Nos. 00-568 and 00-809

In the
Supreme Court of the United States

STATE OF NEW YORK, ET AL., *Petitioners*,
v.
FEDERAL ENERGY REGULATORY COMM'N, ET AL.

ENRON POWER MARKETING, INC., *Petitioner*,
v.
FEDERAL ENERGY REGULATORY COMM'N, ET AL.

On Writ of Certiorari to the United States
Court of Appeals for the District of Columbia Circuit

BRIEF *AMICUS CURIAE* OF ELECTRICAL ENGINEERS, ENERGY ECONOMISTS AND PHYSICISTS IN SUPPORT OF RESPONDENTS IN NO. 00-568

CHARLES J. COOPER
Counsel of Record
BRIAN STUART KOUKOUTCHOS
COOPER & KIRK, PLLC
Suite 200
1500 K Street, N.W.
Washington, D.C. 20005
(202) 220-9600

May 31, 2001

TABLE OF CONTENTS

TABLE OF AUTHORITIES

Cases **Page**

Statutes

Administrative Cases & Orders

Miscellaneous **Page**

Miscellaneous **Page**

INTEREST OF AMICI CURIAE

Amici curiae are electrical engineers, economists, and physicists specializing in the study of electricity and the operation of electric power systems. They have an abiding professional interest in the proper regulation of the ever more important electric energy industry.[1] American dependence upon electric energy has nearly doubled in the last three decades as the nation steadily moves beyond fossil fuels. Electricity's share of U.S. primary energy use is expected to reach 46% by the year 2010. J. Duncan Glover & Mulukutla Sarma, POWER SYSTEM ANALYSIS AND DESIGN 8 (1994).

The division of state and federal regulatory jurisdiction set forth in the Federal Power Act of 1935 was deliberately drawn by Congress in accord with the scientific and engineering realities of electric power generation, transmission, and distribution. As scholars and consultants specializing in those fields, *Amici* respectfully submit this brief as an aid to this Court's understanding of those principles of physics and engineering, and their relevance to the application of the "engineering and scientific test" that Congress has prescribed for deciding questions of federal jurisdiction. Counsel of record for all parties have consented to the filing of this brief.[2]

SUMMARY OF ARGUMENT

Congress wrote the Federal Power Act ("FPA") in the language of electrical engineers and mandated that federal jurisdiction follow the flow of electric energy — an engineering

---

[1] The qualifications of and positions held by *Amici* are set forth in Appendix B, bound with this brief. *Amici* appear here in their individual capacities as scholars, scientists and engineers, rather than as representatives of the institutions with which they may be affiliated. This brief has been financed by the *Amici* with support from DYNEGY, Inc., and Coral Energy. No counsel for any party authored this brief in whole or in part, nor did any party make a monetary contribution to the brief.

[2] Letters of consent have been filed with the Clerk.

and scientific, rather than a legalistic or governmental, test. Yet the state public service commissions ("PUCs") challenging FERC's jurisdiction under Order 888 misunderstand the physics of electric energy and how it is transmitted, and therefore misapply the FPA's test for federal jurisdiction.

The PUCs base their argument for restrictions on FERC jurisdiction on an inaccurate and misleading metaphor. They imagine electrons entering one end of a transmission wire at a generating plant, flowing through the wire like drops of water through a pipe, and then emerging at the other end of the wire in a lightbulb in a home. They imagine electrons as discrete items whose transmission can be controlled, directed and traced. They extend this metaphor to argue that FERC does not have jurisdiction to regulate the interstate transmission of such a stream of electrons unless it can show that every electron used by a retail customer in each state is generated in a different state.

But this is not how electricity works. *Energy* is transmitted, not electrons. Energy transmission is accomplished through the propagation of an electromagnetic wave. The electrons merely oscillate in place, but the *energy* — the *electromagnetic wave* — moves at the speed of light. The energized electrons making the lightbulb in a house glow are not the same electrons that were induced to oscillate in the generator back at the power plant.

Electric energy on an alternating current network *cannot* be addressed like a phone number or an e-mail and dispatched to a particular recipient over a prescribed and fixed pathway. Energy flowing onto a power network or grid *energizes the entire grid,* and consumers then draw undifferentiated energy from that grid. A networked electric grid flexes, and electric current flows, in conformity with physical laws, and those laws do not notice, let alone conform to, political boundaries. If the transmission lines of the system cross state boundaries, then electric currents on the system necessarily do likewise. With the exception of transmissions on the electric grids isolated in the states of Hawaii, Texas, and Alaska, *all* transmissions are interstate because *all* transmission lines are part of one of the two vast

American electric grids that span multiple state boundaries. The State PUCs' arguments to the contrary defy established principles of physics and electrical engineering.

The PUCs misunderstand power system structure and operation and therefore misapprehend the division of state and federal jurisdiction under the FPA. They try to rewrite the vocabulary for electric regulatory discourse by introducing new concepts of "retail transmission" and "wholesale transmission." These terms are fabrications that do not appear in the FPA. "Wholesale" and "retail" are transactional terms, which is why the FPA uses them only to distinguish types of *sales*. These terms have no relevance to the *transmission* of electricity.

The PUCs would like to pretend that the world has not changed since 1935. They contend that the massive increase in interstate, interconnected electric networks is not relevant to the jurisdictional issue because this change did not alter the FPA's language. The PUCs accuse FERC of trying to rewrite the FPA's jurisdictional assignments to invade the regulatory sphere reserved to the states.

There has been no change in the FPA's text or interpretation. The jurisdictional lines drawn in the FPA are still the same: the states get generation, distribution, and intrastate transmission, while FERC gets interstate transmission. What has happened is that the electrical system being regulated has changed. Interconnected networks and interstate transmissions were few and far between in 1935; today every high-voltage transmission line in the continental U.S. (outside Texas) is wired into one of the two vast interstate grids. Thus, the electrical transmission system has become inherently interstate — and has thereby grown away from the state regulatory territory defined by the FPA and grown into federal territory.

ARGUMENT

In the Federal Power Act, 16 U.S.C. § 824(b)(1), Congress allocated regulatory jurisdiction over electric energy along lines drawn, in effect, by electrical engineers.[3] That is, the electric power industry was divided into three categories — generation, local distribution, and transmission — and the states were given jurisdiction over "facilities used for the generation of electric energy or over facilities used in local distribution," while the Federal Power Commission (now known as FERC) was given jurisdiction over "the transmission of electric energy in interstate commerce." *Id*.

Accordingly, this Court has long held that the question of federal vs. state jurisdiction under the FPA turns in large part on the physical realities of science and electrical engineering. Congress wrote the FPA "in the technical language of the electric art" and decreed that "[f]ederal jurisdiction was to follow the flow of electric energy, an engineering and scientific, rather than a legalistic or governmental, test." *Connecticut Light & Power Co. v. FPC*, 324 U.S. 515, 529 (1945). Thus here, as in so many previous cases, it is an "'engineering and scientific test' that controls this case." *FPC v. Florida Power & Light Co.*, 404 U.S. 453, 467 (1972).

Amici curiae, as engineers and other experts schooled and experienced in the "electric art," submit this brief as an aid to the Court's understanding of this "engineering and scientific test." In particular, *Amici* are concerned because the parties challenging FERC's jurisdiction under Order 888 misapprehend and misrepresent the realities of the electric power system. We will first explain some of the fundamentals of physics and engineering relating to (1) the transmission of electricity and (2) the structure, operation and historical development of the electric power system. We will then apply those fundamentals to the arguments of those opposing FERC's jurisdiction.

---

[3] 18 U.S.C. § 824(a)-(e) codifies the FPA § 201(a)-(e). In conformity with the parties' practice, the FPA will usually be cited by reference to its original section numbers rather than as codified in the U.S. Code.

I. THE PHYSICAL REALITIES OF THE TRANSMISSION OF ELECTRICITY.

The State Public Service Commissions ("PUCs" or "States"), which argue for restrictions on FERC jurisdiction over the transmission of electricity, base their argument on an inaccurate and highly misleading, albeit popular, metaphor of electrons flowing down transmission wires the way water flows through a pipe or blood cells flow through a vein. Metaphors are of course familiar elements of human discourse, but care must be taken in their use. "Half the wrong conclusions at which mankind arrive," Palmerston once observed, "are reached by the abuse of metaphors, and by mistaking general resemblance or imaginary similarity for real identity." P. Guedella, PALMERSTON 226 (1927). The problem is that a metaphor can convey a multitude of properties or characteristics, and not all of them may be appropriate as resemblances to the object or concept that is being described by the metaphor.

> [I]t has to be remembered that every image is true and helpful only at its relevant point. God is, in a manner, light: but He is not a succession of wave-lengths in the prime matter . . . . [N]early all heresies arise from the pressing of a metaphor beyond the point where the image ceases to be relevant.

D. Sayers, THE POETRY OF SEARCH AND THE POETRY OF STATEMENT 284 (1963). Therefore, "[m]etaphors in law are to be narrowly watched, for starting as devices to liberate thought, they end often by enslaving it." *Berkey v. Third Ave. Ry.*, 224 N.Y. 84, 94, 155 N.E. 58, 61 (1926)(Cardozo, J.).[4]

---

[4] *See generally* Michael Boudin, *Antitrust Doctrine and the Sway of Metaphor*, 75 GEO. L.J. 395, 414-16 (1986); Brian Koukoutchos, *Constitutional Kinetics: The Independent Counsel Case and the Separation of Powers*, 23 WAKE FOREST L. REV. 635, 643-46 (1988).

The State PUCs indulge in the metaphor that electrons, like water molecules or blood cells, are discrete physical entities that flow though a transmission pipeline. Electrons are deemed to be individual products "generated" in one place by an electric dynamo, then "carried" through a transmission wire where they "mingle" with other electrons, and ultimately "consumed" by a customer to power a lightbulb or appliance. *See* State PUCs Br. in No. 00-568, at 42, 43, 43-44, 45 & nn.27-28. The States extend this metaphor to argue that FERC does not have jurisdiction to regulate the interstate transmission of such a stream of electrons unless FERC can "show that essentially every electron used by a retail customer in each state . . . is generated in a different state." *Id.* at 45 n.27. *See id.* at 43-44.

This is not how electricity works. Water pipe metaphors for the transmission of electricity are popular, *see, e.g.*, Larry Gonick & Art Huffman, THE CARTOON GUIDE TO PHYSICS 131 (1990), but misleading. The "thing" that is transmitted by the wire conduits suspended from those high-tension towers one sees is *energy*, not electrons. The State PUCs imagine electrons entering one end of a transmission wire at a hydroelectric plant, flowing through the wire like water through a pipe, and then emerging at the other end of the wire in a lightbulb in a home. But electricity is not an accumulation of electrons. It is the class of physical phenomena arising from the existence and interactions of electric charge. Electric charge is one of the fundamental properties of matter. Generators do not "generate" electrons — they do not create electrons from nothing. Nor do toasters and air conditioners "consume" electrons. Electrons are not generated or consumed — but *electric energy* is. Electrons do not "flow" — but *electric current* does.

Energy, or more precisely current, is indeed measured in terms of the net charge (that is, the electrons) flowing across an area per unit of time.[5] However, it is not these electrons that travel at the speed of light and so transmit energy from generator to consumer. The electrons that actually move through the conducting wire, hopping from one atom to the next, pressed on by the electromotive force created at the generating plant, move much too slowly to transmit much energy. These electrons collide with atoms along the way, giving up some energy as heat (which is why an electrical appliance and the wire leading from it to the plug in the wall become warm).

This broken-field running of electrons through the conducting wire is known as drift velocity and it is quite slow — less than one inch per second, as compared to 186,282 *miles* per second, which is the speed of light and the speed at which electric *current* flows through a transmission line.[6] And in an *alternating current* ("AC") system, the dominant form of energy transmission in the United States, the flow of current reverses course sixty times a second. Therefore, the electrons *oscillate* back and forth, moving in unison one way, then back the other way, without net movement over time. Hence the movement of electrons from one atom to the next through the wire transmits little energy.

The real energy transmission is accomplished through the propagation of an electromagnetic wave. Each electron is induced, under the effect of the electromagnetic wave generated at the power plant, to repel the electron in the next atom. Assume that energy is being transmitted left to right in a wire.

---

[5] The unit of electric charge is the coulomb. The unit for electric current is the ampere, equal to one coulomb per second. The unit for all types of energy is known as the joule, and the quantity of one joule per coulomb is a volt. Finally, the unit for power, the rate of transfer of energy, is the watt, which can also be represented as the product of voltage and current.

[6] The value of 186,282 miles per second is the speed of light in a vacuum. Energy travels slightly slower in any other material such as the copper conduit of an electric transmission line.

Each electron repels its right-hand neighbor, because they are both negatively charged and similar charges repel each other.[7] This ripple effect can be envisioned as each electron elbowing its neighbor toward the next right-hand neighboring electron, which in turn elbows the next electron, and so on down the power line. The electrons move very little, merely oscillating in place, but the *energy* — the *electromagnetic wave* — moves at the speed of light. The energized electrons making the lightbulb in a house glow are not the same electrons that were induced to oscillate in the generator at the generating plant.

Consider the familiar desktop toy of five or six shiny ball bearings suspended by wires from a pair of parallel horizontal bars. You lift the ball bearing on one end and allow it to fall and strike the neighboring ball bearing, and the first bearing and all the ones in the middle remain still while the bearing at the far end of the line absorbs the energy and swings out and up. The middle ball bearings, like the electrons in a transmission wire, are instrumental in *transmitting* the energy, but they do not themselves *travel* with that energy.

The water flowing in a pipeline differs from the electric current flowing in a transmission line in other respects. Water in a pipeline flows in one direction — away from the pump station to the homes of the users. And that flow is controlled and directed by the water company's staff who open and shut valves as needed. Not so for electricity. The path taken by electric energy is the path of least resistance (as determined in accord with an equation known as Ohm's Law)[8] — or, more accurately,

---

[7] The oscillation of the electrons, initially induced by the electromagnetic wave, is also instrumental in the propagation of the wave throughout the transmission network.

[8] Ohm's Law is: $I = V/R$ (current equals voltage divided by resistance). Thus the higher the voltage, the more current flows through a conduit of a given resistance. Strictly speaking, Ohm's Law applies to direct current (DC) systems. For AC systems such as a modern American power grid, the equation involves complex mathematics (*e.g.*, V and I are represented as

the *paths* of least resistance. When more than one path is available, the energy spreads out and flows on *each path* in inverse proportion to the electrical resistance (or impedance) of that path.

The impedance of a conducting wire varies under the influence of a number of factors, including the temperature and the diameter of the wire, but the salient point is that electrical energy on an AC network *cannot* be directed. If there is more than one path available between two points, power system operators simply do not have the ability to direct the energy from a particular generator to flow on a particular set of transmission lines to a particular user.[9] Electricity cannot be addressed like a phone number or an e-mail and dispatched to a particular recipient over a prescribed and fixed pathway. Energy flowing onto a power grid *energizes the entire grid,* and consumers then draw undifferentiated energy from that grid.

For the power system to work, all the electricity on a given network must be on the same nominal frequency (60 cycles per second in North America) and all of the power generators must be synchronized and operated in parallel while they are simultaneously energizing the common grid. William Stevenson, ELEMENTS OF POWER SYSTEM ANALYSIS 3 (4th ed. 1982). The entire system operates in "electromagnetic unity." *Florida Power & Light Co.*, 37 F.P.C. 544, 549 (1967), *aff'd FPC v. Florida Power & Light Co.,* 404 U.S. 453 (1972).

The application of the concept of electromagnetic unity to power grids is not a novel approach concocted by FERC to

---

vector values rather than scalar values and resistance is replaced by the concept of impedance). But the fundamental point remains the same.

[9] New technologies, including those known as FACTS devices, can assist operators in directing power flows to some degree, and a very small number are currently installed, for example, on the New York-New Jersey border. But their enormous cost prohibits their widespread installation for the foreseeable future.

justify the reach of Order No. 888. It is a fundamental premise of electrical engineering and it has been FERC's approach to jurisdiction over interstate transmission for at least 35 years. This Court summarized "the electromagnetic unity of response of interconnected electrical systems" in *Florida Power & Light*:

> None of the connected electric systems including that of [any particular utility] has any control over the actual transfers of power at each point of interconnection because of the free flow characteristics of electric networks . . . . An electric utility system is essentially an electro-mechanical system to which all operating generators on the interconnected network are interlocked electromagnetically. This means that electric generators, under ordinary operating conditions run either at exactly the same speed or at speeds which will result in a frequency of 60 cycles. No operating generator can change its speed by itself as long as it operates connected to the network . . . .
>
> If a housewife in Atlanta on the Georgia system turns on a light, every generator on Florida's system almost instantly is caused to produce some quantity of additional electric energy which serves to maintain the balance in the interconnected system between generation and load. If sensitive enough instruments were available and were to be placed throughout Florida's system the increase in generation by every generator . . . could be precisely measured.

404 U.S. at 460 (quoting Opinion of the Hearing Examiner, 37 F.P.C. at 567-68).

This understanding of the unity of electromagnetic response is anything but controversial. In *Florida Power & Light* itself, even the complaining utility company conceded that the approach was "technologically sound." 404 U.S. at 461-62. It could hardly have argued otherwise, for electromagnetic unity is dictated by a set of four fundamental physical principles known as Maxwell's Equations. The import of these rules is that the sum of electrical currents flowing into any point in a circuit must equal the sum of currents flowing out, and the sum of voltages around any closed loop in a circuit must equal zero.[10]

These rules explain (1) why physical events — such as the addition of electrical energy or an increase in electrical load — cannot be isolated on an interconnected grid, and (2) why energy flowing on an interstate grid cannot be cabined within an arbitrary geographical boundary. If a generator on the grid increases its output, the current flowing from the generator on all paths on the grid increases. These increases affect the energy flowing *into* each point on the network, which in turn leads to compensating and corresponding changes in the energy flows *out* of each point. The increased generator output also affects the electromagnetic fields and the voltages on the grid, which must adjust themselves to sum to zero around all closed loops within the system. The system flexes and the current flows in conformity with physical laws, and those laws do not notice, let alone conform to, political boundaries. If the transmission lines of the system cross state boundaries, then electric currents on the system necessarily do likewise.

FERC's characterization in *Florida Power & Light* of an interconnected power grid as unified in electromagnetic response

---

[10] Maxwell's Equations explain how oscillating electric fields (fields that vary over time) induce magnetic fields, and oscillating magnetic fields induce electric fields. The role of electric generators is to create these oscillating fields. Under certain conditions two of these equations can be used to derive a more familiar pair of rules known as Kirchhoff's Laws, which are rules for analyzing electrical circuits. Kirchhoff's Current Law states that the sum of electrical currents flowing into any node (point) in a circuit must equal the sum of currents flowing out. Kirchhoff's Voltage Law, based on one of Maxwell's Equations known as Faraday's Law, provides that the sum of voltages around any closed loop in a circuit must equal zero.

was based on a large administrative record of expert testimony. 37 F.P.C. at 549-50. That was the same type of electrical expertise to which this Court deferred in accepting FERC's conclusion that electrical energy from different sources is inevitably commingled in an electrical "bus" (an interconnection between two or more facilities). *Florida Power & Light*, 404 U.S. at 463 (affirming 37 F.P.C. at 550). When resolution of a question "depends on 'engineering and scientific' considerations," this Court "recognize[s] the relevant agency's technical expertise and experience, and defer[s] to its analysis." *Id.* at 463. Indeed, the Court concluded that passing "[j]udgment upon these conflicting engineering and economic issues is precisely" why FERC was created, and therefore deference is due "'so long as it cannot be said . . . that the judgment which [FERC] exercised had no basis in evidence and so was devoid of reason.'" *Id.* at 466.

Therefore, even though this Court declined "to approve or disapprove" the unity of electromagnetic response as an alternative ground for jurisdiction in *Florida Power & Light*, *id*. at 462-63, the principles of deference relied upon by the Court to decide that case support embracing the electromagnetic response approach to jurisdiction in this case.

II. THE STRUCTURE, OPERATION, AND HISTORICAL DEVELOPMENT OF THE ELECTRIC POWER SYSTEM.

A. Structure and Operation.

An electric power system consists of three principal divisions: *generation*, *transmission*, and *local distribution*. *See* Stevenson, *supra*, at 1.

Generation takes place at a power plant where a fuel such as coal, gas, oil, uranium or hydro power is used to spin a turbine which turns a generator to generate electricity.

Transmission lines connect the generating stations to the distribution systems (and also connect the entire utility power system to other power systems). *Id*. Transmission takes place on a network — a configuration of power lines connected so that multiple paths exist between any two points (or nodes) on the network. ABB Power T&D Co., INTRODUCTION TO INTEGRATED RESOURCE T & D PLANNING 10 (1994). This ensures reliability: if any one line fails, there is an alternate route and power is (hopefully) not interrupted. *Id*. As a result of the network arrangement, energy flows every which way on the grid, depending on where the load (demand for electricity) and generation are at any given moment, with the energy always following the path (or paths) of least resistance. Transmission is conducted at extremely high voltages — up to a million volts — because high voltage is necessary to deliver power over any significant distance. The 120 to 240 volt output of the wall sockets in an American home is insufficient to move power more than a few hundred yards. ABB Power, *supra*, at 4.

In addition to moving electricity, the transmission grid is vital to the stability of the power system. Indeed, much of the capital investment in transmission systems has traditionally been driven by the need for stability rather than the need to move power. By ensuring firm electrical ties among all generators, the grid enables even far-flung generators to stay electromagnetically synchronized with one another, which enables the system to function smoothly as the electrical load fluctuates and to pick up load smoothly if any generator fails. *Id*. at 10-11.

The *local distribution* system begins at a substation where electricity is received from the transmission lines and stepped down to a lower voltage by transformers. Simultaneously, the power flow is split to send power to a number of primary feeder lines that lead to other transformers that again step down and feed the power to secondary service lines that in turn deliver the power to the utility's customers. ABB Power, *supra*, at 6-7. Unlike the network arrangement of a transmission grid, more than 99% of all local distribution systems are designed as *radial* systems. *Id*. at 18. Radial systems are *closed* — once power is transmitted to them, it is delivered to customers. Electricity is not stepped up in voltage and put back on the transmission grid. Because there is only a single path between each customer and the substation, the route of power flow in a local distribution system is absolutely certain. *Id*. at 19. The consequence of this simplicity in design is that a radial feeder system is not as reliable as a network; if a falling tree takes down a feeder line during a storm there is no alternate route for power delivery. On the other hand, such an outage is isolated and affects only the customers served by that particular line; neighbors on a different radial line experience no blackout. *Id*. at 19-20.[11]

The most salient feature of a contemporary power system is *interconnection* — a group of individual utility company transmission networks that are themselves networked together. Transmission networks are connected by "tie-lines" over which companies share power. Energy may be bought and sold to economize: for example, if company X's electricity is less expensive to procure at a given time than Company Y's would be to produce, Y will buy electricity from X and have it transmitted over the grid. Energy may be bought when Company A cannot meet demand by itself: for example, if A depends heavily on hydroelectric power (as many western utilities do) and the region where A is located has been experiencing a drought that lowers river levels, or if A needs to take generating equipment off-line for repair or replacement.

---

[11] Thus, transmission is distinguished from local distribution by higher voltage, network configuration, and function. ABB Power, *supra*, at 9-10. Order 888 contains a seven-factor test for distinguishing facilities used for local distribution from those used for transmission: (1) local distribution facilities are in proximity to retail customers; (2) are radial in character; (3) power flows into them but rarely, if ever, flows out; (4) power within the distribution system is not reconsigned to some other market; (5) power is consumed in a relatively confined geographic area; (6) meters are placed at the transmission/distribution interface to measure flows into the distribution system; and (7) distribution systems are of reduced voltage. Order No. 888, FERC Stats. & Regs. ¶ 31,036, 31,770, 61 Fed. Reg. 21,540 (May 10,1996).

Thus, many energy transfers on the grid are pre-arranged by agreement between the parties. But even these transfers are achieved by having the supplying utility ramp up its electrical generators and having the receiving utility either ramp its generators down or simply not interrupt the demand on the grid, with the effect that net power flow over the tie-lines is in the direction of the desired exchange. Thus, this type of exchange confirms, rather than refutes, the proposition that the grid is electrically unified.

Moreover, this describes operation of a power grid only when everything goes according to plan — which happens no more often in the electric power industry than it does in any other part of life. The utility control systems described by the PUCs "are not perfect devices, with the result that there are regularly occurring instances [of] . . . inadvertent interchange." Allen Wood & Bruce Wollenberg, POWER GENERATION, OPERATION AND CONTROL 380 (1996). When a utility gets too far out of line in consuming power beyond the power-sharing plan agreed upon with its neighbors on the grid, this is known as "leaning on the ties." *Id*. Thus, because the individual utility networks are connected by a tie-line "which permits a free flow of power and energy throughout the networks," all the contributing utilities "operate in parallel and are interlocked electromagnetically," and any given utility company on the interconnection "has no control over the actual transfers of electric power and energy with any particular electric system with which it is interconnected." *Florida Power & Light*, 37 F.P.C. at 549.

Another category of inadvertent exchange is a system disturbance — a transmission line goes down or a generator is tripped off-line suddenly and power automatically flows to the newly deficient network before intervention by a system operator is possible. Syed Nasar, ELECTRIC ENERGY SYSTEMS 319 (1996). In such emergencies, the rotor dynamics of the various electrical generators linked on the interconnection are uncontrolled. Olle Elgerd, ELECTRIC ENERGY SYSTEMS THEORY: AN INTRODUCTION 478-79 (1971).

Finally, energy flows across the tie-lines that interconnect separate utility networks in uncontrollable ways due to parallel or loop flows. The problem is that the "contract path" for the electrical transmission agreed upon by the buyer and seller in negotiating the transaction has nothing to do with the route by which the power actually flows. Electrical energy follows the path of least resistance on the grid. The flow of energy is therefore said to be on a different "loop" of transmission lines, which are parallel (electrically speaking, *not* geographically) to the nominal "intended" path. Thus, the exchange of power may have been planned, but the route (or routes) that the energy took across the tie-lines of the grid was not planned — nor could it have been. This form of electrical interchange is up dramatically in recent years due to the growth in energy market transactions spurred by the advent of deregulation.

The structural, engineering differences between network-configured transmission systems and radially configured local distribution systems have important implications. On a network, events cannot be isolated. A physical event anywhere on a grid — a downed transmission line, a failed relay switch, a large generator coming on line — affects every other point on the network.

Perhaps the most dramatic illustration of this was the Great Northeast Blackout of 1965. *See* Bob McCaw, *The Great Blackout*, POWER ENGINEERING 36A-36C (Dec. 1965). When a single relay at a power plant in Ontario, Canada was set incorrectly on November 9, 1965, the 300 megawatt load being carried on the line controlled by that relay was immediately dumped onto the other lines emanating from that plant and they all tripped out, even though they were not overloaded. The 1600 megawatts being carried by those lines into Ontario were suddenly dumped on the New York system, and the resulting power surge knocked out the main east-west transmission line and a series of cascading tripouts shut down seven units that had been feeding the Northeast grid. The consequent drain on systems to the south (New York City) and the east (New

England) caused the whole system to collapse. The remaining plants could not handle the demand and as their generators struggled to make up the lost supply of electricity, automatic safeties shut down those plants to save them from damage. Loss of the upstate power plants caused an immediate, convulsive reversal of energy flow: for example, New York City, which had been drawing 300 megawatts from the network, now was trying to power not only the City but much of the rest of the state. At the height of the evening rush hour, darkness descended as thirty million people in eight states plus eastern Canada were blacked out.

It is therefore undeniable that the entire transmission network of a given interconnection must be operated cooperatively as one big, synchronized system. The North American Electric Reliability Council (NERC) was created as a voluntary industry organization in response to the 1965 blackout, with the goals of preventing such events through improved communication and coordinating the industry response when such events occur. NERC exists precisely because of the inescapable interdependence of the electricity network.

B. Development of Transmission Systems Since 1935.

Both Enron and the State PUCs agree that when the FPA was enacted in 1935, electricity was essentially a local business. State PUCs Br. in No. 00-568, at 27; Enron Br. at 6. *See* J. Duncan Glover & Mulukutla Sarma, POWER SYSTEM ANALYSIS AND DESIGN 7 (1994) (utilities were isolated systems); Nasar, *supra*, at 319 (originally limited to radial feeder systems for single towns); Stevenson, *supra*, at 2-3 (individual, isolated systems). The parties also agree that in 1935 only a fraction of America's electric systems were interconnected across state lines and consequently the vast majority of electrical transmissions were entirely intrastate. Enron Br. at 7; State PUCs Br. as Resp. in No. 00-809, at 26 (over 80% of transmissions were intrastate). Indeed, the first instance of two large power systems actually operating with an interconnection for a meaningful period of time did not occur until 1926, and even that operation was entirely intrastate. Nasar, *supra*, at 319. It is therefore unsurprising that interstate transmission was still in its infancy when Congress enacted the FPA in 1935.

As interconnection among neighboring utilities grew, *see* Glover & Sarma, *supra*, at 7-8, largely due to the pursuit of greater reliability and to technology that made transmission possible over longer distances with higher voltage, power companies isolated within a single state became virtually extinct. With the exception of some companies in Texas, *every* utility in the continental United States, coast-to-coast, is grouped into one of nine regions called Electric Reliability Councils that in turn constitute two huge interconnected networks: (1) Midwest and Eastern U.S. and (2) Rocky Mountains and Western. *See* Robert Sarikas, INTRODUCTION TO ELECTRICAL THEORY AND POWER TRANSMISSION 79-80 (1995). *All* transmission lines (outside the three states listed above) are connected to one of these two interstate grids. Order No. 888, at 31,781.

A map of the North American high voltage transmission system is included in Appendix A at A-1. If the transmission grid conformed to political borders, one could easily discern the boundaries of the 48 states. But as the second map at App. A-2 shows, without an overlay of the borders, a map of transmission lines is useless for defining even the American-Canadian frontier, much less the state borders. The transmission grid is interstate — indeed, inter*national* — and so is the electricity on that grid.

III. THE STATE PUCS MISUNDERSTAND THE PHYSICS OF ELECTRIC ENERGY AND HOW IT IS TRANSMITTED AND THEREFORE MISAPPLY THE FPA'S "ENGINEERING AND SCIENTIFIC" TEST FOR FEDERAL JURISDICTION.

Section 201(b)(1) of the FPA grants FERC jurisdiction over "the transmission of electric energy in interstate commerce," and section 201(c) provides that "electric energy shall be held to be transmitted in interstate commerce if transmitted from a State and consumed at any point outside thereof." 16 U.S.C. §§ 824(b)(1) & 824(c). Accordingly, the issue of federal jurisdiction becomes primarily a question of physics and electrical engineering: is energy transmitted on an interconnected grid that spans state borders transmitted from one state and consumed outside it?

With the exception of transmissions on the electric grids isolated in the states of Hawaii, Texas, and Alaska, *all* transmissions are interstate because *all* transmission lines are part of either the "Midwest and Eastern" or "Rocky Mountains and Western" interconnections. *See* App. A-2. Those interconnections span multiple state boundaries, and every watt of power generated in their territory is fed onto a network where it becomes part of a single, synchronized, inherently multi-state, electromagnetic waveform, from which undifferentiated electric energy is drawn and consumed by customers in every state on that interconnection. The State PUCs' arguments to the contrary defy established principles of physics and electrical engineering.

1. The State PUCs insist that "[m]ost electricity used in the U.S. is generated in the state where it is used." State PUCs Br. in No. 00-568, at 5. The only support proffered for this assertion is several statistical reports describing energy use in New York, Florida, and Idaho. Those reports do not even purport to confirm the State PUCs' assertion, nor could they, since all three states are on multi-state interconnections and there is simply no telling where the energy generated in those states goes once it is on the grid. Those reports establish, at most, only that these states each generate as much power every year as they consume. That may make these states annually self-sufficient in some bookkeeping sense. But that does not change the fact that, in the day-to-day operations of the utilities in these states, they are continuously interconnected with a unified interstate network energized by a single electromagnetic waveform. From a financial or transactional perspective, records are kept as to whether each utility is carrying its own weight and meeting its obligations under the complex power-sharing contracts that are a requirement for connection to the network. But from the perspective of physics and electrical engineering, once a company's generators are wired into the grid the energy on that interstate network cannot be differentiated in ownership or origin. Thus, simply to be a member of a multi-state power network is to participate in interstate commerce in electricity.

Indeed, both the Florida and Idaho reports cited by the PUCs reveal that those states are in fact "Net Importers" of electricity. Idaho State Electricity Profile (1998), U.S. Dep't of Energy, Table 1; Florida Reliability Coordinating Council, "2000 Regional Load and Resource Planning" 33 (July 2000). The very fact that these statistical tables record "net" figures for electrical exchange with sources in other states confirms that Florida and Idaho — like 45 other states — routinely transmit power to, and consume power from, other states.

Actually, Idaho is an egregiously poor example for the "self-contained states" point the PUCs are trying to make, because that state might well qualify as the poster child for interstate interconnections. Idaho is part of not one, but *four* different interstate electrical control areas. The function of a control area is moment-to-moment regulation of the energy on the control area's network through "instantaneous matching of generation and load so as to maintain constant frequency and synchronous time." Sarikas, *supra*, at 69. Control areas also maintain energy accounts for financially settling the energy exchanges that flow back and forth among the utilities that are members of the control area. From an engineering perspective, control areas are the electric power system's jurisdictional entities.

The problem for the State PUCs is that the political borders of the State of Idaho do not constitute such a control area. Instead, Idaho's power system is balkanized into four different control areas, each of which covers part of Idaho and parts of other states as well. The PacifiCorp West control area includes one part of the western border of Idaho — along with parts of California, Oregon, Washington, and Nevada. *See* www.pacificorp.com/paccomp/. PacifiCorp East includes southeastern Idaho — and most of Utah and parts of Wyoming. *Id*. The Idaho Power control area includes most of the central parts of the state — as well as parts of Oregon and Nevada. *See* www.idahopower.com/company/facts.htm. Finally, the Bonneville Power Authority control area includes much of northern Idaho — as well as portions of Oregon, Washington, Wyoming, Nevada, Utah, California, western Montana, and eastern Montana (but not central Montana). *See* www.bpa.gov/corporate/KCC/ff/bpa_facts/page2.shtml.

Thus the moment-to-moment operations and energy transfers of any given electric company in Idaho are controlled in parallel *not* with the other utilities throughout Idaho, but with utility companies in that electric company's *control area*, which may encompass as many as *seven other states*.

2. The States assert (without citation to any authority) that "most energy passes from power plants to the retail customers who are first in line on transmission lines with suitable capacity." State PUCs Br. in No. 00-568, at 45 n.28. *See also id*. at 37 (same). Once again, the States rely on their erroneous model of "electrons" being "carried" here and there in discrete, traceable units, like drops of water in a pipeline. *Id*. at 45. The resulting fallacy is the assumption that, because electric energy is generated and electric energy is consumed within a state, this energy can be treated as though it were somehow identifiable as the *same* energy — as if it were somehow distinguishable from the rest of the undifferentiated electromagnetic wave that was electrifying the interstate grid at the moment the user flipped on his television set. Again, that is not how electricity works.

Unsurprisingly, the State PUCs' argument has already been rejected by this Court. In *Florida Power & Light*, the FP&L utility claimed that, even though it was on a grid that crossed into Georgia, it somehow knew that all of its wattage was exhausted by its own nearby users (or those of a neighboring Florida utility) "before the point, further down the line, where Georgia's load intervenes." 404 U.S. at 462. The dissent accepted the utility's argument, 404 U.S. at 471-72 (Douglas, J., dissenting), but the majority did not. FERC's expert conclusion that energy from multiple, multi-state sources "commingles in a bus" at the interconnection and is then "transmitted in commerce" was sufficient to confer federal jurisdiction under the FPA. 404 U.S. at 463.

3. The PUCs offer no proof that the power they generate and transmit on an interstate network nevertheless is consumed solely by in-state customers. But nothing would change if they made such a proffer because this Court has already rejected such tracing efforts as misguided. In *Florida Power & Light*, FERC rebutted the theory of "point-to-point tracing" of alternating current electric power, noting that it was inappropriately based on "principles of direct current [DC] circuits with static power sources and with steady state power flows," and erroneously assumed power flow through an interconnection was "constant in value and direction." *Florida Power & Light Co.*, 37 F.P.C. at 551. Therefore, the theory did "not fully or accurately reflect . . . the physical reality" of an AC electric power system. *Id.* On appeal, this Court confirmed that, "'where the utility is a member of a combination of utilities and has continuous access to an integrated pool of interstate energy, the tracing of out-of-state energy is indeed difficult, burdensome, and perhaps impossible.'" 404 U.S. at 468 n.18.

4. The PUCs contend that to establish federal jurisdiction over interstate transmissions, "FERC would have to show that essentially every electron used by a retail customer in each state (other than Hawaii, Texas, and Alaska) is generated in a different state." State PUCs Br. in No. 00-568 at 45 n.27. But as explained above, electricity is not a stream of discrete electrons that travel to consumers to be individually consumed; it is not electrons that flow through transmission wires, but electric *current*. And the current generated by all the power plants hooked up to a given multi-state interconnection energizes the entire transmission grid with one single, continuous electromagnetic waveform that by its very nature moves in interstate commerce.

5. The States argue that "all generation on the interconnected grid does not serve all customers on the grid," citing B.M. Weedy & B.J. Cory, ELECTRIC POWER SYSTEMS 175 (1998). State PUCs Br. as Resp. in No. 00-809, at 26. Professors Cory and Weedy were discussing control area operations and the management of power and frequency. But the very existence of control areas negates the States' argument. If energy flows on the grid were as discrete and containable as the States contend, then there would not be a need for control area operators to balance supply and demand for their region or to monitor both planned and inadvertent energy flows on the interfaces between control areas.

Indeed, the cited section from Weedy and Cory stresses the fluid interdependence of networked systems, by pointing out that if the electrical load (demand) changes in one company's system, the frequency of the electromagnetic wave on that system and on every other interconnected control area changes. Thus, as the authors demonstrate, if the power system in New York City were isolated from external supplies of electricity, the frequency of the electricity on the system would rapidly decline from the required 60 cycles per second and the City would be blacked out within minutes. Weedy & Cory, *supra*, at 174.

The State PUCs' premise that state power systems are self-contained explodes upon examination of the geographic outline of almost any control area in the nation, because *electric power system control areas do not respect state borders*. As explained above, Idaho is carved up among four control areas, each of which spreads into two or more other states. The PJM Interconnection spans Pennsylvania, New Jersey, and Maryland, yet excludes a large area in central Pennsylvania. *See* www.pjm.org. The American Electric Power control area snakes like a gerrymandered congressional district through the States of Michigan, Indiana, Ohio, Kentucky, Tennessee, Virginia, and West Virginia. *See* www.aep.com/about/territory.htm. Thus, it is simply impossible to contain electricity on the grid within state borders because that electricity is generated, transmitted, and managed within control areas that are not drawn in accord with state boundaries.

6. The PUCs ultimately retreat and admit that the proposition that all transmissions "affect the entire grid" is "arguably accurate, from a theoretical standpoint" and is "technically correct." State PUCs Br. as Resp. in No. 00-809, at 25. The PUCs then fall back on the contention that any such effect is "inconsequential" because the "reaction of distant electrons in the grid is immeasurable." *Id.* The PUCs offer this example: "When a customer in New York City turns on a 60 watt lightbulb, the energy required to light the bulb is supplied by increases in output of nearby New York City generators." *Id.*

It is true that a lightbulb turned on in New York City will not have an appreciable effect on a generator very far away. It is also true that it will have almost no effect on even the closest generator. Indeed, a lightbulb or any other small device will have no effect on anyone except for the people in the room. But any event of note, such as a large industrial plant coming on line, or a large building such as the World Trade Center turning on all of its equipment, will ripple across transmission lines to affect generators both near and far, within New York and without.

7. The PUCs' concession that the premise of unity of electromagnetic response on a grid is "technically correct" is fatal to their cause, and the impact of their concession is not diminished by their qualifier that the ripple effect on a network is supposedly "inconsequential." For it is well established that there is no de minimis exception to federal jurisdiction over interstate transmissions, no minimum threshold of megawatts. "We do not find that Congress has conditioned the jurisdiction of the Commission upon any particular volume or proportion of interstate energy involved, and we do not . . . supply such a jurisdictional limitation by construction." Connecticut Light & Power Co., 324 U.S. at 536 (jurisdiction based on "one-fifth of one per cent of all the energy received and generated" by the company throughout entire state was transmitted interstate). "If [Congress] thinks the Commission is over-extending its attention to trivial situations it has ready means of control in its hands." *Id*. at 536.

8. The States retreat even further, falling back on the contention that, even if a transmission anywhere on a network affects the unified, interstate electromagnetic wave, "these indirect reactions do not occur in radial (direct line) delivery systems designed to serve retail load." State PUCs Br. in No. 00-568, at 45 n.28. But this proves *our* point: the PUCs have confused transmission on an interconnected, *interstate network*, where events cannot be isolated (and where FERC has jurisdiction), with *local distribution* on a *radial delivery system*, where events are isolated by the system's design (and where the states have jurisdiction). *See Connecticut Light & Power Co.*, 324 U.S. at 518, 530 (federal jurisdiction follows interstate electric flow, and therefore reaches "interstate power pool" existing on network among states, but does not reach systems of "local distribution").[12]

---

[12] The PUCs' twice cite Sarikas, *supra*, at 70, 82, for the proposition that locally generated electricity is consumed locally even when transmitted on a network with interstate connections and that local events have no impact elsewhere on a network. *See* State PUCs Br. in No. 00-568, at 45-46 n.28; State PUCs Br. as Resp. in No. 00-809, at 25. But the quoted passage states only that a utility "that is generating only to meet its own requirements will have zero net interchange and will not be a net seller or buyer." True enough, but so what? The very fact that the passage refers to *net* interchanges indicates that *the utility is engaged in interchange*

IV. THE STATE PUCS MISUNDERSTAND POWER SYSTEM STRUCTURE AND OPERATION AND THEREFORE MISAPPREHEND THE DIVISION OF STATE AND FEDERAL JURISDICTION UNDER THE FEDERAL POWER ACT.

1. The PUCs confuse transmission with local distribution. For example, they purport to refute the proposition that *transmission* falls within federal jurisdiction by emphasizing that, on the contrary, "'electric current *distributed* is subject exclusively to the jurisdiction of the State.'" State PUCs Br. as Resp. in No. 00-809, at 11 (emphasis added). They answer the statement that events on an interconnected *transmission network* cannot be isolated with the pointed rejoinder that such "indirect reactions do not occur in *radial* (direct line) *delivery systems*." State PUCs Br. in No. 00-568, at 45 n.28 (emphasis added). But as explained on page 25 above, network transmission and radial distribution are fundamentally different systems, and FERC is asserting jurisdiction only over interstate transmission, in accord with § 201(b)(1) of the FPA, and not over local distribution.

2. The State PUCs try to rewrite the vocabulary for electric regulatory discourse by introducing new concepts of "retail transmission" and "wholesale transmission." *See*, *e.g.*, New York PUC Cert. Pet. at 2; State PUCs Br. as Resp. in No. 00-809, at 4, 5, 10, 17, 24, 25, 26, 27; State PUCs Br. in No. 00-568, at i, 26, 28. The States apparently believe that smuggling the term "retail" into the case in association with "transmission"

---

transmissions on the network, but that at the end of the relevant accounting period the *net* exchange is zero. The fact that the utility may thus be "self-sufficient" in some accounting sense and in some time frame, does not negate the fact that, by virtue of being interconnected, it constantly exchanges power on an interstate network, one moment taking power from the grid, the next moment adding power to the grid. Dr. Sarikas points out in the same section that every utility in America, outside Texas, Hawaii, and Alaska, is part of an interstate transmission network. *See id.* at 79-80.

will aid them in their effort to persuade this Court that Congress ousted FERC from the jurisdiction over interstate transmission explicitly conferred by FPA § 201(b)(1) by, supposedly, "implicitly recogniz[ing] the states' jurisdiction over retail transmission" in § 206(d). State PUCs Br. as Resp. in No. 00-809 at 6. *See also id.* at 7, 26. Perhaps the PUCs' hope is that "retail transmission" will sound inherently local and therefore appropriate for state rather than federal regulation.

Of course, the term "retail transmission" does not appear in the FPA, which is why the PUCs refer to the statute's supposed preservation of this power as "implicit," and why the PUCs repeat their newly coined term frequently in an effort to make it sound familiar. But the only distinction the FPA makes with respect to transmission is between in*ter*state and in*tra*state, with federal jurisdiction over the former and state jurisdiction over the latter. *Compare* § 201(c) *with* §201(b)(1). "Wholesale" and "retail" are transactional terms, which is why the FPA uses them only to distinguish types of *sales*. *See* §§ 201(b)(1), 201(d). These terms have no relevance to the transmission of electricity.[13]

Unable to locate their new vocabulary in the statute, the State PUCs attempt to give it respectability by purporting to derive the terms "retail transmission" and "wholesale transmission" from the Glossary of Terms Task Force of the North American Electric Reliability Council (1996). *See* Cert. App. Q to the NY Pet. at Q-3, Q-4. Appendix Q states (at Q-1 n.1) that the terms it sets forth have been "selected and adapted" from the official NERC Glossary of Terms, but neither of the terms in Appendix Q ("retail transmission service" and "wholesale transmission service") appears anywhere in the actual

---

[13] Perhaps the wholesale/retail distinction for sales had some utility as shorthand in 1935 for discussing transmission and distribution, because at that time wholesale sales corresponded to transmission and retail sales to local distribution. *See* NY Cert. App. C-27 (opinion below). But that neat correspondence no longer applies in the 21st century. *See* C-28.

NERC Glossary. Indeed, there is no term even referring to "retail" or "wholesale" in any way. The PUCs' portrayal of the structure of the electric power system and its implications for federal jurisdiction is therefore not only unpersuasive, it is utterly baseless.

3. The PUCs argue that, because the states regulated "retail transmission" in 1935, and because Congress intended the FPA to preserve pre-existing state regulation, the states continue to have jurisdiction over "retail transmission." In the first place, as explained above, what the FPA reserved to states was regulatory power over "the transmission of electric energy in *intrastate* commerce." FPA § 201(b)(1) (emphasis added). The category of "retail transmission," which the PUCs describe as far broader than "intrastate" transmission, is the PUCs' own invention.

The existence of section 201(b)(1) of the FPA is awkward for the PUCs' argument, so they instead invoke section 201(a), which states that "Federal regulation [shall] extend only to those matters which are not subject to regulation by the States." State PUCs Br. as Resp. in No. 00-809, at 6. *See also id.* at 5, 12; State PUCs Br. in No. 00-568, at 27-28. But that section likewise does not mention "retail transmission." The PUCs therefore devote most of their energy to arguing that the legislative history of the FPA is replete with congressional reassurances that state jurisdiction would be preserved whenever possible and that the new federal jurisdiction would be limited to those matters which cannot effectively be regulated by the states themselves. State PUCs Br. in No. 00-568, at 17-26; State PUCs Br. as Resp. in No. 00-809, at 7-12. Therefore, we are told, reading the FPA to give control over "retail transmission" to FERC would be inconsistent with the FPA's legislative purpose.

But there is no inconsistency at all. Section 201(a) formally "declare[s]" that "Federal regulation of matters relating to . . . the transmission of electric energy in interstate commerce . . . is necessary in the public interest." The next section then unambiguously grants FERC jurisdiction over "interstate" transmission while reserving to the states most jurisdiction over "generation," "local distribution," and "intrastate" transmission. FPA § 201(b)(1). Thus those local matters subject to effective regulation by the states are still within the state bailiwick, whereas *interstate* transmission, plainly beyond *any single state's* control, is to be regulated by FERC.

When enacting the FPA in 1935, Congress could give FERC jurisdiction over all interstate transmission and simultaneously proclaim that the new statute would not, in fact, erode state regulatory power, *because in 1935 there was hardly any interstate transmission.* The federal government received jurisdiction only over what the states could not regulate effectively — *which in 1935 was not much*, given that the nation's electric power industry was almost entirely local and isolated, and electric transmission was overwhelmingly *intra*state. *See supra* pages 17-18. Thus, in 1935 the regulatory jurisdiction that the FPA conferred upon FERC constituted a relatively small portion of the total regulatory power exercised over the electric power industry.

4. The State PUCs would like to pretend that the world has not changed since 1935. They contend that increased "interconnections since 1935 are not relevant to the states' jurisdiction over retail transmissions." State PUCs Br. as Resp. in No. 00-809, at 26. Such changes, they argue, "do not alter the FPA's language." *Id*. The PUCs accuse FERC of trying to rewrite the FPA's jurisdictional assignments to invade the regulatory sphere reserved to the states.

There has been no change in the FPA's text or interpretation. The jurisdictional lines drawn in the FPA are still the same: the states get generation, distribution, and intrastate transmission, while FERC gets interstate transmission. What has happened is that the electrical system being regulated has changed. It has shifted underneath the FPA's jurisdictional lines as high-voltage interstate transmission wires have grown like new nerve fibers across the American landscape. Interconnected networks and interstate transmissions were few and far between in 1935; today every high-voltage transmission line in the continental U.S. (outside Texas) is wired into one of the two vast interstate grids. Thus the electrical transmission system has grown away from the state regulatory territory defined by the FPA and has grown into federal territory.

As the States point out, Congress foresaw this trend to increased interstate interconnections when it drafted the FPA in 1935. State PUCs Br. as Resp. in No. 00-809, at 26. Congress accordingly defined FERC's jurisdiction in terms that would allow it to match the need for effective regulation even as the industry changed. By unambiguously providing for federal jurisdiction over "the transmission of electric energy in interstate commerce," FPA § 201(b)(1) — rather than retail transmission, wholesale transmission or some other subset of interstate transmission — Congress ensured that no gaps would develop in federal jurisdiction as the transmission system evolved. In 2001, even more than in 1935, federal regulation of this interstate commerce "is necessary in the public interest." FPA § 201(a).

CONCLUSION

For the reasons given above, *Amici curiae* urge this Court to uphold federal regulatory jurisdiction over transmissions on the nation's interconnected, multi-state electricity networks.

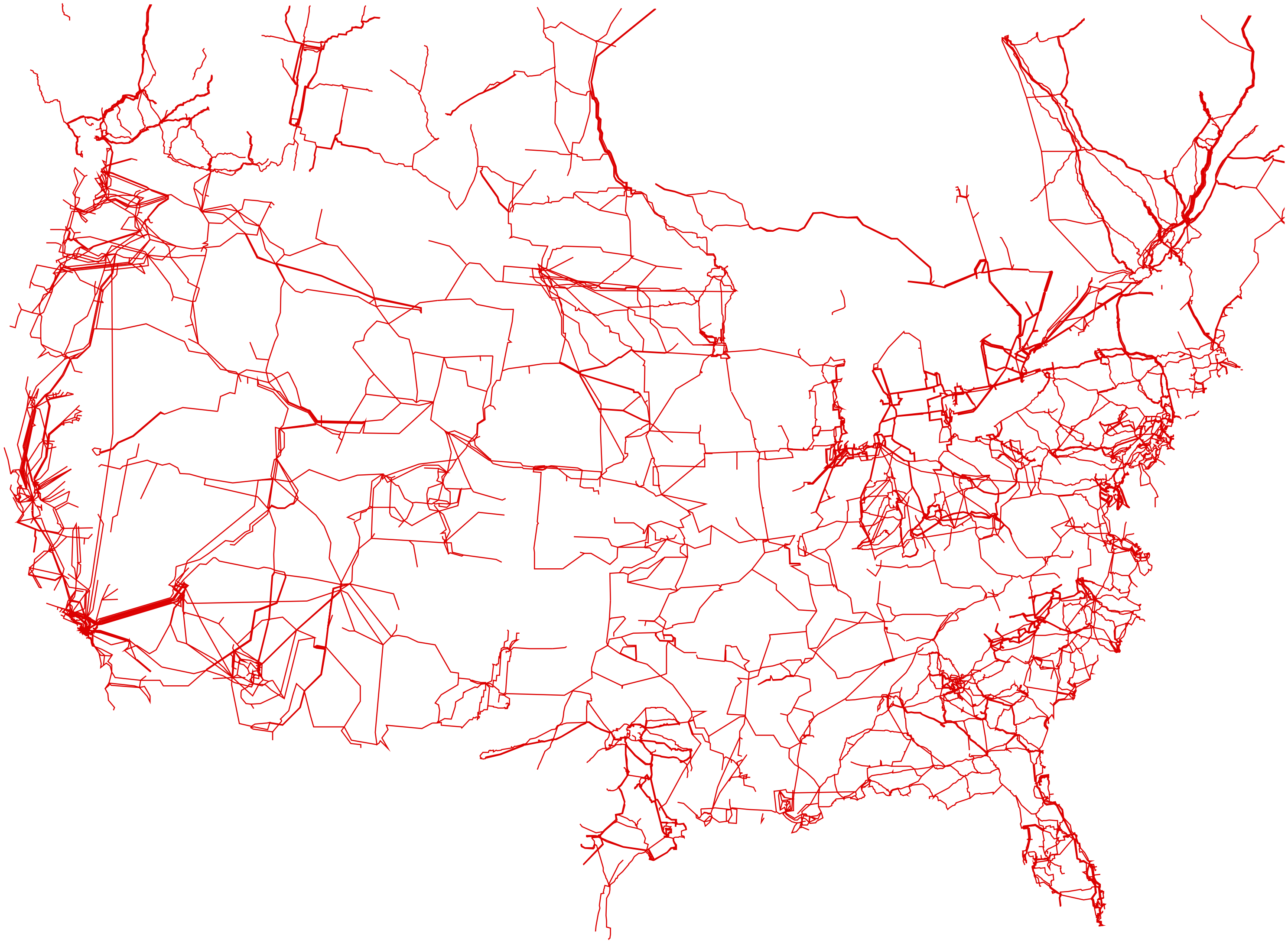
Respectfully submitted,

CHARLES J. COOPER
Counsel of Record
BRIAN STUART KOUKOUTCHOS
COOPER & KIRK, PLLC
Suite 200
1500 K Street, N.W.
Washington, D.C. 20005
(202) 220-9600

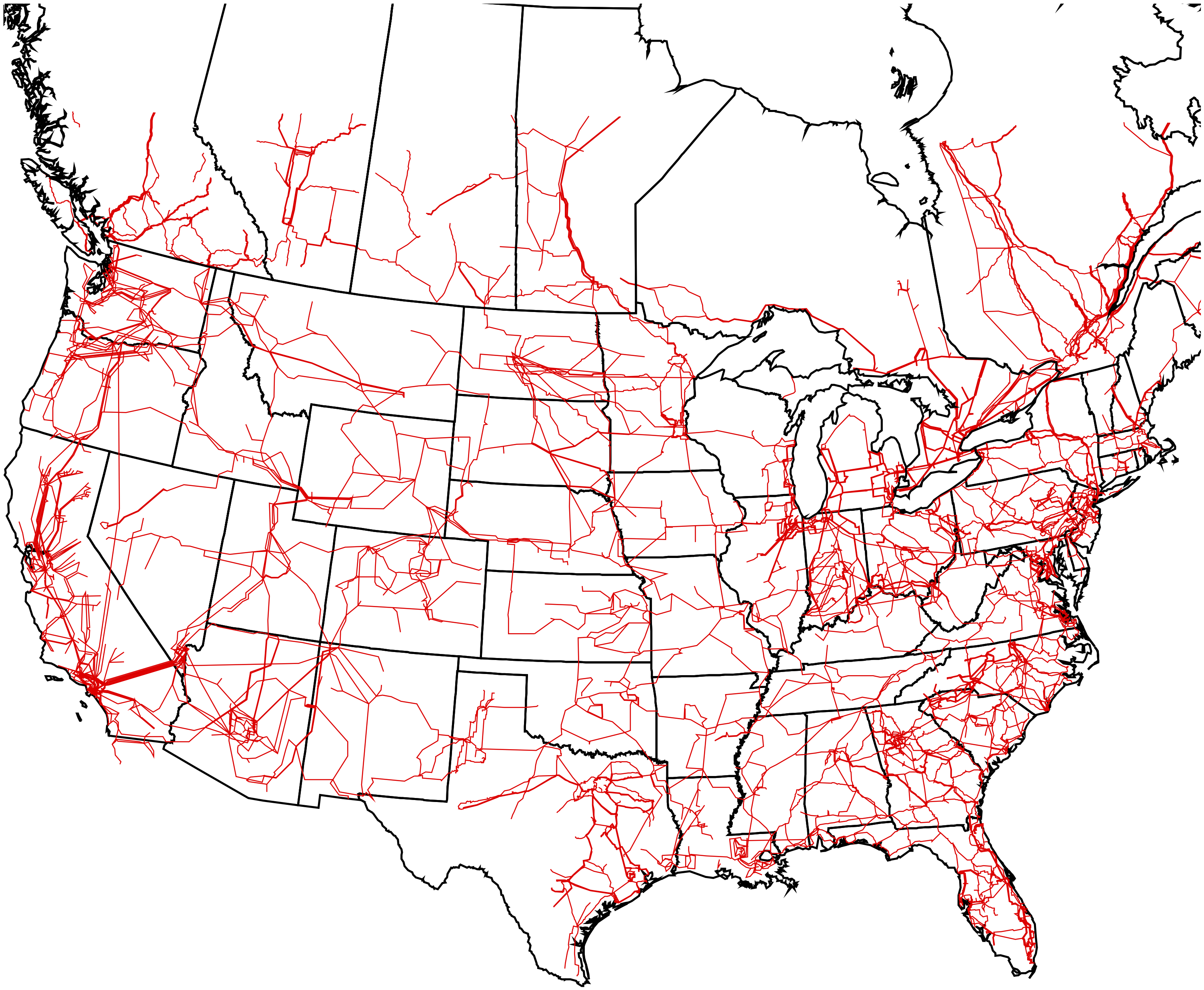
May 31, 2001

APPENDIX A

High Voltage Transmission System:
USA and Canada



High Voltage Transmission System: USA and Canada with State and Provincial Boundaries



APPENDIX B

AMICI CURIAE

FERNANDO L. ALVARADO is professor of Electrical and Computer Engineering at the University of Wisconsin at Madison. A professional engineer and computer scientist, Professor Alvarado is an established leader in technical policy elements of the electric power industry. His areas of expertise include policies for market design and power system operation and power system security and stability issues in interactions between power systems. He is the author or coauthor of more than 80 technical journal publications, books and book chapters, and almost 200 conference presentations and reports. Professor Alvarado is a member of the IEEE, the Society for Computer Simulation (SCS) and the Society for Industrial and Applied Mathematics (SIAM), as well as vice chairman of the IEEE Energy Policy Committee. He earned his Bachelor of Science in Electrical Engineering at the National University of Engineering in Lima, Peru, his Master of Science in Electrical Engineering from Clarkson College of Technology, and his Ph.D in Computer, Information and Control at the University of Michigan at Ann Arbor.

CLINT ANDREWS, P.E., Ph.D., is an assistant professor in the Bloustein School of Planning and Public Policy at Rutgers University. He was educated at Brown and MIT as an engineer and planner. Previous experience includes working in the private sector on energy issues, helping to launch an energy policy project at MIT, and helping to found a science policy program at Princeton. He is Vice President of the Society on Social Implications of Technology of the Institute for Electrical and Electronics Engineers (IEEE); he is a member of the IEEE-USA Energy Policy Committee and the IEEE Power Engineering Society System Economics Committee, a past consultant to numerous electric utilities and their regulators, and an active energy policy researcher. He has authored three books. In 2000, he received a *3rd Millenium Medal* from the IEEE for contributions at the interface of technology and society.

SHIMON AWERBUCH has 30 years of experience in finance, regulatory economics, energy economics and economic development, involving the private sector and all levels of government. Dr. Awerbach has served as Chief of Economic and Policy Studies for the Utility Intervention Office of the NY State Executive Department. He has also served with the Management Consulting Service of Ernst & Young and held policy positions with the NY State Governor's Economic Development Board and the NY State Legislature. He has contributed over 50 articles to such journals as the *American Economic Review*, *Journal of Regulatory Economics* and is a member of the Editorial Board of *Energy Policy*. He is the co-author of *Independent Transmission Companies: Unlocking the Benefits of Electricity Restructuring* (PUR, November 1999) and the co-editor of *The Virtual Utility: Accounting, Technology and Competitive Aspects of the Emerging Industry* (Kluwer, 1997). He has also presented his research findings to delegates of the *United Nations Commission on Sustainable Development* in New York and has testified extensively in regulatory proceedings. Dr. Awerbach received his Ph.D. in Urban-Environmental Studies from Rensselaer Polytechnic Institute.

JUDITH B. CARDELL is an electrical engineer and policy analyst with 10 years of experience in modeling and analyzing electric power systems and electricity markets. Currently a Senior Associate with Tabors Caramanis & Associates, Dr. Cardell also spent several years as an economist and engineer for FERC. Dr. Cardell previously worked at the MIT Laboratory for Electromagnetic and Electronic Systems, and was a graduate instructor at MIT for power systems and energy policy courses. A member of the IEEE's Energy Policy Committee, Dr. Cardell has published articles on energy policy and electric market modeling. Dr. Cardell earned her Ph.D. in Technology Management and Policy from MIT's Department of Electrical Engineering and Computer Science.

BRIAN CORY is Professor Emeritus in Electrical and Electronic Engineering at Britain's Imperial College in London, where he taught for almost 40 years until 1993. Dr. Cory's research interests have been focused on virtually all aspects of electrical energy supply, including both operating systems issues as well as policy issues in the deregulation and privatization of Britain's electricity industry. In the last five years alone, he has published close to a dozen professional journal articles on topics ranging from the pricing of electricity transmission and distribution to optimizing pumped storage generation, as well as a critical review of Great Britain's reorganized electricity supply industry and a proposal for neural-network based methods for evaluating power system voltage stability.

PETER CRAMTON is Professor of Economics at the University of Maryland and President of Market Design Inc. For several electric utilities, Professor Cramton has led the auction designs for generation asset divestiture, standard offer service, and NUG entitlements under power purchase agreements. He has advised ISO New England on the design of New England's wholesale electricity market. He has also advised numerous e-commerce market makers on market design for business-to-business trading. He has served as an auction advisor in spectrum auctions for many companies worldwide, as well as the FCC, the U.S. Department of Justice, and several foreign governments. Before joining the University of Maryland faculty in 1993, he was an Associate Professor at Yale University and a National Fellow at the Hoover Institution at Stanford University. He has published numerous articles on auction theory and auction practice in major journals. Professor Cramton received his B.S. in Engineering from Cornell University and his doctorate in Business from Stanford University.

DAVID HAYWARD is an electrical engineer with a long career in the electric utility industry, specializing in power systems operation. Mr. Hayward worked at New England Electric System for close to 40 years, where he held a number of key positions in bulk power system operations. He worked as a Power System Dispatcher, then spent several years doing long range system planning and performing transmission network analysis studies. He served on the committees that analyzed the 1965 Northeast Blackout. Mr. Hayward is a Senior Member of IEEE and has served on a number of regional and national IEEE committees. He is a former Chairman of the Current Operating Problems Subcommittee (COPS) and a former member of CIGRE. Mr. Hayward has a BS in Electrical Engineering from Tufts University and is a graduate of the Greater Boston Executive Program at the MIT Sloan School.

ERIC HIRST is an independent consultant focusing on issues related to restructuring the U.S. electricity industry. He holds a doctorate in Mechanical Engineering from Stanford University. For 30 years (1970 through 2000) he worked at Oak Ridge National Laboratory, rising to the position of Corporate Fellow, a distinction shared by only 1% of the lab's technical staff. He has published almost 500 articles in the technical and semi-technical literature related to energy efficiency, utility resource planning, transmission adequacy and planning, generation adequacy, system operations, wholesale markets, and other issues related to the changes underway in the U.S. electricity industry.

JOHN B. HOWE is Vice President of Electric Industry Affairs for American Superconductor Corporation, a leading developer and manufacturer of superconductor technology for the electric power industry. Previously, he served as Chairman of the Massachusetts Department of Public Utilities (now the Department of Telecommunications and Energy), where he spearheaded early stages of the effort to restructure and introduce retail competition to the state's regulated energy industries. Mr. Howe was also formerly a Vice President with U.S. Generating Company (now PG&E Generating Company). He has held leadership positions in the National Association of Regulatory

Utility Commissioners, the New England Conference of Public Utility Commissioners, and several national and regional independent power industry organizations. He holds a B.A., Magna Cum Laude in Political Science from Amherst College and a Master of Arts in Law and Diplomacy, with a concentration in Energy and Resource Economics, from Tufts University's Fletcher School of Law and Diplomacy.

JAMES L. KIRTLEY is Professor of Electrical Engineering at MIT, where he has specialized in the development and analysis of electric machinery for 30 years. He is also Vice President and Chief Scientist at SatCon Technology Corporation, and has held positions with the Swiss Federal Institute of Technology, General Electric and Raytheon. A Fellow of the Institute for Electrical and Electronic Engineers, Dr. Kirtley is Editor in Chief of IEEE’s Transactions on Energy Conversion and was the recipient of IEEE’s Third Millennium Medal in 2000. He has published 45 professional journal articles, numerous conference papers, and been awarded 17 U.S. patents. Dr. Kirtley received his undergraduate, masters, and doctoral degrees in Electrical Engineering from MIT.

RALPH D. MASIELLO holds a doctorate in Electrical Engineering from the Massachusetts Institute of Technology where he worked on some of the first applications of modern control and estimation theory to electric power systems, as well as state estimators for Transmission Operations. Since then, Dr. Masiello has acquired over 20 years of experience in Transmission and Distribution Operations, having been involved in the implementation of control systems at many of North America’s largest utilities. In addition he has assisted in the design and set up of deregulated energy markets across the United States and around the world. He is currently Senior Vice President of Caminus Corporation, a leading provider of software solutions and strategic consulting to entities participating in competitive energy markets. He was formerly the global Business Unit manager for Energy Information Systems for ABB, as well as marketing manager for ABB Information Systems Division, and General Manager of ABB's Systems Control Division in Santa Clara. Dr. Masiello has been an adjunct professor at the University of Minnesota and lectured at University of California at Berkeley, the University of Arizona, and the University of Wisconsin. He is a Fellow of the IEEE and has held several committee, advisory and editorial positions within IEEE and authored numerous technical papers.

HYDE M. MERRILL is the founder of Merrill Energy LLC, which provides advanced risk, engineering, and economic analyses for participants in modern energy markets. He is currently leading a major study of power plant reliability and market behavior for a US ISO. He has advised the Peruvian Tariff Commission on transmission planning, standards, economic and institutional issues associated with competitive power markets, as well as being a member of an international consortium guiding the creation of a power pool in Southern China. Dr. Merrill organized a team that assessed market risks in four US regions, as well as advising on a Quebec commission charged with investigating the massive power losses in the Province. Dr. Merrill was the executive chairman of the Power Industry Computer Applications (PICA) Policy Committee for four years, and is currently a fellow of IEEE. He is the author of more than 70 technical publications on the power industry. Dr. Merrill holds an undergraduate degree in mathematics from the University of Utah and a Ph.D. in electrical engineering from MIT.

TIMOTHY DOUGLAS MOUNT is professor at Cornell University in the Department of Applied Economics and Management. His research areas include market power and price volatility in restructured markets for electricity, alternative auction institutions for electric power markets, as well as global environmental economics. Among other societies, he is a member of the International Association of Energy Economics, American Statistical Association, and Association of Environmental and Resource Economists. Professor Mount has published numerous articles on the power industry as well as environmental and agricultural economics. He received his doctorate in agricultural economics from the University of California at Berkeley.

SHMUEL S. OREN is Professor of Industrial Engineering and Operations Research at the University of California at Berkeley. With a doctoral degree from Stanford University in Engineering Economic Systems, Dr. Oren's research has focused on electric power system economics, and in particular on optimization and pricing strategies. In addition to his position at Berkeley, Dr. Oren has served as an expert consultant to numerous agencies, research institutes, and private entities including EPRI, SRI International, Niagara Mohawk Power Corporation, Entergy, and the Texas Public Utility Commission. He is a Senior Member of IEEE's Power Engineering Systems Society, as well as a member of the Institute for Operations Research and Management Science (INFORMS), the International Association of Energy Economists (IAEE), and the Mathematical Programming Society. Dr. Oren serves on the editorial boards of both INTERFACES and ENERGY ECONOMICS, and has published dozens of professional articles in his field, covering such topics as transmission congestion, flow-based transmission rights, generation unit commitment methods, and market pricing methodologies.

MICHAEL H. ROTHKOPF received his doctorate in operations research from MIT in 1964, and has been a professor of management and operations research at Rutgers University since 1988. He has served as the senior scientist as Lawrence Berkeley Laboratory, as well as leading their energy analysis program. His research and professional interests of long standing include models of markets and of competitive bidding, applications of operation research, and energy economics. Professor Rothkopf has edited a book on the power generation-unit commitment problem. In addition, he has written over 50 papers that have appeared in archival journals. Professor Rothkopf is a member of the Institute for Operations Research and Management Science, International Association of Energy Economists and American Economic Association. In addition, he was Editor-in-Chief of *Interfaces* from 1993 to 2000, and area editor for Operations Research Practice for the Journal Operations Research from 1984 to 1993. Professor Rothkopf is also a part-time consultant for FERC.

ROY J. SHANKER received his doctorate in industrial administration from Carnegie Mellon University in 1975. Dr. Shanker has been an independent consultant since 1981, providing management and economic consulting services in natural resource-related industries, particularly in the electric and natural gas utilities. In this capacity he currently serves on the Energy Markets Committee, the Transmission Expansion Advisory Committee and the Tariff Committee of the Pennsylvania Maryland and New Jersey (PJM) Office of Interconnection. Dr. Shanker also serves as a member of the New York Independent System Operator Technical Information Exchange Committee and participates on the NYISO Business Issues Committee, the Scheduling and Pricing Working Group, the Market Structure Working Group and several other working groups supporting the New York wholesale electric market.

THOMAS R. SCHNEIDER is a principal in the consulting firm of TRSenergy in Portola Valley, CA, specializing in technology evaluation and product positioning in restructured electricity markets, in addition to the development and implementation of technology acquisition strategy. From 1987 to 1997 Dr. Schneider was the executive scientist at the Electric Power Research Institute in Palo Alto, California, where he conceived and led institute efforts to sponsor fundamental and novel research in power systems engineering, as well as identifying the importance of power-industry restructuring on power system operations and reliability. In addition to numerous other appointments in the power industry, Dr. Schneider is currently the Chairman of the IEEE-USA Energy Policy Committee, where he served as Vice Chairman from 1998 to 2000, and a member of the IEEE Technology Policy Council. Dr. Schneider has contributed extensively to books on the power industry, proceedings and congressional testimony, and holds a Ph.D. in Physics from the University of Pennsylvania.

RICHARD TABORS is an engineering economist and scientist with over 30 years of domestic and international experience in energy systems planning and pricing. Dr. Tabors is President and founder of Tabors, Caramanis and Associates (TCA), an engineering and economics consulting firm specializing in policy development, business planning and technical analysis in the energy and utility sectors in the United States and internationally. He is also Senior Lecturer in Technology and Policy at Massachusetts Institute of Technology and has provided testimony and worked with clients throughout the country. His work with coauthors Fred C. Schweppe, Michael Caramanis and Roger Bohn published in SPOT PRICING OF ELECTRICITY is recognized as one of the theoretical foundations of electric industry pricing and restructuring. Dr. Tabors earned his undergraduate degree from Dartmouth College, and his doctorate from the Maxwell School at Syracuse University. He is co-author of 5 books and over 100 professional articles and reports. He is a member of the IEEE and the International Association of Energy Economists.

ROBERT J. THOMAS is Professor of Electrical Engineering at Cornell University, where he specializes in power systems analysis and in particular the analysis and control of linear and nonlinear continuous and discrete time dynamical systems, complex networks, and applications of these to large-scale electric power systems. He is also currently the Director of the Power Systems Engineering Research Center (PSERC), a National Science Foundation Center and a Steering Committee Member for the Consortium for Electric Reliability Technology Solutions (CERTS). Dr. Thomas' affiliations and awards are far too numerous to list in full, but have included a variety of memberships and positions with the USDOE Secretary of Energy's Power Outage Study Team, the Institute for Research and Education for Electric Power, the Edison Electric Institute, and Drexel University's Department of Electrical and Computer Engineering Advisory Committee. He is a member of the Board of the IEEE and Chair of the IEEE Technology Policy Council. He has published approximately 60 professional articles and served as Editor for a number of prestigious technical journals. Dr. Thomas received his undergraduate, masters, and doctoral degrees in Electrical Engineering from Wayne State University.

LEE WILLIS is a registered professional electrical engineer with 30 years of experience in the electric power industry, specializing in transmission and distribution systems issues. Currently Vice President of Technology and Strategy at ABB Consulting, he has held executive positions with ABB Inc as Vice President of Distribution Systems, Director of Technology for Distribution Automation, and as an Institute Fellow at ABB's R&D Lab. He has also held positions in transmission and distribution at Westinghouse Electric and Houston Lighting and Power. He is a Fellow of the IEEE, a member of the National Research Council, and the editor of the Power Engineering Series for Marcel Dekker Publishers of New York. He is the author or coauthor of 47 engineering journal articles, and five books including the POWER DISTRIBUTION PLANNING REFERENCE BOOK, SPACIAL ELECTRIC LOAD FORECASTING, and DISTRIBUTED POWER GENERATION–PLANNING AND EVALUATION. He earned his undergraduate and master's degrees in electrical engineering from Rice University.

BRUCE F. WOLLENBERG has been a professor in the Electrical Engineering Department at the University of Minnesota, Twin Cities, since 1989. Prior to his appointment, he worked at Control Data Corporation's Energy Management System Division, where he was responsible for the development of Artificial Systems Applications. He consulted on advanced research projects in energy management system application software, and he also participated in the power system operator training simulator project for the Electric Power Research Institute. Professor Wollenberg's current interests involve the development of large scale network solution algorithms using vector processing supercomputers, the extension of traditional power system control techniques to incorporate spot pricing algorithms and distributed computer technologies, as well as the application of expert systems to enhance the information presented to power system operators using real time computers.

ADDITIONAL SUPPORTERS
AFTER FILING DATE

ROSS BALDICK is a Professor of Electrical and Computer Engineering at the University of Texas at Austin. His research is in electric power systems, optimization, and in the interface of policy and engineering issues. His research group is currently focused on the development of power systems models to complement the emerging competitive economic environment in electric utilities. Prior to joining the faculty at the University of Texas, he was Assistant Professor of Electrical and Computer Engineering at Worcester Polytechnic Institute in 1992-93. He received an NSF Research Initiation Award in 1993 and an NSF Young Investigator Award in 1994. He has authored numerous technical papers. Dr. Baldick received his doctorate in Electrical Engineering and Computer Science Engineering from the University of California at Berkeley. He is a member of IEEE.

JOHN A. CASAZZA is an expert in the field of electric power systems, holding the position of Life Fellow in the IEEE. He is presently a member of the executive committee of the New York State Reliability Council, previously a chairman of the US Technical Committee of CIGRE (International Council on Large Electric Systems), and previously the vice president for planning and research at the Public Service Electric & Gas Company. He has received the Herman Halperin Electric Transmission and Distribution Award and the Philip Sporn Award for contributions to the electric power industry. The author of two books and over 100 articles, Mr. Casazza received a degree in electrical engineering from Cornell University.