electric Power Research Institute. Further, utilities often collaborate in demonstrating new technology and share information on improvements. Competing companies have less incentive to cooperate to this degree, and it is questionable how much joint R&D will continue. Similarly, utilities have fostered emerging technologies that they believed to be in the national interest but that entailed considerable initial economic risk. Competitive generators may be less likely to take such a long-term perspective.

Uncertainties

One notable feature of the debate over competition is the lack of data and analysis. Experience with competition in the electric power industry has been limited, and much has not been relevant to a situation where competitively procured supplies represent more than a small part of the whole. **For the most part, the advantages and disadvantages discussed above are speculative.**

We do not know how much more efficiently, if at all, nonutility generators can build and operate power plants. Nor do we know how much more difficult it will be to plan and operate a bulk power system that incorporates increasing competition among generators and expands access to the transmission system. **Thus we**

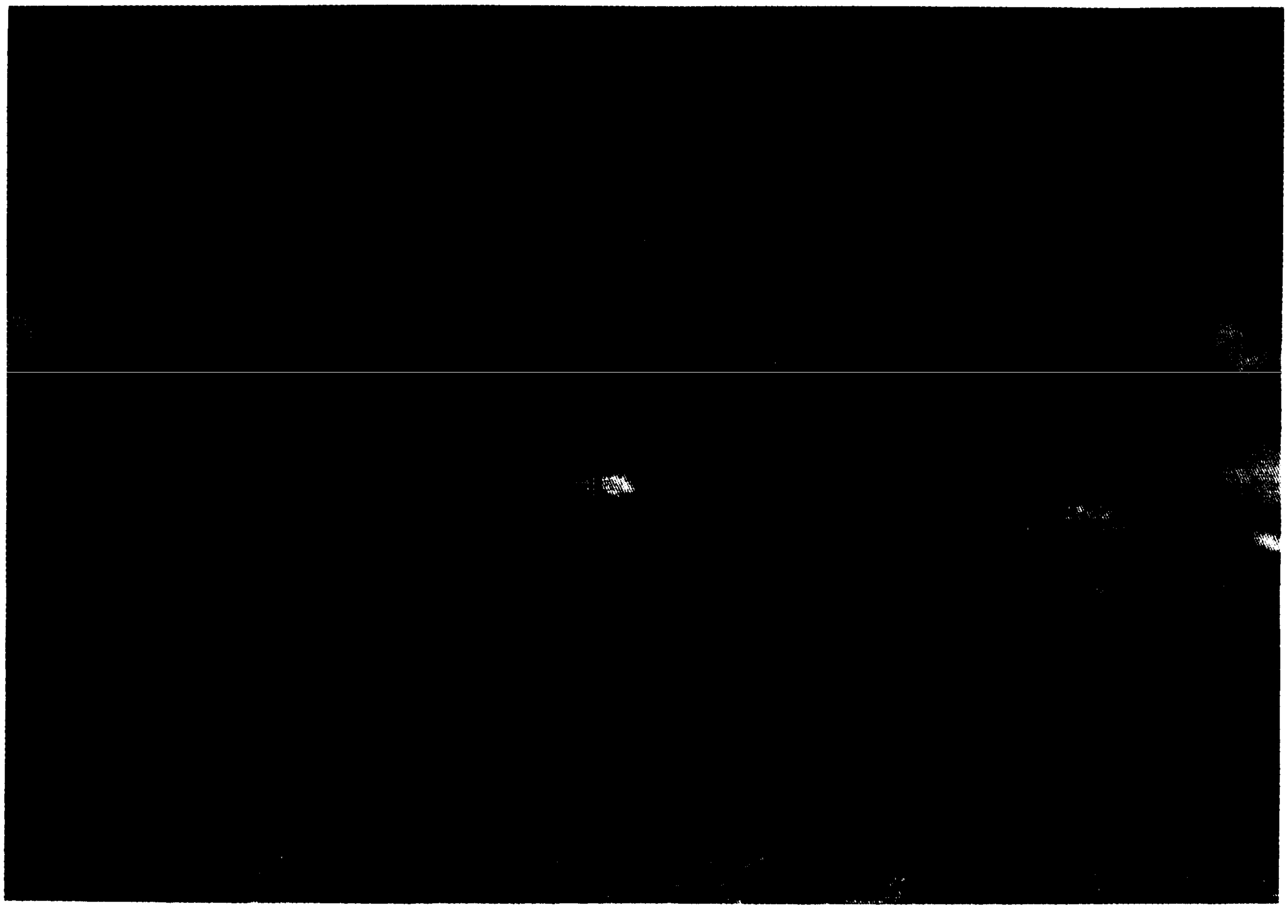


Photo Credit: Casazza, Schultz & Associates. Inc.

Three extra high voltage lines share a single right of way

cannot say whether economic gains induced by competition outweigh additional costs.

Maintaining reliability under competition also poses uncertainty. Most of us take the reliability of electric power for granted, but it doesn't happen by accident. It has required investments in equipment and manpower and emergency assistance to other utilities that at times have gone beyond legal requirements. Utilities have a deeply engrained ethos that interruption of service should be minimized. The operating availability of nonutility generators to date is at least comparable to that of utilities (the owners have incentive to stay on line because otherwise they don't get paid), and appropriate reliability requirements can be built into contracts. However, system reliability is as yet untested for a situation where a large proportion of components are operated under contract rather than under direct ownership of a utility committed to meeting demand under all conditions.

Increased access to transmission should facilitate transfers of bulk power, but the growth that would result is uncertain. Bulk transfers have increased as utilities took advantage of the availability of lower cost power. More such transfers might be advantageous, but more analysis is required of where these transfers would take place, what factors are hindering them, or what their value would be.

Pricing and equity questions will be crucial to successful implementation of competition. Pricing policies will guide the operating and planning decisions made by buyers, sellers, and transporters, which will determine whether increased access to the transmission system actually allows a more efficient pattern of bulk power transfers. Contentious equity issues will emerge if some groups seem to benefit at the expense of others. For instance, large industrial customers could bargain for low rates, leaving those who lack that option (e.g., residential users) with much higher costs. In addition, if utilities are broken up into generating, transmission, and distribution companies, the transfer of the value of existing assets (which maybe worth much more than their depreciated book value) will be controversial.[5]

As already noted, future fuel choices have vital national energy implications, but it is not clear what technologies or fuels either utilities or nonutility generators are likely to prefer, in part because long-term economics are not clear. National energy choices may require fuel shifts, for instance to avoid gas and oil shortages or reduce emissions of carbon dioxide because of the greenhouse effect. If responsibility for generation has diffused among a large number of independent power producers, the effectiveness of policy changes will be less predictable.

Another question is on end-use efficiency improvements. Many institutional barriers hinder otherwise economic investments to improve efficiency of end-use. For example, consumers often lack information on the availability and advantages of high-efficiency appliances. At present, utilities have some incentive to help their customers with these investments in order to avoid building expensive, new **generating** facilities. The impact on efficiency of use depends largely on how competition is implemented. Increased competition may improve price signals, which would improve consumer decisions, and bidding programs can include demand-side management investments. However, competition could also eliminate utility interest in overcoming noneconomic barriers to efficiency gains. A strong emphasis on increasing the efficiency of electricity use could reduce the need for new construction. A full analysis of the costs and benefits of a Federal program focused on efficiency gains as a means of optimizing the value of electricity to society was beyond the scope of this project. However, the report notes the impact on demand management of policy initiatives for implementing competition.

This assessment has not identified any specific reason why competition cannot be made to work well, but insufficient analysis has been done to determine whether benefits outweigh costs overall. It is clear that there are ways of implementing competition that would work very poorly. There are many pitfalls that must be avoided.

THE BULK POWER SYSTEM

The production and delivery of electric power is extremely complex, both physically and institutionally. This characteristic of the system will largely determine how competition can be introduced and its success. Box 1-A presents the basic concepts of the electric power system. The bulk power system consists of the generation and transmission sectors. Distribution networks receive power from the transmission system for retail delivery to customers.

The System Today

The industry consists of over 3,200 entities supplying power to over 100 million residential, commercial, institutional, and industrial customers. Most electricity (76 percent) is supplied

[5] Questions of risk and equity are critically important to the acceptance of competition, but they are not analyzed in this study because they are not directly related to the technology.

Box I-A—Electric Power Systems

An electric power system is comprised of: **generating units** that produce electricity; **transmission lines** that transport electricity over long distances; **distribution lines** that deliver the electricity to customers; **substations** that connect the pieces to each other; and **energy control centers** to coordinate the operation of the components. Figure 1-1 shows a simple electric system with two power plants and three distribution systems connectedly a transmission network of four transmission lines.

Fossil fuels, nuclear fission, and falling water are commonly used energy sources in the **electric generators.** A wide and growing variety of unconventional generation technologies and fuels also have been developed, including cogeneration, solar energy, wind generators, and waste material.

Generators typically produce 60 cycle/second (Hertz or Hz) alternating-current (AC) electricity with voltages between 12 and 30 thousand volts (kV). The frequency of all generating units on a system must be precisely synchronized. Generating units have **automatic voltage regulators,** which control the unit's voltage output, and **speed governors,** which adjust power output in response to changing system conditions, In addition to the real power that lights lamps and drives motors, an inescapable companion of alternating current, called reactive power, or VARs, must be monitored and controlled to maintain voltage.

Transmission lines carry electric energy from the power plants to the distribution systems. Most transmission in the United States consists of overhead AC lines designed to operate at a specific voltage between 69 and 765 kV. **Power transformers** raise the generator voltage to the transmission voltage and back down to the distribution network level (typically under 35 kV) at the other end. There are some segments of direct current transmission and underground cables for special applications, but these are less common than overhead AC lines.

An interconnected group of individual transmission lines comprises a **transmission system.** Virtually all electric utilities in the continental United States are connected to neighboring utilities through one or more lines of a transmission system.

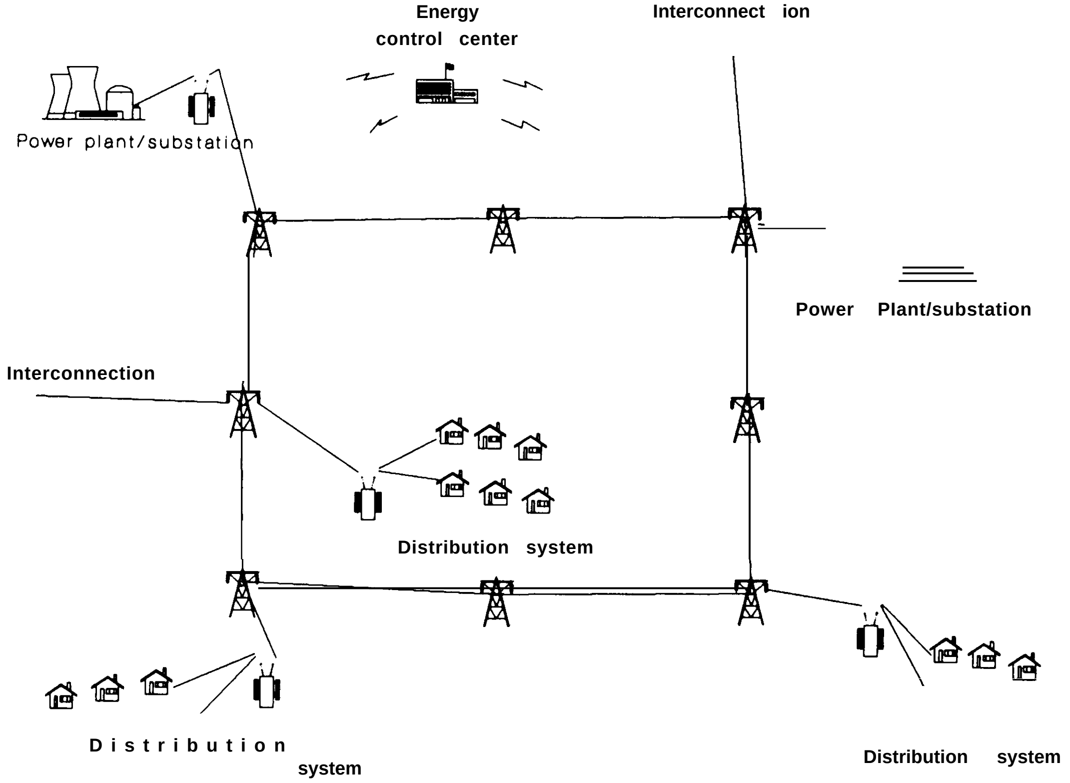
Coordinated operation of the power system components is implemented through institution of **control areas.** A control area is a geographic region with an **energy control center** (ECC) responsible for operating the power system within that area. One or more utilities may make up a control area. The control area in figure 1-1 is interconnected to two neighboring control areas through transmission lines.

Energy control centers employ a variety of equipment and procedures: monitoring and communication equipment called **telemetry** to constantly inform the center of generator output and system conditions; **computer-based analytical and data processing tools** which together with engineering expertise specify how to operate generators and transmission lines; and governors, switches, and other devices that actually control generators and transmission lines. The control center equipment and procedures are typically organized into three somewhat overlapping systems which are sometimes integrated in a full **energy management system** (EMS). They are the **automatic generation control** (AGC) system which coordinates the power output of generators; the **supervisory control and data acquisition** (SCADA) system which coordinates the transmission line equipment and generator voltages; and an analytical system to monitor and evaluate system security and performance, and plan operations.

by the 203 investor-owned utilities that generate the power they need, deliver it to their load centers over high-voltage transmission lines, and distribute it to their customers. Most of these utilities are vertically integrated, owning or controlling all the generation, transmission, and distribution facilities required to meet the needs of the customers in their assigned service area. Publicly owned utilities (Federal, State, and local) and consumer cooperatives also generate electricity (**24** percent).

Nonutility generators (NUGs, including any producer of electricity not functioning as a public utility) are important in some regions and are starting to become a significant national

Figure l-l—A Simple Electric System



SOURCE: Office of Technology Assessment, 1989.

factor. Statistics on NUGs are uncertain, but they appear to own about 25,000 megawatts (MW) of capacity out of a total of over 700,000 MW in the Nation.

The transmission system allows a utility to build a generating station wherever appropriate and deliver power to the load center, sometimes hundreds of miles away. In addition, it links utilities so that they can back each other up during emergencies and transfer power when it is economically advantageous to do so. The latter is normally accomplished by contract between utilities, specifying the power (megawatts), voltage, and the time period of the transfer, among other things. Transfers for economic purposes have become common in recent years.

The bulk power system is a combination of generating units and transmission lines that must be operated as a coordinated system. This requirement has governed the institutional evolution of the industry as well as the development of its physical system. The addition of nonutility generation to the system must be understood in this context.

In particular, the industry has developed an unusual level of cooperation among private companies as well as government agencies. All large utilities in the 48 contiguous States are members of one of nine regional reliability councils that form the North American Electric Reliability Council (NERC). *NERC, through* the utilities, issues standards and operating guidelines to improve overall coordination of utility procedures in the United States and

Canada and parts of Mexico. The regional councils coordinate planning and operations and exchange information on electricity demand and reliability. Table 1-1 describes the nine regional councils.

Some utilities have also formed ''tight" power pools, which involve a high level of coordination and a central dispatcher to ensure the use of the most economic mix of generation throughout the pool. New England and New York are each essentially a single "control area. " The Mid-Atlantic Area Council coincides with a single pool in addition to being a regional reliability council. Tight pools maximize the use of low-cost generation and minimize new construction and the cost of maintaining reserve capacity. Other utilities have formed "loose" pools to coordinate planning but with no contractual reserve requirements. In addition, several holding companies (e.g., American Electric Power) coordinate the activities of their subsidiary utilities as power pools. Utilities also make bilateral arrangements, and brokers match buyers and sellers of bulk power, usually for short periods of time.

In addition to pools, most utilities belong to an interconnected network, the largest operating unit. There are three such networks in the United States: the Eastern Interconnection (which extends nearly to the Rocky Mountains), Texas Interconnection (only in Texas), and the Western Interconnection. Within each of these three systems, all connected generators must be synchronized. Connections between two networks are accomplished through direct current interties to avoid synchronization problems.

Power System Technology and Requirements

The bulk power system (described in box l-A) must be designed and operated according to certain physical principles of electricity. In particular, two key technical factors dictate many features of the bulk power system. **First, electricity flows at nearly the speed of light with virtually no storage of power in the system: electricity must be generated as it is needed.**[6] Automatic generation control (AGC) coordinates the operation of generators moment by moment to balance supply with demand. Control is maintained by individual utilities or by pools of interconnected utilities. There is usually a choice of generators to be turned up or down to meet changes in demand, each with individual cost and operating characteristics. Utilities spend considerable effort implementing "economic dispatch, " or ensuring that the mix of units operating at all times represents the least-cost combination. They also must ensure that generating units will be ready when needed to follow the daily load cycle, that the transmission system is capable of carrying the loads, and that backup generating and transmission capacity is available in case of equipment failure.

Second, every flow of power from a power plant to a distribution system affects the entire transmission network, not just the most direct path. Electricity cannot be simply loaded onto a convenient transmission line and delivered, as trucks use the interstate highways to deliver products. If one utility sells power to another, they both must ensure that no components are overloaded on any of the paths available. The network connects many different utilities, and lines hundreds of miles away carry part of the load, a phenomenon called parallel path flow. Such flows can reduce the power that other utilities can place on their own lines. In some cases, a line may already be fully loaded, and the new power flow would overburden it. Therefore, the overall system's transfer capacity is constrained by the single most limiting transmission line.

Total system capacity is considerably less than the sum of the capacity of all lines in it. In

6 Pumped hydroelectric facilities store energy but not electricity. In effect, the system sees them as generating stations. Development of economic battery or magnetic storage technology for use within the distribution system could have important advantages for the electric power system.

Table 1-1—Characteristics of the Nine Electric Reliability Council Regions

NERC regions	States	Member systems	Projected 1988 installed capacity (MW)	1988 minimum capacity margin (percent)	Projected average annual growth 1988-97 (percent)	Net 1987 imports (billion kWh)
ECAR—East Central Area Reliability Coordination Agreement	MI,OH,WV,IN Most of KY and parts of VA,MD,PA	16 IOUs 2 Cooperatives	97,380	23.0	1.5	–20
ERCOT—Electric Reliability Council of Texas	Most of TX	6 IOUs 49 Cooperatives 20 Municipals 1 State agency	0	21.3	2.9	1
MAAC—Mid-Atlantic Area Council	DE,NJ,PA,DC, and parts of MD & VA	11 IOUs	48,582	19.0	1.8	
MAIN—Mid-American Interconnected Network	IL, and parts of MO,MI,and WI	11 IOUs 1 Municipal 1 Cooperative	49,607	25.4	1.7	
MAPP—Mid-Continent Area Power Pool	IA,MN,NB,ND, and parts of WI,SD,MT,MI,IL	1 IOUs 8 G&T Cooperatives 4 Municipals 3 Public Utility Districts 1 Federal agency		28.4	1.7	–8
NPCC—Northeast Power Coordinating Council	CT,ME,	17 IOUs 1 State authority	53,714	22.1	1.8	27
SERC—Southeastern Electr Reliability Council	AL,FL,GA,NC,SC,TN, and parts of VA,MS, and KY	16 IOUs 8 Municipals/public 2 Cooperatives 2 Federal agencies	139,334	20.0	2.4	9
SPP—Southwest Power Pool	AR,OK,KS,LA, and parts of MS,MO,TX and NM	17 IOUs 12 Municipals 8 Cooperatives 4 Government agencies		26.7	1.9	7
WSCC—Western Systems Coordinating Council	AZ,CA,CO,ID,NV,OR,UT, WA,WY, and parts of NM,MT,SD,TX	19 IOUs 17 Municipals 16 Public power 5 Government agencies	23,022	31.5	1.8	8

SOURCE: NERC 1986 Annual Report; the 1988 Reliability Assessment: The Future of the Bulk Electric System in North America 1988-1997; and 1988 Electricity Supply and Demand for 1988-1997, October 1988.

addition to individual line constraints, the system imposes its own limitations because of reliability and stability concerns. Utilities generally operate the system with reserves sufficient to handle rapid shifts in power flows that occur when a transmission line or generating unit fails.

The capacity of the transmission system is not a fixed, exact limit that balances the utility's costs of providing reliability with the consumer's benefits of uninterrupted service. Rather, capacity is defined by utilities from operating practices and from trade-offs among several factors, including the operation of generating units as well as transmission lines. Capacity also varies over time, depending on factors such as air temperature. Determining whether an additional transfer can be accommodated often requires considerable engineering expertise, data, and analysis, and it is possible for different analysts to arrive at opposite conclusions.

Determining how to increase capacity is also complex. The system can be upgraded by increasing the capacity of individual lines; improving control of flows on the network; and adding new circuits. Table 1-2 lists technological options available to overcome specific limitations. Costs and benefits of implementing most of these options are highly site specific.

A variety of constraints can account for the capacity limit for any specific line. Lines can overheat with too much current, or high voltage can cause arcing in equipment. The limit also depends on a line's specific configuration, its relation to the rest of the system, and variables such as air temperature.

Improved control over the flow of power can increase capacity by bypassing constraints. Adjusting power output of generators on the network can maximize flow (but this can also result in noneconomic dispatch) and improving generator response times can reduce transmission reserves required in case of equipment failures. Phase shifting transformers, which act as valves to control individual flow, are gaining popularity. Transmission limitations can also be alleviated by control of reactive power.

Table 1-2—Technologies to Increase Transfer Capability

Remedies to individual line constraints
Voltage uprating
Tower extensions
Upgrading insulators
Upgrading terminal equipment (circuit breakers, relays, transformers)
Current uprating
Dynamic conductor rating
Sag assessment and monitoring
Restringing (live-line restringing)
Changing operating standards
Tower design **and** *new lines*
Conversion to multiple circuit towers
High-voltage direct current lines
Remedies to steady state system operating constraints
Control of load division
Phase angle regulators
Series reactance and capacitance
System reconfiguration
HVDC control features
Redispatch of generation
Reactive power management techniques
Shunt or series capacitors
Shunt reactors
Static VAR compensators
Synchronous condensers
Generators as VAR sources
Remedies to contingency security and stability constraints
Improving generation response controls
Generator tripping and fast runback
Fast valving
Braking resistors and load switching
Advanced excitation systems and stabilizers
Transient excitation boost
Improving transmission response controls
High-speed reclosing and reducing clearing time
Rapid adjustment of network impedance
Fast acting phase angle regulators
Sectionalizina (adding switching stations)

SOURCE: Adapted from "Technical Background and Considerations in Proposed Wheeling, Transmission Access, and Non-Utility Generation," contractor report prepared for the Office of Technology Assessment, by Power Technologies, Inc., March 1966, p. 6-2.

When large increases in capacity are required, it generally is necessary to add high-voltage lines. Not only can these lines carry large amounts of power, but they can raise the capacity of other lines if they eliminate constraints. The use of high-voltage direct current (DC) lines is increasing, even though considerable investment in conversion facilities is required at both ends, because control of direct current is much simpler than alternating current, and the lines themselves are cheaper.

Three R&D programs have the potential for significantly changing the electric power system. **High-power semiconductors are** already being applied to reactive power control, and further development may lead to switches for controlling power flow and to less expensive AC/DC conversion. Second, developments in **computing and data processing techniques,** including artificial intelligence and supercomputers, should have several applications for power systems, such as optimization of operations and power plant diagnostics and monitoring. Finally, in the long term, **superconducting materials** could improve the economics of the power system not necessarily in the transmission cables themselves but in generators, line control devices, and electric storage technology.

Technical Issues in Competition

The greatest challenge to increasing competition in generation and expanding transmission access is maintaining the high degree of coordinated planning and operation among bulk power system components. If coordination is not addressed with appropriate care, the system may experience increasing costs and decreasing reliability. Coordinated planning and operation of generation and transmission are required in performing three basic functions: following changing load, maintaining supply reliability, and transactions among utilities and generators, as described in box 1-B. **The key to coordination will be in defining workable institutional arrangements among participants in the power system. Some new physical facilities and improved analytical capabilities may be required, but all these functions can be provided with familiar technology.**

At present, a single utility or group of cooperating utilities is responsible for system planning and operations in a control area. As nonutility generation and transmission access increase, responsibility for coordinating the overall power system is separated from ownership of system components. Functions now routine to utilities would increasingly have to be unbundled and established by contract or other agreements among generators, purchasers, and carriers.

As in today's power systems, the arrangements may include formal contracts between parties as well as less formal agreements on standards and procedures. As unbundling increases, bilateral and multilateral contracts will be increasingly important instruments to communicate needs and define obligations of suppliers, transporters, and power purchasers. By specifying prices and performance, including penalties for failure to perform, contracts can help ensure that competitive supplies meet power system needs and mitigate uncertainty for all parties. However, contracts may have some shortcomings when compared to arrangements within a single organization, as in a vertically integrated utility. For example, given the overall uncertainty in the power industry, anticipating all terms and contingencies that a contract should cover requires extensive effort. Even with carefully crafted and flexible contracts, unexpected events outside the scope of the contract may occur.

How suppliers, purchasers, and transporters of power will respond to any competitive proposal is speculative. It is this individual behavior and how it is coordinated, however, that determines the real feasibility, reliability, and economic impact of increased competition in the electric utility industry. This study has identified no insurmountable problems of technical feasibility, although there are some substantial institutional challenges in developing new planning and operating arrangements. The ease or difficulty of implementing the institutional changes to meet technical requirements is, again, necessarily speculative.

Box l-B-Coordinated Operations and Planning

An electric power system is composed of many interacting electrical and mechanical parts. Because of the complex and nearly instantaneous interactions between the components, their operation and planning must be carefully coordinated. For example, a decrease in output of one generator instantly changes power flows and voltages across the system, automatically causing other generators to increase their output. This could result in overloads or unacceptable voltages if not properly coordinated.

Coordinated operation and planning involves several procedures, ranging from moment-to-moment coordination of generator power and voltage output, to long-term planning and addition of transmission and generation. Together, these procedures control generation and transmission to perform three basic functions: **following changing loads; maintaining supply reliability:** and **coordinating transactions between utilities (see** table 1-3). These functions are performed in a way that seeks to minimize cost.

Following Load

Consumer demand for electricity changes continuously and somewhat unpredictably. Some changes tend to repeat cyclically with the time of day, day of week, and with the season. Others result from the vagaries of weather, economic conditions, and from the random turning on and off of appliances and industrial equipment.

Following load involves preparing generators for operation (e.g., warming them up) under **unit commitment schedules,** which reflect forecasted load changes over daily, weekly, and seasonal cycles plus an allowance for random variations. Some generators in a unit commitment schedule increase or decrease their power output either according to a schedule, following predicted loads; others are under **automatic generation control (AGC)** and **economic dispatch** to follow actual loads as required. Voltage control and reactive power devices on the transmission system and in generating plants are simultaneously coordinated to maintain system voltages as loads and supplies change.

Maintaining Reliability

From one moment to the next, any generator or transmission line may fail, either on its own or due to external influences (e.g., lightning strikes). Preparing for continued operation after equipment failure is called maintaining **security. Security is** maintained through unit commitment schedules and **security constrained dispatch,** which provide reserves of both generation and transmission. Together with the coordinated engineering of relays and circuit breakers used to isolate failed or overloaded components, they ensure that no single failure will result in cascading outages.

Ensuring sufficient availability of supplies, called maintaining **adequacy,** is also essential for reliability. In addition to unit commitment and economic dispatch for load following and security, maintaining adequacy involves coordinated **maintenance scheduling** of individual components and **planning** new generation and transmission capacity. Planning new capacity involves selecting the right mix and location of both generation and transmission to meet the needs of following load and maintaining security.

Coordinating Transactions

Nearly all utilities are interconnected with other systems, allowing for a variety of transactions. Transactions may take a variety of forms, including purchases and sales with neighboring utilities; purchases from suppliers within a utility's service area (e.g., an independent power producer); operation of jointly owned power plants; and wheeling of power. Except where contrary arrangements are specifically made, it is the responsibility of each utility to provide the power used by its customers without absorbing power from its neighbors or sending unwanted power to them. Coordinating transactions involves scheduling and control of generation to implement power transfers, as well as monitoring and recording transactions for billing or other compensation.

Some believe that in both the short and long term, competitiveness is likely to be detrimental to the cooperation among companies that is characteristic of the electrical power industry. Utilities routinely exchange information, coordinate planning, and provide backup for each other in emergencies. Companies that may be bidding against each other have less incentive to extend this level of cooperation. However, it is not clear how valuable this

Table 1-3-Operation and Planning Functions

Function	Purpose	Procedures involved
Fe//owing load		
Frequency regulation	Following moment-to-moment load fluctuation	Governor control Automatic generation control (AGC) and economic dispatch
Cycling	Following daily, weekly, and seasonal cycles (within equipment voltage, power limits)	AGC/economic dispatch Unit commitment Voltage control
Maintaining reliability		
Maintaining security	Preparing for unplanned equipment failure	Unit commitment (for spinning and ready reserves) security dispatch Voltage control
Maintaining adequacy	Acquiring adequate supply resources	Unit commitment Maintenance scheduling Planning capacity expansion
Coordinating transactions	Purchasing, selling, and wheeling power in interconnected systems	AGC/economic dispatch unit commitment

SOURCE: Adapted from F. Mobosheri, southern California Edison, letter to Office of Technology Assessment, May 13, 1989.

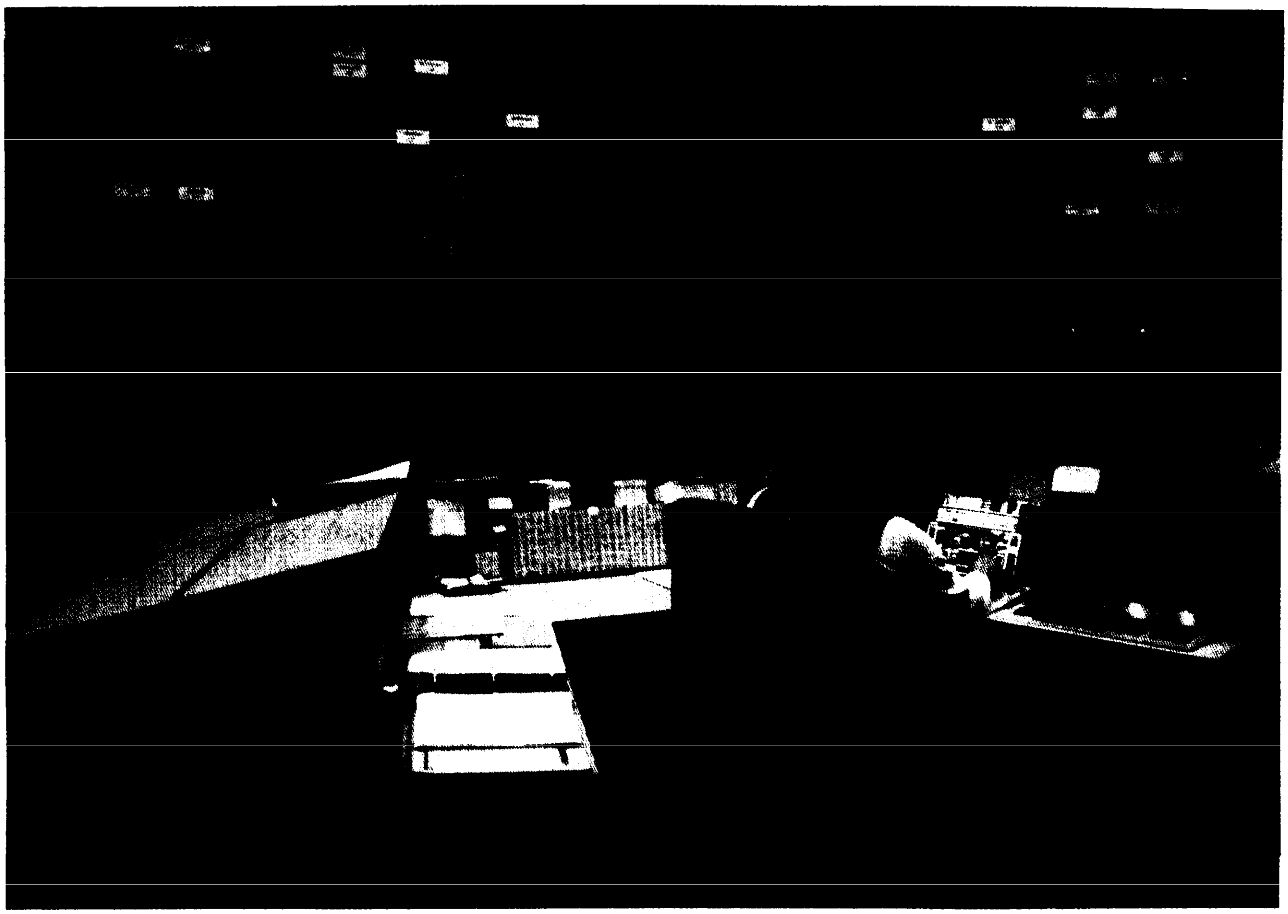


Photo credit: Cassazza, Schultz & Associates, Inc.

Energy control center

cooperation is or how well contracts could duplicate actual activities.

Nonutility Generation

Nonutility generators are likely to use familiar equipment and fuels, and suitable controls for frequency and voltage can maintain output compatibility. Therefore, the equipment itself should not create undue problems if planning and operation are carefully coordinated.

However, it is not certain how difficult it will be to meet the technical requirements of coordinated planning and operation if competitive generation becomes widespread. These requirements do not preclude competition, but inattention to them will result in a needlessly unreliable and high-cost system, and it should be noted that the costs of meeting several of these requirements are quite uncertain.

Maintaining the efficiency of economic dispatch for load following will be a challenge. Competitive generating companies may operate more efficient and lower cost facilities than regulated utilities, but overall costs could still be higher if units are not dispatched to minimize total costs. For example, if generating companies contract directly with customers (retail competition) for the output of specific machines, then low-cost sources may be idled while a more expensive but nondispatchable source operates. Utilities, whether operating independently or in a pool, try to maximize the use of the lowest cost units. This interest will not automatically be duplicated in a system where many different entities own and operate generating units. To minimize operating costs under competition, centralized control of dispatch or other mechanisms to select the lowest cost of generation must be established. Contracts to establish control for economic dispatch may prove to work adequately, but they are likely to be less flexible than direct control by an integrated utility.

Maintaining reliability requires nonrevenue-generating functions such as keeping reserve units warmed up and immediately available for emergencies. Downtime for maintenance must be scheduled to minimize interference with system operation. Institutional adaptations will be necessary to perform these functions under competition. Increased reserve margins may be necessary to account for the uncertainty in how well these new institutional relations work. In addition, new monitoring and communication equipment may be needed to track and control the new unbundled transactions.

The costs of unbundling these services under competition are not yet known. Utilities now can simply lump the costs of these functions into their overall operating costs and have no need to determine exactly what each one entails.

Meeting demand growth with adequate and appropriate capacity is necessary for long-term reliability. **When utilities are evaluating bids for new generating capacity, they must not be forced to accept automatically the lowest price offered.** In the long run, the lowest costs will result if the bidding process provides an appropriate mix of operating characteristics. For instance, power generated to meet peaks usually costs more per kilowatthour because the plant is idle much of the time. If bids were to be accepted purely on price, proposals for nondispatchable (base load) generators would have a major advantage, but the bulk power system must have a large fraction of dispatchable generation to follow load. Reliability is another key factor affecting value. A power source that cannot be counted on because it is intermittent by nature or unreliable in operation is worth less than a facility that is almost always available when needed.

Power system planners are likely to need to continue specifying the attributes required of new generating units, including: type of fuel used; location; and ability to operate for base-load, intermediate, or peak use. Whether a competitive supply market will provide a full range of desired options and at what cost remains to be seen. Utilities may remain the preferred builder or the builder of last resort.

Ensuring that competitive generation will be completed as planned is another important challenge. Even with contracts for the right facilities, there is some uncertainty that the facilities will actually be completed as required because the contractor could encounter problems and withdraw. Utilities also can misestimate costs, but they are unlikely to cancel a plant that is needed to meet their obligation to serve. Depending on circumstances, either outcome (cancellation or completion of the plant) could be correct; institutional arrangements will need to be designed for flexibility to encourage the right response. Some possible approaches include specifying liquidated damages for nonperformance and allowing the purchasing utility to take over an abandoned project. Both reduce the incentive to abandon a construction project when faced with some cost overruns, and give the utility additional resources for acquiring needed supplies.

One factor that may ease the implementation of competition is the trend toward smaller generating facilities close to the load centers. Small facilities usually entail less uncertainty over construction leadtime and cost. Not only are the risks of failure less for small facilities, but the consequences of individual failures are minor.

Transmission Access

As the number of players in the electric power industry increases, demand for wheeling will increase. Competing generators will want to sell to whomever will pay the most, whether that is the local utility or a distant customer, and some consumers will want to shop for supplies. In either case, they will ***require*** transmission services. Some proposals would require a transmission company to wheel for any and all customers unless it can show that it would be infeasible, for instance if their system has” no additional capacity. There would be established a rebuttable presumption that transmission service could be provided.

The technical challenges of increased transmission access will be significant. As discussed above, available capacity on transmission systems is difficult to determine. It depends on the specific conditions at the time transmission is desired, the reliability and longevity levels selected by the utility, and the parallel path flows that will result. Therefore **disputes over the feasibility and cost of wheeling may be difficult to resolve.** In addition, control of transmission loading currently is effected largely through control of generation. As lines approach full capacity, increased demand is met by shifting to generating units that do not require these lines, even if they are more expensive to operate. If independent generators have access to the system, such shifts could be more difficult to manage. Also, if a substantial amount of the power flow on the transmission network is not dispatchable, balancing demand with supply for the remainder of the load will be more difficult. Finally, long-term planning for transmission capacity additions would be complicated by the uncertainty of where new generating units were going to be located and where their power would be delivered.

To a large extent, the success of implementing increased transmission access depends on developing workable definitions of obligations and rights of all parties and the institutions to carry them out. Various wheeling arrangements are possible, depending on the types of power suppliers, purchasers, and transporters and the specific agreements between them. Wheeling agreements must specify the amount of advance notice and other conditions under which the transporter can halt a transaction and the amount of advance notice buyers and sellers must give the transporter before increasing or decreasing the amount of power to be wheeled. These rights and obligations, while critical for determining technical feasibility and economic impact, also raise fundamental questions of equity and appropriate levels of cooperation.

It should be noted that it is not clear how much expansion of the transmission system will be necessary or practical. The decrease in surplus generating capacity in all parts of the country will reduce the availability of inexpensive bulk power. The apparent reversal of the trend toward large, remote generating stations in favor of smaller generators located close to load centers, if continued, will also reduce future needs. In addition, the costs of siting and constructing transmission lines may exceed their benefits. Major upgrades and new lines frequently encounter opposition, as discussed below. New technology, such as fuel cells or small photovoltaic systems, could completely revamp the way we generate and deliver power. Thus it is not clear that massive upgrades are inevitable, especially in the long-term, though it is likely that some continued growth will be required.

CHANGE AND THE BULK POWER SYSTEM

A variety of futures has been espoused for the electric power industry, including different forms of competition. This assessment presents five scenarios based on recent proposals representing the major themes in this debate. The scenarios provide a framework for analyzing technical considerations. In particular, they focus on competition in generation and access to the transmission system. Table 1-4 lists the main characteristics of the five scenarios.

Scenario 1 assumes that with some modifications to the current regulatory process, the existing organization for supplying electric power will be the most effective. Proponents of this approach believe that the major problem is that utilities will be reluctant to build adequate new capacity to meet future growth. Therefore, the ''regulatory bargain" is strengthened by reassuring utilities and their investors that a reasonable return on investment will be allowed. A potential vehicle for this reassurance would be ''rolling prudence"—prior approval by the State utility commission of the need for new facilities and periodic progress reviews during construction. If there is a problem, adjustments can be made or the plant canceled before costs have become too high, but the utility would be guaranteed recovery of all costs already certified. In addition, minor modifications to PURPA regulations would be implemented to correct perceived imbalances in avoided-cost pricing for QFs. Competition could continue to grow incrementally as an alternative, but no special measures would be implemented to promote it. Transmission access would be voluntary.

Scenario 2 expands the environment for competition through increased access to the transmission system for utilities, QFs, and IPPs. It adopts a broad public interest standard for issuing wheeling orders, including requests by large retail customers shopping for the best price. There would be a presumption that the capacity to wheel exists, and the utility denying the services would bear the burden of showing otherwise. Scenario 2 also broadens the definition of qualifying facilities. Changes to PURPA, the Public Utility Holding Company Act (PUHCA) and the Federal Power Act (FPA) would be required. The industry structure and regulation would remain much the same. Prime responsibility for operation and development of the bulk power system would remain with utilities.

Scenario 3 would create a competitive generating sector incrementally. When a need for new generating capacity is established, a utility would solicit proposals to supply it. The utility would select the best bids based on price and other factors, purchase the power under contract, and distribute it to customers. Participating utilities would have to guarantee transmission access for other generators, but would not be required to provide wheeling for retail

Table 1-4--Summary of Alternative Scenarios

Scenario 1 Strengthening the Regulatory Bargain	Scenario 2 Expanding Transmission Access and Competition in the Existing Regulated Utility Structure	Scenario 3 Competition for New Bulk Power Supplies	Scenario 4 Competition for All Bulk Power Supplies	Scenario 5 Common Carrier Transmission services in a Disaggregate Industry Structure
• Industry consists of a mix of vertically integrated utilities, IOUs, public power, cooperates, Federal power authorities, self-generators, QFs, and IPPs. • Existing regulatory structure with State proapproval of new generating projects and periodic prudence reviews during planning and construction. • Negotiated transmission access arrangements, • Traditional system coordination and control by integrated utilities or control centers. • Prices set by regulatory proceedings and cost of service. Transmission prices and wholesale rates set by FERC (including approval of negotiated IPP power purchases) State oversight of retail rates and PURPA Implementation. • Federal and public power agencies and cooperates affected only to the extent State law provides.	• Industry consists of existing mix of entities. • Existing regulatory structure with wider QF eligibility under PURPA including full utility ownership/control of QFs (may require amendment of PURPA). • New Federal wheeling authority under a public interest standard for wholesale and retail transmission access (requires amendment of the Federal Power Act). • Traditional system coordination and control by integrated utilities or control centers with contracts for unbundled services. • Prices set by regulatory proceedings and cost of service. Transmission prices and wholesale rates set by FERC (including approval of negotiated IPP power purchases). State oversight of retail rates and PURPA implementation. • Federal and public power agencies and Cooperates affected only to the extent State law provides.	• Existing mix of generating entities expanded by IPPs and unregulated utility generating subsidiaries. • Existing regulatory structure with market-based rates for new competitive generation. Utilities use all source procurement for new bulk power needs. Contracts awarded to lowest cost supplier with consideration for non-price factors. • Transmission access provided by utilities as a bidding condition, or by privately negotiated arrangements, or under new Federal public interest wheeling authority (no retail wheeling). • Traditional system coordination and control by integrated utilities or control centers. Unbundled bulk power dispatch, control, and transmission services provided through contracts. • Retail and transmission prices set by regulatory proceedings. Wholesale power prices set through competitive procurement except for cost-base plants built by utility as last resort supplier, State and Federal regulators oversee terms and conditions of wholesale sales. • Federal and public power agencies, and cooperates can participate in competitive generating sector to extent provided by Federal and State law and policy.	• Industry structure: Ownership of competitive generating sector segregated from transmission and distribution sectors. • New Federal and State regulatory systems. Price and entry regulation of generation sector replaced with competitive market. Continued regulation of transmission and distribution utilities and retail sales. • Revised Federal wholesale wheeling authority. Transmission utility to plan for and provide nondiscriminatory access for bulk power supplies. • Most of traditional utility system planing and coordination taken over by transmission and distribution entities. Competitive generators plan and build generation. Transmission operator assumes responsibility for bulk power system control and operation. Distribution utility retains retail obligation to serve. Unbundled bulk power dispatch, control, and transmission services provided through contracts. • Bulk power prices set by market through bidding, negotiation. Transmission and retail prices are set by regulatory proceedings Some State and Federal oversight of competitiveness of generation markets and prudence of bulk power contracts. • Federal and public power agencies, cooperatives can participate in competitive generating sector to extent provided by Federal and State law and policy.	• Ownership and control of existing integrated utility industry is disaggregate into separate generation, transmission, and distribution segments. • New Federal and State regulatory system. Price and entry regulation of generation replaced with competitive markets. Distribution utilities' services and retail prices remain regulated. Transmission prices and activities are strictly regulated. • Transmission sector operates as a common carrier providing nondiscriminatory access to all wholesale and retail customers. Reasonable conditions on reserving transmission services may be imposed. • Bulk system planning and coordination is split among generation, transmission, and distribution entities. Generators identify, plan, and build new generation in response to market signals. Transmission utility assumes responsibility for reliability of bulk system operations. Responsibility for estimating demand and securing adequate power supplies rests with distribution utilities. Unbundled bulk power dispatch, control, and transmission services provided through contracts. • Bulk power prices set by market. Transmission and retail prices are set by regulatory proceedings. Some State and Federal oversight of competitiveness of generation markets and prudence of bulk power contracts. • Federal and public power agencies, cooperatives can participate in competitive generating sector to extent provided by Federal and State law and policy.

SOURCE: Office of Technology Assessment, 1989.

customers. Some modifications to the FPA, PURPA, and PUHCA would be required.

A two-tiered pricing system would result: competitive power under minimal regulation; and power from existing generation under the current State-Federal regulation. Transmission and distribution prices would remain regulated. Scenario 3 differs from recent proposals by FERC in that utility participation in bidding programs would be mandatory, and transmission access is guaranteed.

Scenario 4 would drastically restructure the industry to create a competitive generating sector over a short period of time, rather than incrementally as in scenario 3. Utilities would spin off their generating facilities and activities into affiliates or even independent companies. Transmission and distribution could, but would not have to, be separated from each other and would remain heavily regulated. Safeguards would be needed to prevent self-dealing and cross subsidization in cases where a generator was bidding to supply power to a transmission/ distribution affiliate.

Competitive companies would generate the power and sell it to regulated transmission and distribution companies (which could be either combined or separate). Transmission and distribution utilities would be responsible for contracting for adequate power to meet expected demand at all times. Most of the other coordinating functions that integrated utilities now perform internally, such as dispatch and system control, would be arranged by contract. The transmission companies would have an obligation to maintain adequate capacity to wheel power as required for regional needs, their own distribution clients, and for generating companies selling directly to retail customers. Wheeling for retail customers would be voluntary. This scenario would involve a substantial reevaluation and redistribution of rate-base assets in a transition period, entailing major public policy issues.

Scenario 5 would completely separate utilities into generation, transmission, and distribution sectors. Entry into the generation sector and bulk power pricing would be left to market forces. Electricity would be Supplied under long-term contracts and spot sales by competitive generators. Retail prices would still be regulated. Transmission utilities would be converted into common carriers (i.e., providers of a nondiscriminatory service based on approved wheeling tariffs for all parties on request). All customers would have the option of obtaining their power from any willing supplier with the assurance that such power would be delivered under reasonable terms. Transmission and distribution companies would be obligated to plan for adequate capacity for all anticipated needs, as in scenario 4.

Technical Implications of the Scenarios

Any proposed change raises uncertainty as to how well the new system will work, though competitive changes to date have been assimilated. **There is no point at which increased competition becomes clearly infeasible. Rather, increasing competition expands the institutional modifications required and raises the uncertainty of success in maintaining reliability and improving economics. The** feasibility of these scenarios depends largely on developing new institutional relationships among suppliers, consumers, and transporters to preserve the coordinated operation and planning of the power system. Implementing these new relationships is likely to require some new physical facilities and improved analytical capabilities. Without careful preparation, changes to the institutional structure of the industry can affect the operation of this system in ways that are not necessarily obvious.

Scenario 1 would produce only evolutionary changes in competition and industry structure. Utilities would continue to build most new capacity and coordinate the power system. Thus no major technical challenges are likely to appear as a result of implementing scenario 1.

The major technical impact of scenario 2 will bean increase in the required level of analysis of transmission availability and costs. One difficulty with increasing access to the transmission system is that transmission capacity is a matter of trade-offs and assumptions, not an objectively defined limit. Additional information and analysis of availability, costs, and reliability of transmission services would be needed by the operators of the transmission networks, suppliers of power including utilities and nonutility generators, and regulators. In addition, some increase in system complexity is expected (with more actors and more transactions), resulting in a need to upgrade control centers and AGC systems. New procedures for dispatch and scheduling of wheeling would be required. Additional generation and transmission reserves might be needed to account for increased uncertainty or loss of coordinated control.

The technical challenges of scenario 3 would be similar. Control of generation will be more complicated if many different entities are responsible for generation. Analysis will be required to operate the system most efficiently and allocate costs and benefits. Procedures will need to be developed to ensure economic dispatch. Regulators and utilities will also have to quantify the value of supply characteristics such as dispatchability, fuel diversity, location, and risk of project failure. Reserve margins for both generation and transmission might have to be increased to allow for uncertainties, though this might be balanced by a trend toward smaller, dispersed generating units.

Scenario 4 differs from 3 largely in the rate and extent of change. Instead of incremental competition with just new generation (which is only several percent per year), utilities would rapidly spin off their generating facilities. Substantially new operating and planning procedures would have to be developed and implemented rapidly. Maintaining coordinated generation and system reliability will present significant challenges. Rapid change is riskier than gradual change because mistakes can become widespread before they are recognized. If not done well, the result could be lower reliability and higher costs.

Scenario 5's common carrier wheeling and complete separation of generation, transmission, and distribution into separate companies compound the risk and uncertainties of scenario 4. Coordinated operation of the bulk power system will require careful definition and unbundling of services for wheeling as well as generation. Transmission companies will have to be particularly alert to potential problems since they will have only contractual control over generation and possibly incomplete control over the use of the transmission system. As in scenario 4, the rapidity of change greatly increases the likelihood of making expensive mistakes.

Regional Differences

Conditions that will affect the desirability and feasibility of competition vary widely across the country. Some impacts will be local and utility-specific.

Scenario 1 would affect existing State regulatory programs though some States have already incorporated elements such as prior review and certification of new capacity needs. Most States have allowed recovery of prudent investment on abandoned plants and require utilities to submit long-range plans for generation and transmission requirements. However, no State has initiated all the provisions of scenario 1. Some increase in regulatory activity would be required, especially in States with traditional approaches to ratemaking (primarily in the West and Southeast). Lowered avoided cost payments might reduce QF growth, particularly in California, Texas, and Colorado.

Scenario 2 could have significant local impacts. The encouragement of QFs and greater access to the transmission system could increase wheeling, though the degree cannot be predicted confidently. Power wheeling from low-cost suppliers to high-cost areas should increase, possibly reducing rates in those areas, depending on local conditions. If scenario 2 results in a large net increase in system demand, the stresses on already heavily loaded systems would increase and create pressure for new capacity. The areas most likely to be seriously affected are the East Central Area Reliability Coordination Agreement (ECAR), the Mid-Atlantic Area Council (MAAC), the Northeast Power Coordinating Council (NPCC), the Electric Reliability Council of Texas (ERCOT), and the Western Systems Coordinating Council (WSCC).

The impacts of scenario 3 will depend largely on how competitive procurement is implemented, and will not be great for at least a decade, especially in States with little need for new generating capacity. Specific provisions in solicitations and nonprice considerations can determine who is willing to bid. Small generators and renewable energy could be disadvantaged unless protected. Regional price discrepancies should diminish over time as low-cost power is bid up and wheeled, displacing high-cost suppliers. Areas that become heavily dependent on NUGs must be especially careful to properly integrate these facilities or they risk lowered reliability. State regulatory activity could increase significantly.

Scenario 4 would accelerate the impacts of scenario 3, and introduce questions of equity, the viability of competition, and the role of State regulation. Prices to consumers are largely unpredictable if this scenario is imposed rapidly. Some regions may not have enough viable suppliers to sustain a competitive market. In regions with no surplus generating capacity, low-cost power from older plants could suddenly increase in price. Newly independent generators could also flee an existing service area to sell in a higher price region, creating instability in the supply. Regions with a strong transmission network arrangement might have an advantage in creating the necessary institutional infrastructure for separate transmission utilities. Thus costs and benefits are likely to vary widely.

Scenario 5 shares many of the impacts of scenario 4, but is even more extreme and unpredictable because there are few precedents for determining how a common carrier transmission network would work. Multi-State common carrier companies will require considerable attention from Federal and State regulators.

Economic and Institutional Impacts

While it can be stated with reasonable confidence that any of the scenarios can be made to work if carefully defined, increased competition involves significant economic uncertainties. **Success depends on the ability of competitive suppliers to function more efficiently than utilities to overcome any additional costs from increased difficulties of coordination. It is not clear how extensive the opportunities for improved efficiency are, how costly maintaining coordination will be, or how much wheeling would increase if a "broad public interest standard" for transmission access is implemented.** Thus the economic merits of scenarios 2-5 cannot be predicted accurately.

It is likely that the costs and benefits would be unevenly distributed, depending on specific utility and local factors. Scenarios 4 and 5 present the greatest uncertainties, especially during the transition phase. Balancing the interests of consumers, utility shareholders, and new entities will be particularly difficult if existing, rate-based assets are spun-off to competitive generating companies.

The “rolling prudence” of scenario 1 could result in greater reassurance to utilities interested in building large coal or nuclear plants, but a survey of utilities did not provide much support for the concept. Only a few believed that rolling prudence would eliminate regulatory uncertainty, which is only one of several disincentives working against these plants.

Under scenarios 3-5 utilities will have to unbundle many of the services they now provide internally-dispatch, maintenance scheduling, new construction, etc.—and arrange to have them accomplished under contract with other companies. If contracts are prepared carefully they may serve as well as internal control, but they will require considerable foresight and analysis, and may be less flexible in meeting changing needs.

SITING, ENVIRONMENTAL, AND HEALTH ISSUES

Increasing competition and opening up the transmission grids raise many public policy issues beyond the technical and institutional feasibility of accommodating these changes. Three of the most significant and potentially contentious of these issues are: transmission line siting, environmental impacts, and potential public health effects of electric and magnetic fields.

Siting

There is a widespread perception in the industry that siting new electric transmission lines has become almost impossible because of the obstacles encountered in the process of regulatory review and approval. While there are a number of well-publicized cases where construction of transmission lines has been delayed or prevented as a result of public opposition in the siting process, these cases are the exceptions, not the rule. The process of gaining approval for transmission line construction has become more formalized as opportunities have been provided for public involvement and greater scrutiny of potential environmental and social impacts of proposed projects. Competition for land to route transmission lines has become more intense and right-of-way costs are increasing. Nevertheless the Nation's transmission networks have continued to grow. According to a survey of State agencies by the National Governors' Association and the National Association of Regulatory Utility Commissioners, more than 515 requests for transmission lines have been filed with State agencies in the last 10 years, and all but 18 have been approved.[7] The survey did not distinguish between major, high power lines and short, noncontroversial lines, but it shows that the licensing process generally is still a routine (though sometimes difficult) process.

Planned investment in new transmission lines has been declining. At least part of the reduction in planned new transmission projects reflects the completion, deferral, or cancellation of associated generating facilities. Eventually, however, new and expanded transmission systems will have to be built to provide an adequate and reliable power supply, whether a competitive future path is taken or not. The challenge for industry and regulators is to create a system which plans for and encourages needed expansion while at the same time accommodating other competing interests, and resolving or minimizing conflicts.

Environmental Impacts

Overall, neither expanded competition nor increased transmission access is inherently incompatible with national environmental objectives. None of the scenarios is demonstrably preferable on environmental grounds, but uncertainty over impacts increases with the degree of change from the status quo.

Decisions over the future structure and composition of the electric power industry in the United States have direct environmental impacts from shifts in the choice of fuels used for generation and in requirements for increased transmission

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

with increased competition. However, it is not clear at this point what shifts would occur.

One possibility is that competition could encourage the protracted operation of older, dirtier generating facilities which otherwise would have been retired by a utility.[8] Competitive generators may not use the same fuels and generating technologies as traditional utilities, which would result in a different mix of pollutants. The first solicitations for competitive generation in Massachusetts suggested a wide variety of fuels will be used, including coal and trash. Alternatively, if competition discourages the development of environmentally benign but economically risky alternative energy technologies, the net effect would be negative for the environment and human health.

However, none of these arguments is conclusive, and competition could prove beneficial for the environment. Many observers believe that reliance on competitive bidding for new generation could cause a shift toward natural gas and oil (though under some schemes the purchasing utility could express a preference for specific fuels). Both have been cleaner fuels than coal, but are not entirely devoid of pollutants. Furthermore, recent technology such as fluidized bed combustion permits coal to be burned very cleanly even in small plants, suggesting that air pollution can be tightly controlled under any scenario. Thus the environmental impacts are not a clear function of the competitiveness of the industry structure, but the possibility exists for some significant unintended effects.

Transmission line construction, operation, and maintenance also create direct and indirect impacts on the environment. Concerns often center on land use, aesthetics, destruction of forests and wildlife, corona discharges, and the biological effects on human health (discussed below). These are the primary issues affecting siting disputes. Several of the scenarios are likely to increase demand for transmission services. As capacity is expanded (new lines and greater use in existing corridors) the number of such disputes and the environmental impacts of transmission will increase.

Health Effects

Until relatively recently, there was little or no scientific evidence that power frequency fields could pose a threat to human health. However, laboratory studies have now demonstrated that even relatively weak electric and magnetic fields have effects on living cells and systems. Scientists are still investigating whether these effects have public health implications. In addition, several recent epidemiologic studies have suggested an association between exposure to electric and magnetic fields and cancer. While these epidemiologic studies are controversial and incomplete, they do provide a basis for concern about effects from exposure.

The research results to date are complex and inconclusive. Many experiments have found no differences in biological systems that have been exposed to fields and those that have not. **It still is not possible to demonstrate that such risks exist, and they may not. However, the emerging evidence no longer allows one to conclude that there are no risks.**

If power frequency fields do prove to pose human health hazards, the implications for the electric power industry will be great whether competition is encouraged or not. Already, health effects are one of the most prominent concerns raised by people living near existing or proposed transmission lines. However, it is important to recognize that exposure from high-voltage transmission lines is only one, perhaps minor source. Exposure to local electric distribution lines, appliances, lighting fixtures,

[8] The argument is that many old, fully depreciated plants are no more expensive to operate than new plants, but rate regulation provides limited incentive to keep them on line. If a utility can spin off this asset, as in scenario 4, the value of the plant would rise considerably, and it would be worth operating longer. A counter argument is that competition will drive down the costs of new plants, making older plants less competitive. Individual cases are likely to hinge on specific costs as well as on how competition is implemented.

and wall wiring are more common and could play a more significant role in any public health risks.

POLICY

Even without legislative action, the competitive generation segment in the electric power industry is growing. Also FERC and the States are incorporating a greater reliance on market forces in existing regulatory standards and procedures. These trends are likely to continue. There is no crisis mandating immediate action by policymakers. However, the structural changes sought and the way in which they are effected have major public policy implications worthy of congressional consideration. If Congress wishes to encourage increased competition and transmission access, several technical and institutional changes could help ensure that the electric power system operates reliably and economically.

The policy options discussed here are not directed at implementation of the OTA scenarios.[9] Rather, the policy discussion focuses on three areas of potential congressional concern: the technical and institutional changes that must occur to assure that the reliability and economy of operation of the bulk power systems do not suffer in any competitive transition; the lack of information, analysis, and experience to support decisionmaking about electric power industry structure and regulation; and the broad public policy questions that will be central to any debate over fundamental changes in the regulation of electric utilities and bulk power markets.

Maintaining Reliability and Economy of Operation

The key technical/institutional issue that has been identified in this analysis is how to maintain the coordinated planning and operation of the bulk power systems as competitive trends result in a growing separation of ownership and operation of generation and transmission facilities. Responsibility for establishing an adequate technical framework to support a more competitive generating sector or increased transmission access will fall largely on the utilities, the competitive generators, and several voluntary and professional associations. Federal and State policymakers can further some of the required changes and will have a major oversight role in determining whether the changes are proceeding in the public interest.

Technical Requirements for Competitive Generation

Additional information and research are needed to establish a firm technical foundation in the key areas of: a) load following and system support and b) coordinated planning. Unbundling generation and bulk power system support functions will require development of new standards, analytical methods, and data collection and accounting practices that are acceptable to all or most participants. Additionally, the extent of system support and reliability services that integrated utilities now provide internally or cooperatively will have to be defined and the costs evaluated so that they can be properly allocated in an unbundled competitive system. Appropriate contractual arrangements or regulatory guidelines will need to be devised to assure compliance with load following and other responsibilities and to require information sharing.

Federal and State regulatory agencies can aid in the development of adequate technical and institutional responses to the challenges created by unbundling through:

1. establishing clear guidelines for determining and allocating the costs of providing unbundled services and system support;
2. establishing minimum or standard bulk power contract provisions that provide for the necessary technical conditions of gen-

[9] Scenario 1 could be implemented with State action and some Federal regulatory changes, but scenarios 2 through 5 would require Federal legislation and corresponding changes in State law and regulation.

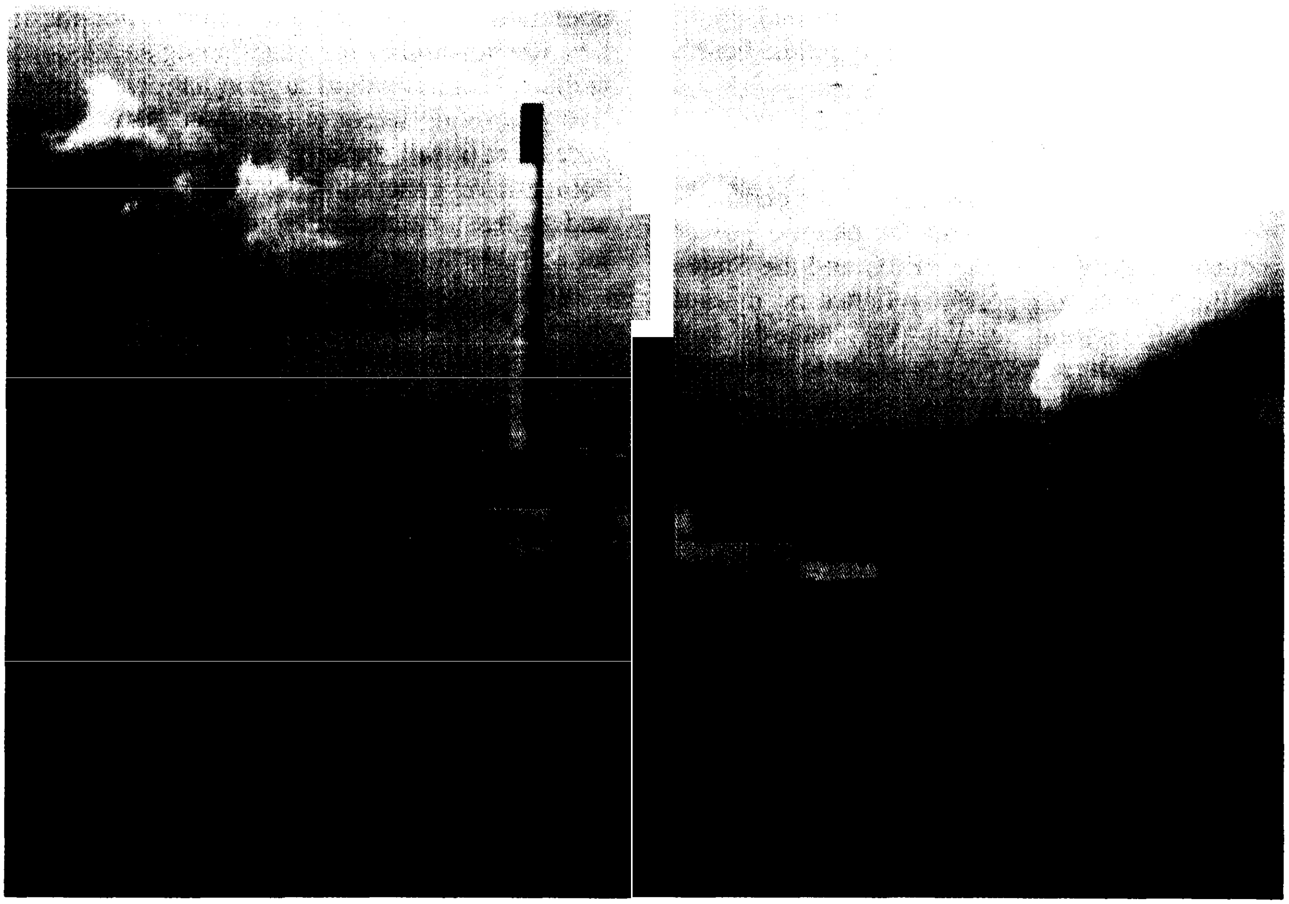


Photo Credit: Casazza, /scgyktz Associates, h.

Coal-fired power plant

eration control, coordinated operations, and system support obligations; and
3. requiring that competitive supply contracts contain adequate enforcement and default terms to assure that power supplies will continue to be available.

In addition, revised planning methods maybe required to integrate competitive power supplies into utility resource plans and operating guidelines and to accommodate the new uncertainties that they may bring. State regulators could change their utility planning programs to require more detailed information on resource needs and technical standards. Regulatory agencies may have to adopt a systematic process to ensure that reasonable choices are made for generation type and location, and transmission capacity, perhaps requiring expanded State involvement in planning.

Technical Requirements for Transmission Access

A greater diversity among generators and bulk power customers and an increase in wheeling will create a need for new methods of coordination, capacity evaluation, compensation for unbundled transmission services, and regulation. The actions that could be taken by Federal and State governments include:

1. funding research needed to resolve common problems in transmission availability standards, costing and pricing of transmission services, and minimum contract provisions for wheeling services;
2. reviewing and modifying existing regulatory practices to assure effective oversight of transmission contracts, pricing, and impacts on other interconnected systems;
3. encouraging consideration of overall regional transmission capacity needs in utility transmission planning activities;
4. requiring FERC to act promptly in setting guidelines or rules for determining and allocating the costs of unbundled transmission services, including reliability support; and
5. requiring FERC or DOE to perform more detailed study of the technical and institutional changes required to provide transmission access in a more competitive industry and to report back to Congress on any desirable legislative changes.

Strengthening the Transmission System

No systematic review of the Nation's transmission system's constraints and bottlenecks has been conducted recently to determine whether bulk transfers can be increased or how much additional access could be easily accommodated. Congress could commission a new detailed study of the capability of the transmission systems to serve projected needs and to respond to emergency situations. Two earlier federally sponsored studies of the Nation's power grid proved useful for improved system operations, and an updated study could be essential for potential industry restructuring, future planning, and regulatory oversight. New analytical techniques for measuring transmission capacity and availability are also needed.

Congress could also encourage better information gathering and more frequent assessments of transmission capacity needs by FERC and DOE in cooperation with State utility commissions. These efforts could complement ongoing efforts by industry groups, such as NERC.

Better Information and Analysis for Public Decisionmaking

This report has noted a dearth of information, analysis, and experience to support policy decisions over whether further competitive changes should be adopted and how they could best be implemented. Additional research and information are needed on:

- bulk power markets,
- transmission system capabilities,
- nonutility generation,
- potential efficiency gains from expanded competition,
- alternatives to competition to achieve similar cost savings, and
- impacts of competition on other Federal energy and environmental goals.

The uncertainty resulting from this lack of information could seriously hamper Federal and State regulators' efforts in: 1) assuring the fairness and competitiveness of the bulk power market, 2) assuring continued reliability of the system, 3) protecting the interests of consumers, and 4) achieving other energy policy goals. The uncertainties also could hinder efforts of power buyers and sellers to make arrangements for competitive bulk power sales and wheeling transactions that are adequate to protect system reliability.

Congress could direct DOE and FERC to expand their information gathering and analysis activities to provide more accurate, timely, and usable information on bulk power transactions and wheeling. The existing competitive experiments could be more rigorously analyzed to provide necessary data to proceed to the next stage of competition. For example, the Southwest experiment was not conducted in a way that provided this information. The initial efforts by several States to initiate bidding procedures also could provide critical information if analyzed promptly.

Finally, it is important to resolve concerns over the possibility that exposure to electric and magnetic fields may pose human health hazards no matter how the electric power industry evolves. If such hazards exist, health considerations will likely create additional constraints on siting of transmission lines. Funding for additional research on health effects and potential remedial measures could resolve some of the uncertainties and permit better decisions on protecting public health and on siting transmission lines.

Expanding Competition—Institutional and Public Policy Issues

Proposals for changing the regulatory and institutional structure of the bulk power industry raise many legislative issues. Most major strategies for significantly expanding competition will require congressional action to eliminate institutional and regulatory problems and to assure orderly development. It is also possible that growth of a competitive generation sector may be so rapid that congressional or regulatory action may be required to allow the regulated transmission and distribution sectors adequate time to adjust their own operations and procedures. Among the major public policy issues likely to arise under alternative paths of industry change are: encouraging broader market participation, expanding transmission access, and establishing an appropriate balance in Federal and State regulation of electric power.

Enhancing Bulk Power Competition

Congress can affect the rate of increase of competitiveness even without legislation by encouraging or discouraging FERC's proposed rulemaking and other regulatory initiatives. In addition, Congress could direct FERC to prepare a report evaluating the effectiveness of the existing limited experience with competitive markets before revising Federal utility regulation on a broad scale.

If Congress chooses to encourage the trend toward competitiveness, it could remove some of the constraints imposed by existing law on potential participants in a competitive generating sector. Modifications to the Federal Power Act, the Public Utility Regulatory Policies Act, and the Public Utility Holding Company Act have been suggested by utility and independent power groups as a means to attract potential new competitors in bulk power markets. Generally, the proponents argue that the amendments would lessen constraints created by either direct limitations on participation by utilities and others in the independent generating sector or by disincentives associated with the regulatory requirements imposed on public utilities. It should also be noted, however, that changes in these laws would be controversial and could undercut other important public policy goals.

Expanding Access to Transmission Services

Under existing law, most transmission access and wheeling arrangements are the result of voluntary, negotiated agreements. Pressures for utilities to allow access to their grids will grow with the competitive bulk power market. But it is not clear that under existing laws transmission access will expand rapidly enough so as not to be a constraint on market participation. FERC has only limited authority to order utilities to provide wheeling services. If Congress chooses to address transmission access problems, there are several alternative approaches available. Congress could direct FERC to change administrative processes and transmission pricing policies to encourage access. Congress could amend the FPA and PURPA to provide more expanded wheeling authority. One possibility would be to repeal the more restrictive aspects of the existing wheeling provisions and allow FERC to order wheeling in appropriate cases under a broad public interest standard. Congress might also consider whether a more direct Federal role is needed in encouraging expansion of transmission capacity though authorization of more cooperative State planning efforts and/or expansion of regional transmission services provided by Federal power agencies.

Striking a Balance Between State and Federal Jurisdiction

Federal jurisdiction over electric power regulation has been growing at the expense of State regulation. This trend will accelerate under a competitive bulk power market structure unless Congress changes existing laws to limit or override Federal court and agency decisions. Examples of possible congressional remedies include: returning jurisdiction over instate wholesale transactions to State authorities, giving States jurisdiction over instate wheeling activities, and requiring FERC to defer to State regulators in matters of prudence and resource planning.