Title
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Publication Date
1989

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Working Paper 89-26

INSTITUTE OF GOVERNMENTAL STUDIES
UNIVERSITY OF CALIFORNIA, BERKELEY

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October 1,1989

Analysis supported by the Universitywide Energy Research Group, University of California, Swedish Energy Research Commission (Efn) and the National Energy Administration (Statens energiverk). Comments on earlier drafts from Lars Ingelstam, Stuart Chaitkin, Evan Mills, Arne Kaijser, and Peter Steen are appreciated.

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Abstract.

Encouragement and accommodation of small scale independently produced electricity raise important questions of <u>who</u> will produce electricity in the future--large centralized utilities or dispersed industrial, entrepreneurial, and municipal projects. A number of countries are restructuring their utility grid system in response to dispersed electrical production. In California, implementation of the federal Public Utilities Regulatory Policy Act (PURPA) legislation led to over 1,400 contracts to supply the state's three major utilities with nearly 15,000 MW capacity from independent power producers in the 1980s. The large amount of non-utility capacity in California presents four major issues: the setting of rates using the "avoided cost" formulation, the management of potential oversupply, the accommodation of extensive self supply usually from cogeneration, and the greater access of transmission lines for wheeling arrangements. It is argued that independently produced electricity can be beneficial to a utility grid, but complex organizational issues need to be properly understood and managed.

TOWARD A DISPERSED ELECTRICAL SYSTEM: CHALLENGES TO THE GRID

I. Introduction

Fifteen years after the Arab oil embargo, the fundamental question of what sources of electricity should be utilized in major industrialized countries has been joined by an equally far-reaching and controversial question of who should supply electrical power, which is a challenge to the traditional monopoly of the utilities as the primary supplier of electricity. The issue is no longer limited to the nuclear versus solar debate[1] or how to reduce dependence on oil. An emerging issue in many industrial countries is how to manage a rapidly changing organizational system in which the monopoly utility accommodates dispersed producers. Certain aspects of ownership and control over means of generation, transmission, and distribution must now be shared with a number of new participants who have new technologies, new markets, and new regulatory mandates. The character of a more dispersed system for the supply of electricity can be outlined now, and despite utility efforts to retain control of the electrical system, a dispersed electrical generation and distribution system promises to provide considerable societal benefits.

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[1]M. Lonnroth, T. Johansson and P. Steen, Solar Versus Nuclear: Choosing Energy Futures, Pergamon Press Inc., Elmsford New York 1980.

In parts of North America and Europe dispersed electrical production is gaining legitimacy and experience. In California, under the state's implementation of the federal Public Utilities Regulatory Policies Act (PURPA) of 1978, some 1,400 independent (non-utility) energy projects now have contracts to supply over 10 percent of electrical production capacity to the state's three major private utilities[2]. In Great Britain, an electricity bill calling for the restructuring and privatization of the Central Electricity Generating Board and the organizing of electrical generation and distribution into separate companies is being acted upon in the House of Commons; if approved, the bill will decentralize the organizational base of energy supply. The Netherlands has already reorganized its electricity sector by separating different functions and has also taken steps to stimulate market entry of small cogeneration projects[3]. In Italy, which made a decision in 1987 to phase out all nuclear power, a government proposal requiring the country's single utility to purchase power at specified prices from independent projects using renewable resources is currently being debated.[4] In Denmark, utilities are being forced by political mandates to accept considerable amounts of wind power and small-scale cogeneration.[5] In Sweden, the introduction of natural gas by utilities and a national decision

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[2]California Public Utilities Commission, "Summary of Cogeneration and Small Power Production Projects in Service Areas of Pacific Gas and Electric, Southern California Edison and San Diego Gas and Electric (As of June 30, 1988).

[3]Mans Lonnroth, "The Coming Reformation...", in T. Johansson, B. Bodlund, R. Williams, (eds.) Electricity: Efficiency End-Use and New Generation Technologies and Their Planning Implications. Lund University Press, 1989, p. 781.

[4]Giovanni Silvestrini, Consiglio Nazionale Della Richerhe, private communication.

[5]Mans Lonnroth, p. 782.

to decommission all nuclear power plants between 1995 and 2010 raise critical questions as to future sources of electrical power and who will introduce, own and control them. The Swedish State Power Board has announced a willingness to purchase power from non-utility small cogeneration projects starting in the early 1990s.[6]

The reasons for these various changes and the driving forces behind them vary between the different societies, but the underlying phenomenon appears to be the same: the long-held view that electricity is ideally provided by a centralized and integrated utility industry[7] has been substantially challenged in the 1980s. The challenge comes from a number of directions - from a range of economic and environmental pressures, from small power producers with competitive new technologies who have gained system and market access, and from policy makers and regulators interested in new alternatives for achieving diversity in electricity supply and organization. Utilities in some places are also faced with new kinds of customers, ones that now have considerable options in terms of the kinds of energy they use, the prices they pay, and the suppliers for that energy.[8] Regulators and utilities are being forced to respond to these pressures, and as a result, utility roles and societal expectations of them are changing.

This paper concentrates on the changing patterns of electricity supply in California in the 1980s and the implications of these changes for the

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[6]Swedish State Power Board, "Inbjudan," 1988.

[7]Thomas P. Hughes, Networks of Power: The Electrification of Western Society 1880-1930, Baltimore: Johns Hopkins University Press, 1983.

[8]John Laun, Director of Marketing, SDG&E Company, cited in California Energy Commission, Conservation Report, Sacramento, California, August 1988, p.33.

organizational structure of the electrical grid. The contribution of California's small power industry to the state's supply has exceeded expectations and has been at the cutting edge of technology developments worldwide. This phenomenon is interesting for several reasons. Events in California represent a departure from traditional utility operations and ways of thinking that constitute what one regulatory agency has noted is "the most fundamental industry reorganization since the appearance of large, franchised monopoly utilities earlier in this century."[9] California's experiences offer an opportunity to examine critical issues in the transition from a tightly integrated, utility based electrical supply system toward a more dispersed one as defined below. Finally, events in California form an intriguing case study of a well-established, large technical system in which the controlling organizations (utilities) have been forced to radically "change direction" in ways of thinking (from a supply orientation to an integrated supply-conservation approach), size of operations (from large power plants to medium and small sized ones), and organizational roles (from monopoly control to competing for markets).

Grid Systems As Analytical Tools.

The perspective we take is that these changes and the issues they raise need to be understood within the particular logic and structure of the electrical system as an integrated "grid" system. Grid systems are large technical systems organized around a specific distribution net that is used for the exclusive purpose of connecting producers and consumers of some

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[9] California Public Utilities Commission, 1988 Electricity Report, Draft, Sacramento 1989, p. I-1.

commodity. Grid systems for energy supply are electricity, gas and district heating; other examples of grid systems include water supply, waste disposal, telecommunications, and railroads.[10] The physical infrastructure of a grid is coupled with intensive technical and organizational management to achieve the standardization, coordination and reliability that make the grid successful.

Grid systems have a number of technological, economic, and organizational characteristics that place particular demands on how the systems are built up, operated, and developed over time. More significantly, these characteristics constrain the ability of the system to adapt to change. The core characteristics of grid systems as they have traditionally been organized can be summarized in five points.

-First, grid systems typically are based upon a limited number of large, centralized, and technologically sophisticated production units that require long construction lead times. Economies of scale have traditionally motivated grid consolidation and expansion.

-Second, grid systems are capital-intensive, with high fixed costs that must be recovered over considerable time. These fixed costs "bind" the system in a number of ways: expansion must be planned well in advance, and once the large units are in place, there is often little flexibility. To recover the sunk costs of investment, market certainty over the long term is sought.

-Third, grid systems are tightly-coupled in terms of both technological components and the organizations that surround them, leading to a high degree

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[10]For a discussion of grid systems, see Arne Kaijser, Arne Morgren and Peter Steen, Att ändra riktning: villkor för ny energiteknik, Liber: Stockholm, 1988, pp. 33-43.

of interdependence between producers and consumers. New components that enter a part of the system or existing participants that withdraw or change their consumption are "disruptions" that can affect the entire system. Successful operation of the system therefore requires not only a high degree of technical standardization but also cooperation and coordination between participating organizations.

-Fourth, the focal supply organization has, or at least strives to attain, a monopoly to prevent competitors from diluting the ability to recover fixed costs and maintain the integrity of the system.

-Finally, grid systems are characteristically public systems, if not always legally, at least in terms of their societal function and accountability. This service role legitimizes regulatory oversight as well as a measure of democratic influence and participation on the part of the public it serves.

Thus, grids are among the most tightly structured technical systems we have in modern society, and as Todd LaPorte suggests, they must operate in a nearly failure free mode[11].

A contrast to the conventional grid system is a dispersed system. By a dispersed system, we mean a system that, although it can be grid-based, interconnected, and standardized, exhibits diversity in four critical aspects. First, a variety of resources and technologies are employed. Second, a sizeable portion of the system's production capacity comes from small- or medium sized facilities. Third, the facilities are located in a

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[11]Todd LaPorte, "The United States Air Traffic System: Increasing Liability in the Midst of Rapid Growth", in R. Mayntz, and T.P. Hughes, (eds.), The Development of Large Technical Systems, New York, Martinus NIJHOFF, 1988.

variety of physical locations. Fourth, these facilities are owned by a range of different organizations. A dispersed system is neither a monopoly nor necessarily tightly coupled on a systemwide basis. In organizational theory terms, it operates with enough redundancy to be organizationally robust.[12] A dispersed system is an ideal type of which the best example is personal computer networks.[13]

Electricity is a prototypical example of a convention grid system that is showing signs of becoming more dispersed in several parts of the world. Following concepts advocated by Emery Lovins and others, electrical production now includes new technologies, small plants, many organizations, plants located close to end use, and diverse ownership. The system often operates with less central control and includes autonomous subunits located throughout the system.

Our intention in the next section is to review developments over the last decade in California and to trace the critical events as they evolved through 1988. Five significant factors leading to the California experiment are identified. In the third section we address four major issues which illustrate the ways in which an increasingly dispersed electrical system affects and often clashes with the operation and long term interests of the grid system: how the concept of avoided cost provided economic access, how the system continued to be challenged with the problem of assuring proper levels of supply, what the consequences were of selective withdrawal from the grid to self-generate, and how significant the problem of open "wheeling" is

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[12] Martin Landau, "Redundancy, Rationality and the Problem of Duplication and Overlap," Public Administration Review, 1969.

[13] We thank Evan Mills for this point.

for maintaining the grid. We conclude by considering some of the implications of constraints on the ability of conventional grid systems to become more dispersed.

II. Dispersal of Production in California

California has a vast electricity system to serve its 25 million population, using 200,000 GW annually[14]. The state's peak summer electrical load has been approximately 41,000 MW. Natural gas, the fuel used for about 40 percent of production, is burned in base load plants, peaking turbines, and cogeneration applications. Nuclear power and indigenous hydro resources contribute about 10 percent each to total electrical generation. Geothermal, solar, wind, and other (primarily) renewable sources together contribute about 5 percent, with the remainder (about 35 percent) imported from out-of-state--primarily hydroelectric sources from the Pacific Northwest and coal from the Southwest.[15]

In terms of organizational structure, the state has three large private (investor owned) utilities which serve about 75 percent of the population, two large municipal utilities, and a number of small municipal utilities that are primarily distributors. California utilities are large by most standards: Pacific Gas and Electric (PG&E) is the largest combined gas and electricity utility in the United States, Southern California Edison (SCE) is nearly as large, and the two municipal utilities, Los Angeles Department of

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[14]California Energy Commission, 1987 Biennial Report, p. 35.

[15]California Energy Commission, 1988 Electricity Report, Appendices.

Water (LADWP) and Power and Sacramento Municipal Utility District (SMUD) are the nation's first and third largest municipal utilities respectively. Today, Southern California Edison is in the process of purchasing San Diego Gas and Electric (SDG&E, the state's third largest private utility), a merger that would make SCE the nation's largest private utility if approved.

California's investor-owned utilities are regulated primarily through legislative and judicial powers granted to two state regulatory agencies, the California Public Utility Commission (CPUC) and the California Energy Commission (CEC). The Federal Energy Regulatory Commission (FERC) has responsibility for inter-utility sales of electric power.

Initially established in 1911 as the "Railroad Commission," the CPUC's primary functions are revising and approving rates, setting standards of utility services, and hearing complaints against utilities on specific issues. The CPUC has jurisdiction only over private utilities; municipal utilities are regulated by their own local boards and are responsible to the local government rather than to the state.

In 1974 the CEC was established to complement the CPUC by developing and implementing research and development programs for alternative energy technologies and conservation measures, planning state energy policy, forecasting electricity price and demand, and approving the siting and licensing of large (over 50 MW) power plants on the basis of independent need assessment. The CEC's siting authority, which extends to municipal utilities as well, is just one of the factors which has given the agency a key role in the changing energy environment.

Until the energy crisis, California utilities consolidated electricity generation plants, and the efficiency increases led to declining prices.

Even by the late 1970s new large plants were being planned and construction was anticipated. For example, PG&E had at least five major nuclear, gas, and geothermal baseload plants under design or regulatory review[16], justified on the basis of meeting the 5 percent per year increase in demand they had forecast.[17] By the mid 1980s the situation had changed dramatically. Conservation had reduced demand to around 2 percent per year, non-utility sources proved abundant under PURPA, and all major utility plans for construction of new plants were abandoned.[18] Here we shall concentrate only on the part of the story involving the entry of independent producers onto the grid, which added some 4,800 MW of new capacity through 1988 and is expected to add another 2,500 MW of capacity by 1992.[19]

The PURPA Program.

The single most important factor behind the extensive development of independent power projects in California is PURPA, a national law enacted in 1978 as part of President Carter's National Energy Plan. The aim of PURPA was to reduce dependence on fossil fuels by stimulating conservation and by developing new, alternative technologies for electrical generation, particularly from small renewable resource plants and cogeneration. PURPA's

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[16]David Morse, "Testimony before the CPUC and CEC", Joint Hearings on Excess Electricity Supply, September 4, 1987, pp. 26-27.

[17]California Energy Resources Conservation and Development Commission, California Energy Trends and Choices: Vol. 2 Electricity Forecasting and Planning, (1977 Biennial Report), pp. 31, 37, 45, 54, 61.

[18]California Energy Commission, Energy Development Report, July 1988, p.III-7.

[19]California Energy Commission, 1988 Electricity Report, Draft Final, Sacramento, April 1989, p. IV-24.

guidelines were designed to enable developers of such technologies to enter energy supply markets under favorable economic conditions. Under the terms of PURPA, utilities are required to purchase power offered by small (less than 50 MW) power plants or "qualifying facilities" (QFs) using solar, biomass, wind, geothermal, small hydroelectrical sources, or cogeneration, provided that such projects satisfied certain criteria[20]. One important criterium was that such facilities could not be more than 49% utility-owned. The concept of a qualifying facility was important in that it specifically allowed non-utility producers to operate their plants not subject to regulatory oversight as a "utility." PURPA finally specified that the terms and conditions governing purchase of so-called "QF-power" were to be drawn up by the states, which were given considerable latitude in the actual implementation of PURPA.

By PURPA guidelines, the price that utilities were required to pay for QF-power was stipulated as the utilities' "avoided costs", defined by PURPA as the anticipated marginal or incremental costs to the relevant utility for energy or capacity (or both) that the utility would have incurred if it built a new plant itself or acquired power through other means.[21] Small power producers would thus be paid an attractive high rate (due to the fact that marginal costs usually exceeded average utility costs), but ratepayers would

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[20]As defined by PURPA, a "small power production facility" is a plant that produces power from biomass, waste products, geothermal or renewable resources and that in combination with other plants at the same site has a maximum capacity of 80 MW. To be regarded as a qualifying facility, such a plant may not be more than 49% utility- owned. See Kaufman, Alvin and others, Wheeling in the Electric Utility Industry, Congressional Research Service, Report No. 87-289, Washington, February 12, 1987, p.63.

[21]P.L. Joskow, "The Evolution of Competition in the Electric Power Industry", Annual Review of Energy, vol 13, 1988, p.220.

be indifferent because the so-called "QF power" would cost no more than the utility would otherwise pay for additional power. This standard of market access at prices that would leave the ratepayer indifferent became the regulatory backbone for a dispersed electricity supply.

Each state implemented the provisions of PURPA through their own legislation and regulatory agencies. California pursued PURPA implementation more vigorously than the other states in the early 1980s, in part because the utilities needed capacity and in part because such an implementation fit well into an innovative and aggressive overall state energy policy. A series of "standard offer" contracts governing utility purchases of QF - power were offered in 1983.

Success in California.

The response to the issuing of standard offers was overwhelming. Based on data provided by California's three major investor-owned utilities reporting to the CPUC, this response is indicated in Table 1. The table includes contracts for utility power purchases from small, independently-produced alternative energy production and cogeneration projects, virtually none of which were available before 1980.

Table 1 here

Based on California's demand for electrical capacity of approximately 41,000 MW, the total 15,000 MW in production or under contract shown in table 1 represents an increased statewide electricity production capacity of about one third, most of which was to be on line within five years of the date the

Table 1. Summary of cogeneration and small power production projects in service areas of Pacific Gas and Electric Company, Southern California Edison Company and San Diego Gas and Electric Company

	Projects with signed contracts			Projects with signed letter of agreements		Projects under active discussion	
Utility service area	Number of projects	Projects on line MW	Project commitments MW	Number of projects	Project commitments MW	Number of projects	Estimated project size MW
Pacific Gas and Electric Company	766	2592	8947 1)			111	589
Southern California Edison Company	472	3140	6552 1)			50	262
San Diego Gas and Electric Company	190	122	382 1)	42	24	4	4
Totals	1428	5854	15881 1)	42	24	165	855

1) These figures include projects on line.

Source: California Public Utility Commission, Summary of Cogeneration and Small Power Production Projects, June 30, 1988.

contract was signed. The majority of these power projects are less than 50 MW in size, although some are large cogeneration plants up to 400 MW operated by well-established oil companies for enhanced oil recovery. Generally speaking, cogeneration projects are the most common form of qualifying facilities that are actually in operation, followed by wind power projects. Using PG&E's service area as an example, among almost 500 projects operational in September 1988, about 55% of installed capacity came from cogeneration projects and 26% from wind power projects[22], with remaining capacity from biomass/solid waste, small-hydro, geothermal and solar sources[23]. The picture is similar in SCE's service area where cogeneration projects provided 59% and wind projects about 20% of installed QF-capacity.[24]

The nearly 6,000 MW of QF capacity now on-line in California is about comparable to the output of six nuclear reactors (which would have taken a decade or more to build) or about 16% of total system capacity. The fact that this amount of power was also contracted in less than five years and that two or three times the present capacity has contracts clearly illustrates the enormous potential of dispersed state-wide power production.[25]

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[22]Wind provides less than this proportion of electricity because of the occasional nature of the wind resource. California wind however, is strongest during the summer peak demand, and it is thus especially valuable for this reason.

[23]Pacific Gas and Electric Company, Cogeneration and Small Power Projects - Production Quarterly Report to the California Public Utilities Commission, Third Quarter 1988, p.3.

[24]Southern California Edison, Cogeneration and Small Power Projects - Quarterly Report to the California Public Utilities Commission, September 30, 1988. p.I-2.

[25]Lyna L. Wiggins, Timothy P. Duane, and Allen L. Brown, "Diversification in Energy Production", in John J. Kirlin, Donald R. Winkler, (eds.), California Policy Choices, Sacramento, California 1988.

As a result of the large amount of contracted electrical capacity, California's policy dilemma has shifted significantly from the initial goal of trying to stimulate new suppliers of electricity to managing an apparent oversupply. In late 1984 the oversupply was recognized and consequently the CPUC began taking steps to temper the entry of independent power producers, among other things by suspending the long term standard offer contracts. In late 1987, a CPUC division chief summed up the situation: "Our official position is that things are going a bit too fast."[26] Presently, the oversupply appears to be managed but the question still remains how to "control, nurture and refine"[27] California's PURPA program in order to balance the new, independently-produced power with existing utility resources.

An overview of California's energy supply policy in the ten-year period from 1979 to 1988 indicates three main phases as defined by the dominant policy task in each phase:

1979 - 84	<u>Stimulate</u> alternative, independent power
1985 - 87	<u>Restrict</u> continued entry of independent power
1988 -	<u>Sustain</u> independent power as potential resource

California's electrical supply is not truly dispersed, nor will it likely become so soon. At this writing, the reality of a viable dispersed

[26]David Morse, CPUC, private communication.

[27]William R. Ahern, Presentation to the California Public Utilities Commission's Public Staff Division on Regulation of the Electric Utilities, working paper, March 25, 1985, p.1.

alternative that would cause serious economic problems for the utilities has led to policy and regulatory responses that have dampened potential dispersion in the industry.

Significant Factors in California.

PURPA legislation "paved the way" for the growth of dispersed power in California but beyond PURPA, we see five factors primarily responsible for the strong response by dispersed power producers in California and their ability to enter the grid.

1. State support. The conscious state support of independent, primarily "alternative" power producers led to innovative regulatory actions that were essential to success. California's policy in initiating an extensive set of tax credits and other incentives to stimulate the technological development of renewable energy sources such as wind power is well known. During the early 1980s many regulators were frustrated that not enough alternative energy producers were coming forward with projects and that state funded demonstration projects were having difficulty negotiating purchase agreements with the utilities. A ready market for power produced by alternative technologies was necessary to meet state goals of reducing dependence on oil and gas for power production, and PURPA became the means by which the state could achieve its own policy goals.

2. Economic standardization of contracts. California regulators, utilities and independent producers took a pioneer role in drawing up four standard offer contracts to regulate power purchases. These standard offers had crucial significance in several ways that are detailed in the next section. In addition to setting uniform payment terms, the standard offers resolved a range of complex technical issues. Standard offers provided an

impetus and security to independent producers since they indicated "safer, easier, known" negotiated terms. Standardization speeded up what otherwise would have been a series of long and drawn out case-by-case contract negotiations.

3. Stable long term rates. The avoided costs provision in itself, if implemented only for short term energy supply contracts, could not stimulate extensive long term investment dependent on sales to a single utility. Two California standard offer contracts provided long-term rates based on forecasts of energy prices for 10 years (and capacity for up to 30 years), thereby reducing financial risk for independent producers and providing the assurance of stable income that financial institutions required. As a representative of independent power producers has stated, "Without such long-term contracts, QFs simply will not be built."[28]

4. Special interest groups. In the early 1980s, independent power producers formed several special interest organizations that responded to utility proposals, provided ongoing information to their members, and took a strong participatory role in the legislative and regulatory proceedings involving independent power. Organizing in interest groups strengthened a considerable number of individual producers into a collective with several advantages. As with most special interest organizing, it was an efficient, less costly means of "pooling resources" among the power producers. Perhaps more importantly, independent power organizations in California have proved to be highly competent, employing technical and legal expertise that has continuously challenged utility arguments. Finally, organizing into special

[28]J.G. Hamrin, United States of America before the Federal Energy Regulatory Commission: Written Testimony of National Independent Energy Producers, Docket No. RM87-12-000, p.21.

interest groups allowed independent producers to gain valuable political access to the on-going policy process through organized participation in hearings and workshops, lobbying, and written responses to rule-making initiatives.

5. Problem Solving Strategies. One of the most remarkable aspects of the California story is the ability of the regulatory agencies to find ways of dealing with problems and conflict in an on-going manner. This active, fluid approach was demonstrated in several ways:

- Regulatory agencies often acted as "third party mediators" by actively solving problems and defining terms between utilities and non-utility producers. Their informal approach (workshops, negotiating conferences) helped to avoid litigation and facilitated agreement between parties when sensitive issues were involved.
- Regulatory agencies were also important initiators and facilitators, often adopting preliminary measures pending final review. As Flavin pointed out as early as 1984, "When complex issues will take months or years to resolve, interim rules keep the planning process going."[29] This on-going, successive solving of problems has been a key element in the success of the California policy.
- Regulatory agencies provided competent, in-depth information and analysis that was useful in clarifying issues. A broad-based, open policy process with e.g. early notification of proposed policy changes got a range of parties involved early and kept them informed throughout the process.

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[29] C. Flavin, Electricity's Future: The Shift to Efficiency and Small Scale Power, Worldwatch Paper 61, Worldwatch Institute, Washington D.C., November 1984, p.51.

III. Four Critical Issues in California Alternative Energy.

The process of encouraging production of large amounts of electricity from new sources and new suppliers was a pioneering effort in California that has been the object of a great deal of review and controversy[30]. Based on California's experiences in the 1980s, we will discuss four critical issues or problems posed by grid systems introducing a dispersed production capacity: 1) avoided cost, 2) oversupply, 3) self generation and 4) wheeling. From an empirical standpoint, these critical issues are important because they offer a "bank of experience" concerning system-level problems, organizational conflicts, and policy dilemmas in connection with integrating non-utility cogeneration and small power projects into the electrical grid system.

ISSUE 1: The design of avoided costs.

The most critical resource management problem for a grid is to integrate widely divergent costs of certain production units within a system that provides a uniform product. Most grids charge a relatively flat rate for their product or service, blending inputs of high and low cost in ways that are largely invisible to customers. The purpose of PURPA was to provide a market for innovative non-utility electricity production schemes within part

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[30] See for example, Jesse Tatum and Ted Bradshaw, "Energy Production by Local Governments: An Expanding Role", Annual Review of Energy, 1986, Wiggins, et al. Hans Fransson, Energi Och Miljö: Vad Kan vi lära av Kalifornien?, Stockholm: Byggforskningsradet, 1987.

of the blended mix of sources, thus stimulating new sources and greater overall system efficiency, as long as QF power cost no more than the utility's options. Avoided costs were defined as the "anticipated marginal cost" of the next increment of power the utilities would add to their system. If a utility needed an expensive base load system, the price of such a system would be avoided; but if they already had ample plants, all that would be avoided was fuel costs. After needed capacity was obtained, and displaceable fuel was saved, the avoided cost would fall to near zero because nothing could be avoided.

Economically and technically the avoided cost concept seemed reasonable, but for grids it challenged critical organizational premises and left state regulators with several unresolved issues. For example, PURPA did not specify how to maintain grid stability and reliability; it did not consider the grid's balance of short term and long term investments; and it did not resolve the tradeoff between higher capital expenses for lower fuel costs.

In 1981-82 the CPUC proceeded with plans to implement the PURPA provisions for avoided cost payments to independent producers of electricity. A small number of QF project developers had already negotiated agreements with the major utilities to sell power, but each agreement had been constructed anew, sometimes in a way that was contentious and unsatisfactory from the point of view of one or both parties. The CPUC initiated negotiations on standard offers to define cost provisions and important contract details. In 1983 utilities, developers, and regulators reached consensus on four standard offer contracts as mutually acceptable interpretations of PURPA's notion of avoided cost.

The standard offer contracts dealt with many of the critical variables involved with utility load planning. Different payment rates were set for avoided capacity (cost of investing in a facility) and avoided energy (fuel and operating costs per kWh). Rates differed as well depending on reliability--e.g. if the facility would be available during peak hours--and on the length of the contract. Many utility supply management decisions were given economic value in the final formulas.[31] The critical variables, however, were capacity and energy payments. In general, capacity payments were calculated on an avoided investment in a "proxy" new natural gas combustion turbine plant, which was the marginal facility all three California utilities would have built for additional power at that time. Payments to producers for energy (kWh) delivered were based on a formula of "incremental energy rates" (IER) that are composite ratios of the average cost of service expressed in BTUs, which are multiplied by the cost of fuel to get a sensitive marginal value for energy costs.

Four Standard Offers. The four standard offers varied in how they treated energy and capacity payments. The first three standard offer contracts were relatively simple options. Standard Offer 1 (SO 1) was a short term, as "available", contract. Energy rates were recalculated quarterly and capacity payments made for the time the facility is delivering electricity to the utility based on the value of an avoided combustion turbine. Standard Offer 2 (SO 2) was available to producers who offered firm capacity, meaning that they produced during 80 percent of peak hours. Energy

[31] Contract options differentiated between long and short term commitments, as well as between source and type of fuel (e.g. cogeneration vs other technologies). Ultimately the utilities were permitted to issue riders that increased payment if the independent facility were "dispatchable" or if it met other utility criteria. For an extended discussion of the contracts see Summerton and Bradshaw, "Toward A Dispersed Electricity System - the New Organization of Electrical Supply in California", 1989.

payments for SO 2 were the same as SO 1, but capacity payments were forecast for up to 30 years. As an incentive, some payment was "frontloaded" meaning that it was paid at a higher rate in early years and a lower rate in later years (neutral over the long run). Standard Offer 3 (SO 3) was a simplified contract for small QF's based on SO 1 rates. Standard Offer 4 (SO 4) was the most attractive of the offers, accounting for over 60 percent of contract capacity. Adopted on an interim basis in 1983 for long term suppliers, SO 4 had three separate options. The first, for cogenerators, provided gradually increasing forecasted energy prices for up to 10 years. The second option offered an incentive of levelized (averaged) energy prices based on the 10 year forecast (payments would be higher than the first option initially but followed by lower ones than forecast rates). The third option forecast incremental energy rates but let them vary according to fuel prices. All three options utilized the thirty year firm capacity forecast of SO 2. Thus, SO 4 provided guaranteed rates over a long period for energy or capacity payments, or both. After too much success, SO 4 was suspended in 1985.

A continuous problem with the avoided cost framework was to make it sensitive to both market reality and changing power requirements. A long-term method was needed to determine fair avoided costs, but since the utilities were not building plants it was difficult to say what was avoided. A means was also sought to select the best QF projects from among several applicants. In 1988 the CPUC approved a final SO 4 format through which long term contracts or facility construction will be offered in response to power needs as identified in the CEC Biennial planning process, which reviews demand and supply options for each utility. When a need for power is identified, the utilities will propose how they will meet the need. These proposed projects set the benchmark for avoided cost levels. QF's then have the option of bidding to supply up to the amount of power proposed by the utilities at the same price or less. The lowest bidders will be selected to receive the contracts[32].

Are Rate Payers Indifferent? The obvious risk of having contracts based on long term energy price forecasts is that forecasts can be in error. In California in the 1980s, falling oil prices, reduced demand due to conservation, and abundant out-of-state power introduced very large errors in the energy forecasts. Figure 1 shows energy payments since 1981 using PG&E as an example, with the other utilities having a similar pattern. PG&E's average payments for energy (in cents per kWh) for "as available" power purchases gradually rose to over 7 cents in 1985 and then fell to near 2 cents in 1988. The gradually increasing forecast rate utilized under some SO 4 options started at about 5 cents and move to 6.5 cents by 1988. The long term rate was thus initially below the short term rate; now utilities claim that they are overpaying because the long term rate exceeds the short term rate. While the utilities can pass the costs along to consumers under regulated rates, the question of overpayment continues to be highly controversial. Regulators generally agreed that payments are too high, but a major joint study of rates by the CEC and CPUC did not conclude how large the overpayment was[33]. Notably the problem is concentrated in long term rates for alternative fuels; cogenerator rates were not forecast.

[32]A controversy still exists over what rate should be paid to the successful bidders. The CPUC favors the concept of a "second price" auction (price paid is that of the lowest loosing bid), whereas the CEC is urging a more conservative payment to successful bidders on the basis of the highest successful bid.

[33]CEC/CPUC Joint "Oversupply" Study Report, Spring 1988.

Insert Figure 1 here

The issue is not a quantitative one of how much certain contracts lead to overpayment, but rather how forecasting errors are allocated in the ratebase. If the utilities had completed their planned coal and nuclear plants, their excess capacity would have led to expensive results. In fact, the CPUC staff has argued in testimony that the overpayment for independent power, however calculated, is much less than the anticipated costs to the ratepayer of over 6300 MW of planned nuclear and coal plants that have been avoided[34]. Furthermore, when compared to the cost of large utility projects that have actually come on line, the rates paid for QF power have been favorable. As Figure 1 indicates, the long-term rate that has led to overpayment today initially represented an "underpayment" for independent power.[35] In short, the question of overpayment depends on the criteria used.

Avoided cost is a dynamic concept. With the exception of wrong forecasts of energy prices, the California model has shown that rates that are fair to ratepayers, provide incentives for non-utility producers, and provide long-term advantages to the grid can be set. Moreover, as the industry has evolved, new contracts are signed according to a bidding format

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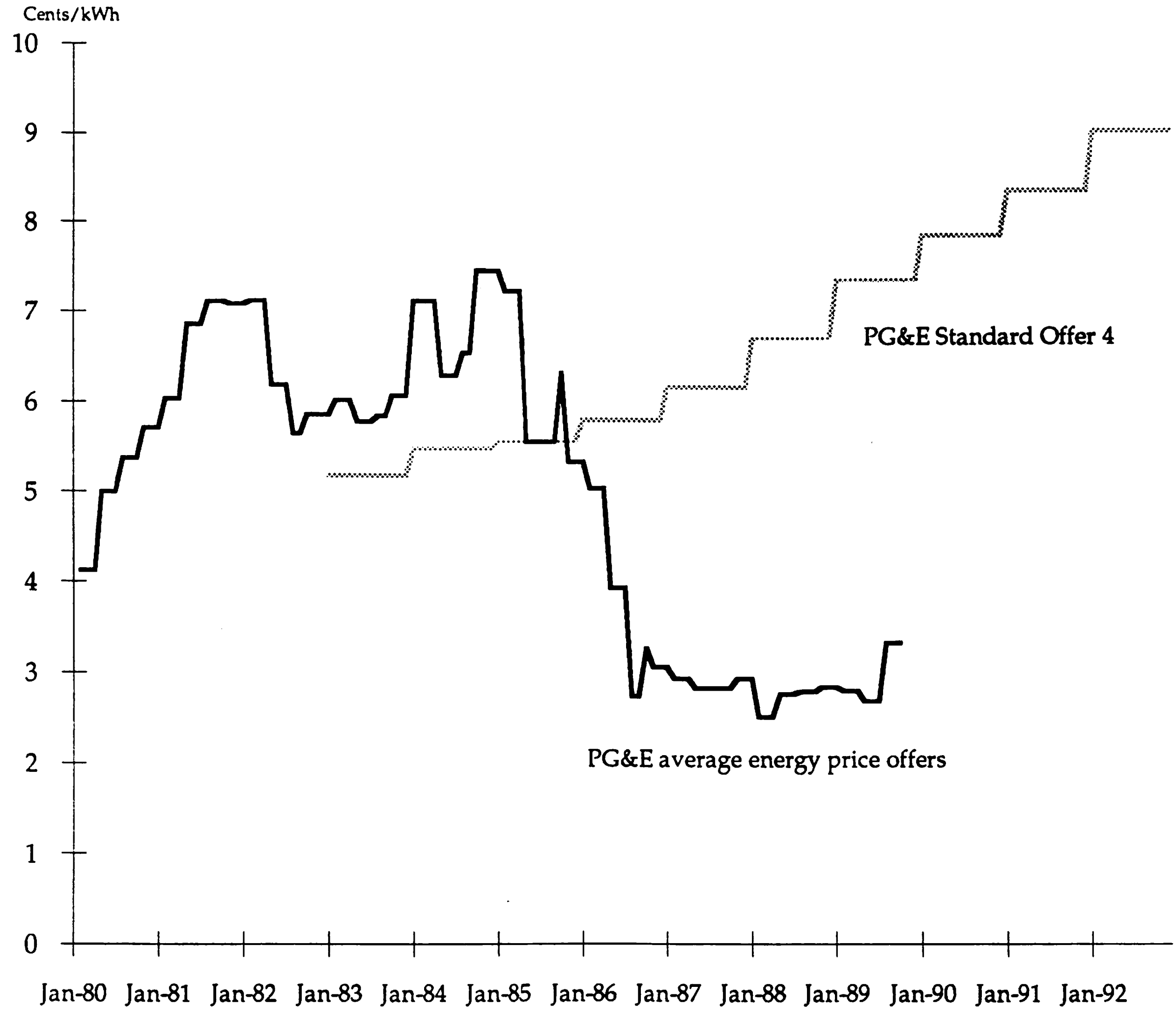
[34]David Morse, Testimony, CEC/CPUC Joint Hearings on Excess Electricity Supply, September 4, 1987, p. 3.

[35]As Joskow has pointed out, "It is well known that traditional regulatory accounting principles do not yield prices at a particular time that reflect the relevant "market value" of more or less electricity. Regulated prices move in a cycle between "too high" and "too low" under the traditional cost-accounting formulas used to set rates, and are "just right" only on average over time." P.L. Joskow, "The Evolution of Competition in the Electric Power Industry", Annual Review of Energy, 1988. p. 223.

Figure 1
QF Energy Price Comparison



The PG&E (Pacific Gas and Electric) average energy price offers are not time-of-day differentiated.
Source: PG&E: *Cogeneration and Small Power Production, Quarterly Report* (First and Second Quarter, 1989), and *Standard Offer 4*

in which QF producers might sell power at rates below avoided cost, leading to a benefit to ratepayers.

ISSUE 2: Excess generating capacity.

Grid systems typically are "lumpy systems"[36]: additions to the capacity of the system are made primarily in large "lumps" (e.g. large power plants, new transmission lines). One of the most attractive features of QF power is that it can be added in small increments as needed. However, California's program resulted in large amounts of QF power entering the grid at the same time as large, much delayed power plants (for example the 2000 MW Diablo Canyon nuclear plant in PG&E's service area) came on line. Contracts for electricity from QF producers, which had filled the gap before Diablo Canyon started producing in 1987, very suddenly became oversupply.

Besides the collision in timing, another reason for the short-term oversupply was that California standard offers were made available without limit as to the amount of capacity that would be accepted. When the standard offers were being designed, some type of limit was discussed but not included because, as Julian Ajello recalled, "no one thought more than 1,000 MW of qualified facilities would sign the offers."[37] By 1985 the CEC and CPUC realized that too much power was being committed through standard offer contracts. The strategy called for by the undersupply situation of the early 1980s had succeeded too well and needed to be revised. In April 1985, less

[36] T. LaPorte, Institute of Governmental Studies, University of California at Berkeley, private communication, August 1987.

[37] Julian Ajello, "Cogeneration - A Major California Resource", California Public Utilities Commission, San Francisco, California, (Unpublished Mimeo, 1986) p.4.

than three years after the standard contracts had been drawn up, the CEC suspended interim SO 4 [38]. This was followed by suspension of the other long-term contract, SO 2, in March 1986.

Interpreting Oversupply. In assessing the supply situation, an important task was determining how much of the 15,000 MW of QF-projects with signed contracts (see Table 1) would actually come on line. All parties agreed that existing contracts would be honored, but that all "milestone" deadlines and stipulations would be rigorously enforced. Many contracts, especially those signed contracts during the final "rush" before the standard offers were suspended, were not economically and technologically feasible, failed to be funded, or could not obtain necessary permits. The state has not encouraged completion of such projects, with the consequence that only half of the 15,000 MW are estimated to be built. The estimate is fairly firm now, since the last standard offer contracts, if not in production, will expire by 1990 (five years after signing).

Need for Additional Capacity. Today, not only have predictions of long-term oversupply been moderated[39], but some utilities already have a need for additional power or expect to have such need in the near future. SDG&E had a need for additional capacity in 1987, and the CPUC approved their request to reinstate SO 2 contracts, resulting in the utility signing new contracts for about 200 MW of additional capacity to come-on line within five

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[38] According to Pacific Gas and Electric Company, it had entered into over 5,000 MW of SO 4 offers by that time. See PG&E, Federal Energy Regulatory Commission, Comments of Pacific Gas and Electric Company, Docket No. RM87-12-000, April 30, 1987, p.44.

[39] California Energy Commission, 1986 Electricity Report, p. III-1.

years.[40] SCE currently has neither a surplus nor a need situation, whereas there are indications that PG&E still has excess power for 3-5 years. However, PG&E came within a few percentage points of its capacity during a recent summer peak, suggesting that it has no oversupply at the present time.

There are two ways of interpreting how a perceived massive oversupply in generating capacity in mid-1980s was replaced by needs for additional capacity in certain service areas within five years. First, the amount of excess capacity has in fact been significantly reduced due to growth in demand, the failure of a number of contracted QF projects to satisfy requirements, and policy measures to discourage new projects. By the second interpretation the utilities' assertions of oversupply have continuously been vastly exaggerated. Independent power producers, wanting to secure and expand their own operations, have pointed out that despite claims of not needing QF-power, many utilities continued to plan for their own future power plants while actively pursuing other long-term power options (notably out-of-state purchases). The question of "oversupply" therefore brings into focus the fundamentally different views of utilities and independent producers concerning the role of independent power projects vis-a-vis utility-owned resources in the grid system.

Even as the current supply situation is being resolved, the issue of California utility oversupply has become more complex due to large amounts of power in the Pacific Northwest area of the U.S. and elsewhere which is

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[40]In September 1988 the CPUC further recommended that SO 2 contracts "should be made available from all utilities, subject to reasonable restrictions, on a regular basis." See CPUC "Final Decision, Compliance Phase: General Resource Planning Issues, Performance Features ("Adders"); Availability of Standard Offer 2"; Decision 88-09-026, September 14, 1988, p. 61.

available at very attractive short-term prices. Current system oversupply in the US and elsewhere means that for a period, utilities will want to "dump" power at a low price even if it fails to cover expenses. Small producers find it difficult to compete in these situations, and as long as the utilities and the regulatory bodies believe that the out-of-state power will continue to be available at a low price, there will be little economic justification for additional QF production. Thus the present projected level of QF power additions over the next decade is less than 100 MW per year[41].

The issue of oversupply is about improving system planning, but it is also about continuing competition between independent producers and utilities. The technical potential for QF production in California is substantial. According to the Energy Commission there will be some 12,000 MW of cogeneration potential in 1999, 1,600 MW of biomass and other methane, potential 7,000 MW wind, 1,300 MW small hydro, 5,400 MW geothermal, 1,800 MW waste to energy, and virtually unlimited solar.[42] Of this specified 29,000 MW potential, only about 7,000 will have been developed by the early 1990s. The balance, of which 2,500 MW is presumed to be economically possible in 1999 under SO 1, remains an uncertain backdrop to California energy policy. Under slightly different economic or technological conditions further QF development might be an attractive resource for meeting future demand or a potential source of oversupply.

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[41]California Energy Commission, 1988 Electricity Report, Draft final, p. IV-24.

[42]Ibid., p. IV-61.

Issue 3: Self generation - impacts, problems, benefits.

A third major issue shaping the dispersion of electrical production in California involves "self-generation" by industries, commercial interests, municipalities or others who generate electricity through cogeneration and use the power internally rather than selling it to the utilities. For our purposes, a self-generator is defined as an electricity producer with the primary purpose of providing on-site, internally used power; excess power can nevertheless be sold to the utility as available. Self-generators usually provide only part of their needs, relying on the utility for the rest, including reserve ("back-up") power.

An increase in self-generation is compatible with a dispersed electricity system but not necessarily with a conventional grid system. The self-generation potential is significant in California: decentralized, on-site self supply is a logical use for cogenerated power as well as a source of overall energy efficiency. From the perspective of grid systems, however, it raises many issues of equalities and points to the problems caused by the high fixed costs of the grid system. The problem of self-generation, like the problem of withdrawals from the grid, is another manifestation of oversupply. Both issues question to what extent a tightly coupled grid system with high "sunk costs" can absorb variations in relation to installed system capacity.

The CEC has estimated that in 1988 approximately 1,200 MW capacity was available from self-generators on a statewide basis, with a likely increase to 1,800 MW by 1992[43]. This amount represents about 3% of California's electrical production, or about 25% of the QF-power for sale to the grid.

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[43]Ibid., p. IV-25.

Self-generators can, roughly speaking, supply their own electrical power for approximately 4-5 cents/kWh or, alternatively, (if they have a SO 2 or SO 4 contract) sell this power to the utility for approximately 5-6 cents/kWh. At the same time, the cost of purchasing retail power from the utility is as much as 7-12 cents/kWh, depending on the service area and the type of industrial rate the cogenerator is able to obtain. The differences in cost is the primary incentive to self-generate.

Benefits and Challenges. Self-generation in substantial amounts provides a number of important benefits for the society. Under most conditions, these benefits would include increased overall reliability in supply (through reduced system demand), increased transmission reliability (since the power is used on-site), and higher efficiency in the use of scarce fuels. In a fuel shortage these benefits would be clear and important. In addition, self-generation in industry provides financial savings and thus increased market competitiveness to energy-intensive firms by reducing their operating costs.

Self-generation can also involve significant benefits for utilities. Large amounts of self-generation reduce marginal costs and increase utility reserve margins, both of which in turn reduce the price that utilities pay for "as available" capacity from independent power facilities under short-term standard contracts. With the exception of the initial reduction of revenue, economic impacts and benefits of self-generation to different utilities can vary considerably and are highly dependent upon the system characteristics of the individual service area involved.[44]

Self-generation raises, however, issues concerning the roles and

[44] Ibid, p. II-1.

responsibilities of utilities. One example is the obligation of utilities to provide "back-up" power. When a customer leaves the grid to self-generate, the utility remains legally obligated to continue to supply electricity to that customer on demand. A major source of contention is how much this service is worth. A recent CPUC decision priced it high; they approved an expensive flat fee for connection capacity (in some cases as much as half the customer's electricity bill) that must be paid regardless of amount of power used.

From a utility standpoint, a self-generator represents a customer who leaves ("bypasses") the grid, resulting in a loss of revenue. Admittedly, utility costs are reduced due to "avoided" generating costs for producing that amount of power, which can be a net benefit if the marginal cost exceeds average cost. In the current oversupply situation, however, the benefits of self-generation are gained by the cogenerator at the expense of remaining ratepayers. They must share the burden for what utilities define as their fixed costs, including transmission and expensive installed baseload power plants (particularly nuclear plants). The utility must either bear a reduced rate of return or shift its revenue loss onto remaining ratepayers in the form of higher electricity rates.

Regulators have responded to protect the utilities. The CPUC provided utilities with special "incentive" rate options to allow them to keep potential self-generators on the grid at substantially reduced, negotiated rates. The large Chevron oil refinery near San Francisco is an example of a plant which designed a cogeneration plant to supply its own electrical needs. With its capacity need of 99 MW and annual electricity bill of $55 million[45],

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[45]Energy User News, March 1988, p. 7.

Chevron is PG&E's largest customer. The $112 million cogeneration plant which Chevron designed was not built. In 1988 PG&E negotiated a substantially reduced retail rate with Chevron with rates close to what Chevron's cogeneration cost would have been (approximately 4 cents/kWh, although the exact figure has not been disclosed). This rate can be compared with the 7 cents/kWh that the company had been paying previously.

While rates that discourage self-generation benefit the utility grid, negotiated rates bring up critical questions of equality between utility customers. Is it fair that some customers (primarily large ones) are able to negotiate lower electricity rates by refraining from self-generating, while other smaller utility customers which do not have self-generating options are "stuck" on a grid with higher costs? From the point of view of a dispersed system, self-generation is ideal, a technology that will increase in value once utility marginal costs rise or regulators aim not to continue protecting grid monopolies.

ISSUE 4: Access to transmission capacity: "wheeling".

The fourth major issue is the question of third-party access to utility-owned transmission lines. "Wheeling" is the use of transmission facilities owned by one utility to transmit or wheel power over the grid to another utility system or to its customers. Like self-generation, wheeling offers the potential for selective "withdrawal" of some customers from the local utility's grid monopoly. When a utility customer has the possibility of "wheeling" lower-cost power than his local utility sells, the utility has lost its monopoly market and must compete with sources well outside its service area. In ways similar to self-generation, when customers withdraw from the grid the regulated utility must continue to cover its high fixed costs for under utilized capacity, further increasing the need to recover income from the remaining customers.

Three kinds of wheeling need to be distinguished. The first is utility-to-utility wheeling, in which a utility transmits excess power to a utility needing power. Inter-utility wheeling is a well-established routine in California and elsewhere, where formal or informal inter-utility "stock exchanges" for power purchases exist. (It is worth noting, however, that in the U.S. this wheeling is done at the discretion of the utility owning the line in question; in certain situations it is not advantageous for the grid-controlling utility to "lease" its lines to a competitor[46]). The second kind of wheeling can be termed non-utility producer-to-utility wheeling, in which cogenerators or others seek to use regulated utility transmission lines to sell wholesale power to utilities outside their own utility service area. The third kind of wheeling is non-utility producer-to-end-user wheeling, whereby independent power producers use utility-owned transmission lines to "wheel" wholesale power to an end-use customer in or beyond that utility's service area. The third form of wheeling is the most contentious form since it implies a more deregulated environment in which non-utility producers sell power directly to today's utility customers. Not surprisingly, it is vigorously opposed by all utilities and most regulatory bodies.

Points of contention. The question of wheeling raises complex technical, economic, legal and regulatory problems. Particularly problematic

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[46]A recent effort to break this bottleneck in Wisconsin has involved the state regulatory agency creating a statewide, mutually owned, transmission system, that would treat all municipal and private utilities equally. See Energy User News, June 1989.

are rate design, the extent to which transmission capacity is available, system reliability, and interconnection contracts[47]. Moreover, the electric utility industry sees expanded wheeling as a threatening loss of markets, where benefits to certain customers may be gained at the expense of others. If large numbers of utility customers "bypass" local utility power by having outside power wheeled into them, the utility's fixed costs would have to be borne by a smaller number of remaining ratepayers, thereby leading to higher rates. This problem is regarded by some utilities as a form of "skimming the cream" which could result in a spiral effect of increasing withdrawals from the grid. Such a development is clearly detrimental to customers who, lacking the means to obtain other alternatives, remain on the utility grid.

Utility monopoly over transmission is a barrier to full competition in electrical generation. Small power producers increasingly want access to markets outside their own utility area. Large electricity customers want to take advantage of lower-cost independently produced power. Wheeling, therefore, is the critical obstacle that stands in the way of a fully dispersed electricity system encompassing a range of independently-owned, alternative power projects alongside of existing utility resources. Also, with some regions showing signs of short-term overcapacity while other areas need power, expanded wheeling opportunities offer a means of alleviating regional imbalances in supply and demand, thereby increasing system efficiency.

In California, some utilities see possibilities of obtaining electricity from new sources at lower cost. However, municipal utilities in California

[47]For a discussion of wheeling issues, see Kaufman, Alvin, et. al., "Wheeling in the Electric Utility Industry", Congressional Research Service, Report No. 87-289 ENR, February 12, 1987.

generally must rely upon the discretionary use of private utility transmission capacity in order to gain access to new sources of electricity because they do not own the needed lines. Transmission lines owned by groups of municipal utilities such as Northern California Power Authority (NCPA) or by LADWP provide some access. NCPA will own a share of a new line to the Pacific Northwest if it is constructed. An example of a municipal utility wanting to wheel power is Sacramento's utility, SMUD, which has contracted with investor-owned SCE for a certain amount of low-cost power which must be wheeled over transmission lines owned by SCE's competitor, PG&E. An agreement was reached with much difficulty, but the lack of provisions for mandatory wheeling in such cases is regarded by many municipal utilities as a substantial barrier restricting their possibilities of obtaining lowest price electricity.

Not surprisingly, cogenerators and other independent power producers see the possibility of selling their power in utility service areas other than their own. Cogenerators whose local utility has an oversupply of electricity and therefore low avoided costs may want the option of selling their power to other utilities with higher avoided costs. With overcapacity conditions in many areas, wheeling can also be a prerequisite for even finding a market.

Large industrial or municipal self-generators with several plants that purchase electricity are also potential beneficiaries of wheeling services. The City of Palm Springs, a desert community located east of Los Angeles, provides an interesting illustration. In an innovative project, Palm Springs completed construction in 1986 of two cogeneration plants designed to supply all of the City's thermal (especially summer cooling) needs, while producing excess electricity on-site that was to be sold to SCE. SCE's payment for this electricity was based on the utility's avoided cost at the time and was anticipated to be a substantial source of revenue to the City. Due to subsequent drops in SCE's avoided cost, however, by March 1987 SCE's "buy-back" rate to the City for this electricity had dropped to less than 25% of the rate that the City was paying SCE for electricity for city buildings at sites not served by the cogeneration plants. According to City testimony before FERC, the economic advantage for Palm Springs to "wheel" their own power to other city-owned sites rather than first selling and then re-purchasing power from SCE was $.071/kWh.[48] City officials were unable to negotiate a contract with SCE to wheel. Noting that taxpayers and utility ratepayers are essentially the same constituency, Palm Springs sees significant benefits in making transmission facilities available, for a fee, "to allow small power producers to utilize their power in other remote facilities, owned by the small power producer, located within the same political subdivision."[49]

The regulatory jurisdiction over wheeling remains unclear. Formally, the Federal Energy Regulatory Commission, FERC, has jurisdiction over interstate wheeling, whereas authority over in-state wheeling lies with state public utility commission, e.g. the CPUC. Since no state except Texas has a self-contained grid, however, ambiguities easily arise in specific approval cases.[50] Some observers argue that the CPUC already has sufficient power to

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[48]Allen F. Smoot, Cogeneration and Small Power Production Issue Paper/Testimony Presented to the Federal Energy Regulatory Commission by The City of Palm Springs, California, Docket No. RM87-12-000, March 27, 1987, p.2.

[49]Ibid., p. 4.

[50]In 1988 a series of hearings by the Energy and Power Subcommittee in the U.S. House of Representatives addressed the question of whether interstate transmission should be in the hands of the state rather than

authorize wheeling but hesitates to do so. In 1987, a bill aimed at providing wheeling access to both utilities and independent power producers was introduced in the California State Legislature but did not pass. A bill calling for mandatory wheeling service between utilities, which would provide new opportunities for municipal utilities in particular, was subsequently introduced.

IV. Conclusion.

The critical issues outlined above point to important technical and economic constraints in grids that adopt dispersed means of production. In countries around the world experimenting with means to include dispersed production technologies in their electric utility systems, issues such as those encountered in California are certain to be important. From the utility perspective, the fast moving independent electricity production industry is a mixed blessing. While the utilities can gain capacity without the problems of large capital investment or the risks of ownership, they also face a loss of considerable control, especially in flexibility to utilize short-term power purchase opportunities. They were made vulnerable to withdrawals, poor limited dispatchability over significant additions to energy and capacity (particularly in the short term), and contentious inequalities in ratepayer absorption of fixed costs. Equally important, it is clear that utilities as a system will face organizational problems and conflicts significantly more complex than the mere technological problems of

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federal regulators.

restructuring their well established grid system. Independent power producers have reconfigured the ownership, organization and working operation of critical components of the grid, necessitating policy and regulatory action in previously uncharted domains.

Historically, electrical grids evolved as a closely integrated system within each service area, with the utility as the focal organization exerting centralized, monopolistic control over its highly-coordinated, multiorganizational system. Although the organizations which made up this system were heterogeneous - ranging from bulk power suppliers to end-users - they were united by a common interest in supporting and expanding the system. Interorganizational linkages and the institutional norms, terms and ways of thinking that regulated them were, in general, well-established. Hughes has likened the complex, far-reaching network often formed by large technical systems to a "seamless web".[51]

The market entry of independent power producers in the 1980s is a departure from the traditional organization of the grid. The new power producing organizations--wind farm entrepreneurs, industrial cogenerators, sewage and landfill operators and others--are not necessarily oriented toward maintaining and expanding the interests of the utility controlled grid. In fact, independent power producers represented interests potentially (or actually) in conflict with those of many utilities which were committed to retaining their long-standing production monopolies.

With the role of independent power in the grid system unclear, the increasing numbers of non-utility power producers raise the question of the

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[51]Thomas P. Hughes, "The Seamless Web: Technology, Science, Etcetera, Etcetera", Social Studies of Science, vol. 16, 1986, pp. 281-92.

future role of electric utilities in industrial society. This future involves two alternative types of grid organizations with different goals, norms, and ways of thinking. The first, increasing monopoly concentration, is based on utilities resisting or absorbing independent power producers, restricting competitive forces, and continuing the concentration of control within the grid. This probably will necessitate the continued expansion of the utilities into new "energy services" functions whereby machinery, conservation, upkeep, monitoring, and other services are provided under contract to the end user who pays a flat rate for the bundle of energy and services provided. In contrast, a second future utility role may be restricted to a narrow range in which utilities just provide grid services for dispersed independent producers and (possibly) distributors. The dispersed option does not mean that there will be less interdependence or interconnection; perhaps the opposite will be true because wheeling will surely be more prevalent. It will also lead to a more reliable system because it is more redundant and less vulnerable.

Worldwide, utility roles are changing rapidly within highly varying institutional and political frameworks in response to the potential of substantial increases in dispersed production. Some systems will retain tight control over producers while others will take advantage of increasing dispersal and diversification of supply. California's experience shows one set of responses while raising many unresolved issues. The viability of a significant increase in dispersed production, however, has been successfully demonstrated.

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