THE BACKSTOP EFFECT OF PURCHASED POWER ON THE PRICE OF STEAM COAL

by

Philip F. Roan

A thesis submitted to the Faculty and Board of Trustees of the Colorado School of Mines in partial fulfillment of the requirements for the degree of Master of Science (Mineral Economics).

Golden, Colorado

Date March 21, 1990

Date March 21, 1990

Signed: Philip F. Roan

Approved: Thomas D. Kaufmann
Thesis Advisor

Golden, Colorado

Date March 22, 1990

Dr. John E. Tilton
Professor and Head,
Mineral Economics
Department

ABSTRACT

This thesis examines the backstop effect of purchased power on the price of steam coal to utilities. In 1988, 42 percent of the electrical output of Public Service Company of Colorado was purchased power. A case study approach based on Public Service Company of Colorado is used to test the hypothesis that the effect of these power purchases on the price of steam coal has been to hold the price to a certain level, thus acting as a backstop. Further consideration of the backstop effect leads to the conclusion that purchased power increases the competitiveness of the coal market. This conclusion is tested by examining the rents and real coal prices realized by the companies that supply PSCO with coal. The results of these examinations indicate that coal companies have become more competitive, supporting the conclusion that in the case of PSCO, purchased power has had a backstop effect on the price of coal.

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ACKNOWLEDGEMENTS

This thesis would not have been possible without the assistance of several people. The foremost among them is my advisor, Dr. Thomas D. Kaufmann, whose suggestions kept the thesis moving forward. Joe Nugent at the Colorado Division of Mines provided helpful information on coal production. Valuble information on wholesale power transactions was provided by Anthony Montoya of Western Area Power Administration, and by Gerry Stellern and William Martin of Public Service Company of Colorado. Finally, I would like to thank Ms. Lita Dunham, the Mineral Economics Department editor, who struggled to reverse the effects of my disinterest in English grammar.

Chapter 1

INTRODUCTION

1.1 The Effect of Purchased Power on the Price of Steam Coal

This thesis examines the effect of wholesale power transactions on the price of steam coal sold to electric utilities. A case study approach is used. The utility studied is the Public Service Company of Colorado (PSCO). The supply of coal and wholesale power to PSCO is examined to determine whether the wholesale power transactions have in fact acted as backstop to the price of steam coal and have prevented the price of steam coal from rising above a certain level.

1.2 The Backstop Concept

The concept of a backstop has received considerable attention from the energy industry since the energy crisis of the late 1970s. Simply put, a backstop is a resource which performs the same service as another resource, but at a higher price (Fisher, 1981). A backstop is simply a higher priced substitute for another resource. In the case of a resource with several substitutes at varying prices, the backstop is the least expensive of the higher priced substitutes. This thesis will consider the effect of a backstop for steam coal on the price of the steam coal sold to electric utilities.

1.2.1 <u>Derived Demand for Steam Coal</u>

Like many metal and mineral products, steam coal has a derived demand. A derived demand means that the product is a raw material for other industries, not a finished good. In the case of steam coal the property desired by the downstream industry is its Btu content, or heat value, mostly as an input to the process of producing electricity. This process is normally carried out by operating boilers to generate electricity from the resulting steam. Utilities in the United States can produce electric power for sale to their customers by purchasing wholesale power on a contract or spot basis as well as by operating their generators. The option to buy wholesale power provides a backstop to burning coal at that particular location and modifies the local demand for coal.

Public Service Company of Colorado (PSCO), the utility under study, uses long-term wholesale power purchases to augment its baseload capacity and buys wholesale power by long-term contract and on the spot market through a power pool to reduce its operating costs. About 95 percent of PSCO's electrical output has traditionally been produced from coal. In 1987 and 1988 nuclear-fueled electric generation increased, reducing the amount of coal-fired generation to about 90 percent. This trend was part of the decommissioning process for the Ft. St. Vrain nuclear plant. PSCO originally intended to use up the remaining fuel in the reactor prior to decommisioning the plant. In August of 1989, Ft. St. Vrain was shut down permanently when hairline cracks were discovered in the tubes that supply steam to the turbine generators (PSCO 1989c). With Ft. St. Vrain closed, PSCO will depend on coal more than ever. This thesis concentrates on the scenario of coal demand displaced by wholesale power.

1.2.2 Possible Backstops for Steam Coal

There are several possible substitutes for steam coal. This study will consider two categories: direct substitutes and indirect substitutes. Direct substitutes are those which compete with coal as boiler fuel: other coals from other regions; petroleum, in the form of light oil and heavy oil; and natural gas. Direct substitutes all have transportation costs from their respective points of origin to the utility under consideration. Indirect substitutes, on the other hand, are those fuels which are not suitable for or available to the utility under consideration but are used at other utilities on an interconnected power transmission network. The electricity produced from these fuels competes with the electricity produced from coal at the utility under consideration. These fuels include nuclear fuel, other coals and natural gas as well as hydropower and alternative fuels such as biomass technology, solar energy, and wind power. These indirect substitutes will be grouped together as purchased power. The appropriate basis for comparison between these direct and indirect substitutes is the marginal delivered cost of electricity produced from each fuel expressed in dollars per kilowatt-hour ($/KWh).

The primary resource under consideration is coal purchased under long-term contracts for use as boiler fuel at a steam generation station in the PSCO system. PSCO's coal comes from three producers with contracts extending, in some cases, well beyond the year 2000. These contracts were not available for this study but they are assumed to include "reopener" clauses or other provisions for dealing with price and quantity variations. Given the small number of producers and the extreme length of the contracts, the price for this coal is assumed to be a negotiated price rather than an exogenously determined price. This price may be tied to some index of escalation or use wages and prices as a basis of escalation. Competition between producers prevents any single producer from realizing monopolistic profits, but producers still try to negotiate the most favorable price.

1.3 The Mechanism of Wholesale Power Transactions

Wholesale power transfers occur between utilities whenever one utility sells a block of power (a certain number of kilowatt hours) to a second utility for less than the cost to the second utility of generating that block of power.

1.3.1 Physical Constraints to Competition

These transfers occur over the same transmission lines that the utilities use to service their customers and are subject to two important mechanical constraints. The first constraint is the capacity of the lines. The transmission lines have fixed capacities and cannot be operated safely beyond these capacities (Moore 1988). Customers of the utilities are given first priority for the use of this capacity. Wholesale power transfers can be cancelled if there is not enough capacity available on the transmission system.

The second mechanical constraint is the problem of wheeling and the related problem of line losses. Electric transmission seldom goes directly from one utility to another. Transmission lines are interconnected, and any electricity sent from one utility is received in varying amounts at all other interconnected utilities. Electricity flows through all available paths in inverse proportion to the impedance along those paths. Wheeling refers to the retransmission of the electricity back to the utility it was intended for. The charge for wheeling can make the transaction less economically beneficial. Often utilities will simply record electricity in and out from interchange at the end of the year as a balance sheet gain or loss instead of retransmitting it.

Line losses also reduce the amount of electricity received, but the cause is different. The loss results from the resistance of the transmission lines themselves. Line resistance increases as a linear function of the length of the transmission line (all other factors: voltage, current, ect. remaining constant). This problem is more pronounced in the western United States than it is in the East since the distance between population centers, the transmission distance, is greater in the West.

1.3.2 Other Barriers to Competitive Wholesale Power Markets

Other than the mechanical constraints mentioned above, two other constraints prevent the market in wholesale power from being perfectly competitive. Both arise from legislation. The first is regulation, which keeps the utilities from acting to maximize their profits. The form of the regulation is usually to limit the rate of return the utility can earn in any given year. In the case of PSCO, amounts above this rate of return are rebated to the customers of utilities in the following year as a one-time rate reduction (PSCO 1989a). This regulation acts as a disincentive for utilities to maximize profits. This disincentive prevents wholesale power transactions from being fully utilized to lower the costs to the utility.

The second disincentive is the Public Utility Regulatory Power Act of 1986 (PURPA). This legislation requires utilities to buy power generated by qualifying facilities (QFs) at the avoided cost to the utility. The avoided cost is determined by the Public Utility Commission (PUC) which regulates the utility. These QFs are usually using alternative, low pollution technologies, such as solar, wind, or biomass, to generate electricity. The legislation states that the utilities must buy the full amount of power offered at the price they would have paid to generate the power themselves. This legislation has been subject to considerable debate and modification by utilities working with their PUCs. In its unmodified form the effect of the legislation, if the avoided cost is correctly calculated by the PUC, is to absorb all the rent a utility could realize by using a lower cost source of power such as wholesale power purchases.

1.4 Methodology

Public Service of Colorado (PSCO) used coal for 91 percent of its 1988 generated electrical output. The rest was generated by a very small amount of nuclear power (until August 1989 when Ft. St. Vrain was closed), hydroelectric power, petroleum, and natural gas. The reason for the limited use of natural gas generation may be because PSCO is a natural gas utility as well as an electric utility and can realize greater profits by selling the natural gas to customers than using it to fuel its steam boilers. PSCO engages in power pooling on a regional basis, which means it has a market to buy and sell wholesale power. For the reasons discussed in section 1.3.2 and elaborated in chapter 2, the incentive to seek a larger market is lacking.

A model of wholesale power transactions and their effect on the price of steam coal will be developed. It will be shown under this model the effect of wholesale power purchases is to increase the competitiveness among the suppliers of coal. The firms that supply coal to PSCO will be examined to find out whether they have become more competitive. An increase in competition among coal suppliers would be indicated by a decrease in rents realized by the companies. Rents and real prices are examined by computing profit margins from balance sheet data. Decreasing rents and real prices in a period of increasing wholesale power purchases would support the concept of the backstop effect of purchased power on steam coal.

Data availability was quite sparce. Without having access to the operations section of PSCO, there is no way to determine the price of wholesale power, and thus no way to observe or identify the backstop effect in action. Regulatory agencies such as the Colorado Public Utilities Commission were not very helpful either since they do not track wholesale power pricing except in the years they are having a regulatory hearing. The last hearing that used wholesale pricing data was in 1980.

1.5 Organization and Findings

Chapter 2 examines the interchange system using case study data from PSCO and describes the supply of wholesale power to PSCO both by interchange and through long-term contracts. Chapter 3 provides a model for wholesale power supply. A time series of PSCO's wholesale power purchases are examined under this model. Chapter 4 examines the price of coal sold to PSCO and the margins of the suppliers of coal to PSCO. The data yields evidence of the backstop effect of wholesale power on the price of coal. Chapter 5 develops the implications of the backstop effect for steam coal, provides a critical analysis of the shortcomings of the methodology and the data available, and presents conclusions.

Study findings do not contradict the hypothesis that the backstop effect holds the price and rents of steam coal down by increasing the competitiveness of the coal industry. Moreover, evidence of increased competition is provided by decreased coal prices and rents to the coal suppliers. Real price data also supports this conclusion.

Chapter 2

DEMAND FOR ELECTRICITY AND THE SUPPLY OF WHOLESALE POWER

2.1 Introduction

PSCO's demand for electricity and supply of wholesale power are examined. The unique demand characteristics of the region PSCO serves and the interconnected transmission system that supplies PSCO with wholesale power are described. A discussion of observed market shares of power generated from coal and wholesale power at PSCO follows.

2.2 U.S. Demand for Electricity

The demand for electricity in the United States has changed radically as a result of the oil embargoes and in response to economic downturns since 1970. Prior to 1970, the demand for electricity grew at a predictable average annual rate of approximately 7.8 percent with peak demand growth averaging 8.1 percent between 1945 and 1970 (OTA 1989). The rate of annual demand growth fell sharply in the early 1970s, possibly in response to higher rates being charged by electric utilities. Decreased demand may also have been the response to a decrease in energy-intensive manufacturing industries or a corrective measure to the "energy addiction" America developed as a result of national energy policies designed to provide abundant, low-cost energy. The correction could also have been the long-run elasticity of demand response to OPEC. Whatever the cause, the growth in peak demand, the traditional indicator of demand for electricity, has grown by only about 2.5 percent annually since 1973 (OTA 1989).

Decreased demand growth resulted in surplus electric generating capacity in the 1980s as plants ordered in the 1970s came on line. There are signs that demand growth increased in the late 1980s in response to growth in the economy in general and strong service and commercial sector growth in particular. According to the National Electric Reliability Council, the goal of the electric power industry is to have 20 percent capacity over the expected peak demand for any given year (OTA 1989). In some regions that limit is being reached. Utilities have so far been reluctant to bring additional capacity on line without stronger evidence of increased demand growth.

The demand for electricity is usually expressed as a function of time. This function is commonly called the load curve. A typical load curve is shown in figure 2.1. The load curve is a sinusoid of irregular amplitude varying over a 24-hour period. The height of the curve at any given time is the amount of electricity demanded at that time. The

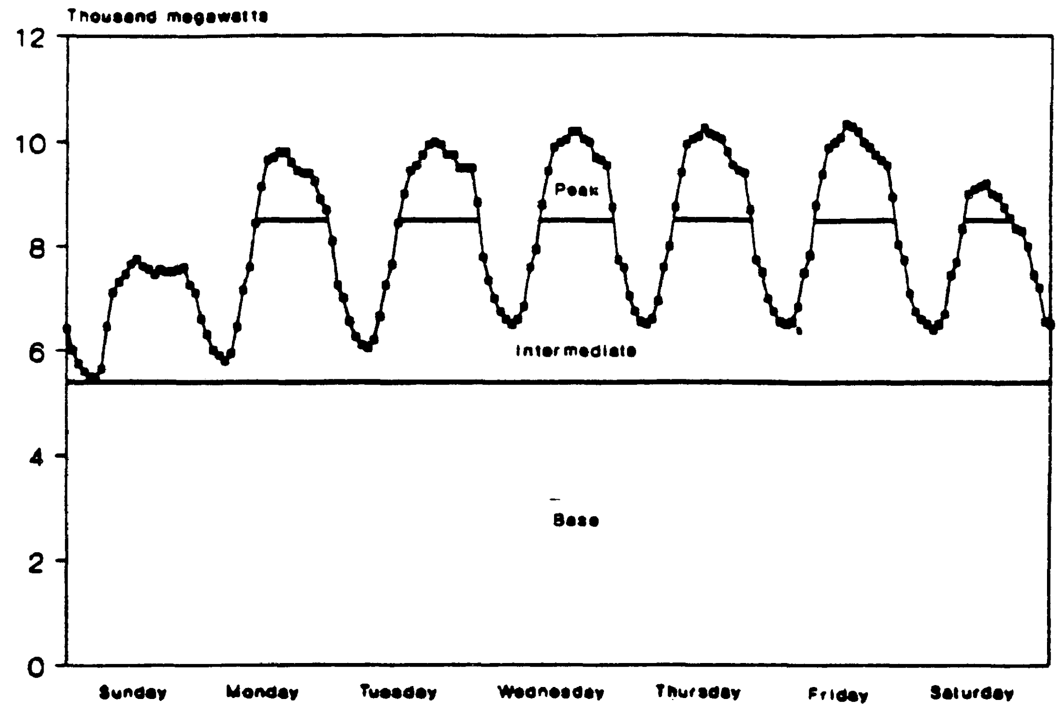


Figure 2.1 Typical Weekly Load Curve

Source: Office of Technology Assessment. Electric Power Wheeling and Dealing: Technological Considerations for Increasing Competition. OTA-E-409. Washington, DC: GPO.

maximum amplitude of the curve is a function of the weather and the time of year. Especially hot summers or cold winters produce peaks in the load curve.

The load curve is arbitrarily divided into three separate parts. The area below the bottom of the curve is referred to as baseload demand. The top third is called peak demand, and the area between the two is called the intermediate demand. Baseload demand is usually satisfied by the lowest cost power source, most often coal, purchased under long-term contract. This demand is reliable and reasonably constant. Peak demand is satisfied by numerous more expensive but less reliable sources, such as gas turbine generators and spot coal purchases. The critical point, or point of contention, occurs at the point on the load curve where these other sources become cheaper than the baseload source. If this contention results in the renegotiation of coal contracts, then the other source is exerting a backstop effect on the primary source. Most often purchased power exerts this backstop effect on coal since it is available throughout the load cycle.

2.2.1 Western Region Electricity Demand

PSCO is a member of the Western Systems Coordinating Council (WSCC), a group of utilities in the western United

States. Growth in peak demand among the WSCC members is projected to be 1.8 percent a year. National growth in peak demand is projected to be much greater at 2.4 percent per year (OTA 1989). This 1.8 percent per year masks several conflicting trends. WSCC is the largest area of its kind in the United States and Canada, and some regions within the WSCC project high growth, such as 3.4 percent per year for the Arizona-New Mexico Power Pool. Other regions, such as the Northwest Power Pool Area, project a growth rate of only 1.1 percent per year (OTA 1989). The main factors accounting for this difference are population growth, climate, industrial activity, regional non-utility generation and price of electricity.

2.2.2 Historical Demand for Electricity at PSCO

Electricity demand is measured in terms of maximum firm peak requirements on the system over the year. For PSCO, peak demand can occur in the summer or winter. By contrast, peak demand for the country as a whole occurs in the summer. PSCO's ability to peak in two seasons is a strong argument for a higher capacity margin. A five-year history of peak firm demand is presented in table 2.1.

Table 2.1 PSCO Peak Demand
(in megawatts of electricity)

Year	Peak(MW)	Season
1984	2,948	summer
1985	3,024	winter
1986	3,237	summer
1987	3,298	summer
1988	3,362	winter

Source: SEC form 10-K filed by the Public Service Company of Colorado for the fiscal year ended December 31, 1988, p. 1.

2.3 The PSCO System

Public Service of Colorado supplies electricity and natural gas to an area with an estimated population of 2.6 million people, 1.9 million of whom live in the Denver metropolitan area (PSCO 1989a). The company also owns Cheyenne, an electric and gas utility in Cheyenne, Wyoming. The figures for electricity supply and demand include Cheyenne.

PSCO has 8 steam generation stations located at various sites throughout Colorado (see figure 2.2, map). These stations account for 2,486,700 KW of effective capacity. All of this capacity is generated by coal except 10,700 KW

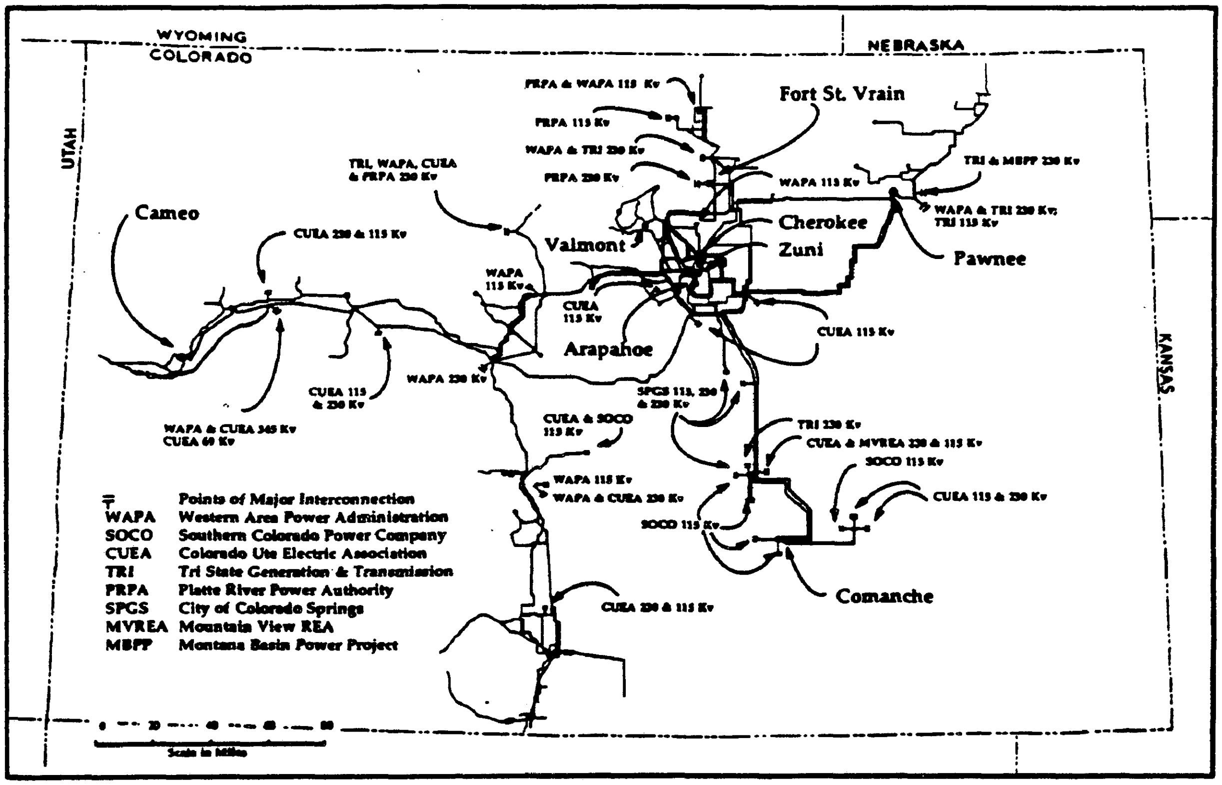


Figure 2.2 PSCO's Service Area and Transmission System

Source: Public Service Company of Colorado. 1989. Securities and Exchange Commission form 10-k.

which is produced by gas and oil at the Zuni Station in Denver. Other fuel sources include 171,000 KW of effective capacity from 6 gas-powered combustion turbines at various locations; 23,400 KW of capacity from 10 hydropower units at various locations; 60,000 KW of capacity from hydro power from the Cabin Creek pumped storage unit near Georgetown; and 15,500 KW from 7 diesel generators at various locations, for a total of 2,757,200 KW of effective capacity of which 2,476,000 KW is generated by coal. In addition PSCO has long-term contracts for 1,185,000 KW of firm power (as of 1989) with other utilities which are interconnected with PSCO's transmission system at various points (see figure 2.2) (PSCO 1989b).

2.3.1 Fuels Used to Generate Electricity at PSCO

Coal is the major fuel used by PSCO with gas a distant second. Nuclear fuel was omitted from the discussion in section 2.3 because Ft. St. Vrain, the only nuclear plant in the PSCO system, was removed from the rate base as part of the decommissioning process. Nuclear-fueled generation from Ft. St. Vrain is included in the 1,185,000 KW of contract power. The percentage of each fuel used from 1984 to 1988 is shown in table 2.2. Given the percentages in table 2.2, it would be a reasonable assumption that, in the period from

Table 2.2 Fuel Use at PSCO

Year	Coal	Gas	Nuclear
1984	98%	1%	1%
1985	99	1	0
1986	98	1	1
1987	94	4	2
1988	91	4	5

Source: SEC form 10-K filed by Public Service Company of Colorado for the fiscal year ended December 31, 1988, p. 7

1984 to 1986, coal was the only fuel displaced by purchased power. Nuclear fuel generation increased in 1987 and 1988 as PSCO attempted to use up the existing nuclear fuel at the Fort St. Vrain plant prior to decommissioning it. Since Ft. St. Vrain was the only nuclear plant in the PSCO system, the assumption that coal is the only fuel displaced by purchased power is even more viable for the future.

Coal is purchased primarily under three long-term contracts. The largest contract currently in effect is with Amax for 3.96 million tons per year until Pawnee #2 is completed and 3.6 million tons per year after that until 2013. The second contract is with Cyprus Coal Company which calls for 1.7 million to 1.9 million tons per year from 1988 to

1997. The third contract is with Atlantic Richfield Coal Company for 190,000 to 210,000 tons per year from 1988 to 1991. The average cost of coal per ton and per Btu is shown in table 2.3.

Table 2.3 Cost of Coal to PSCO

Year	$/ton	$/Btu
1984	23.81	1.275
1985	23.64	1.254
1986	24.18	1.291
1987	25.05	1.325
1988	22.39	1.200

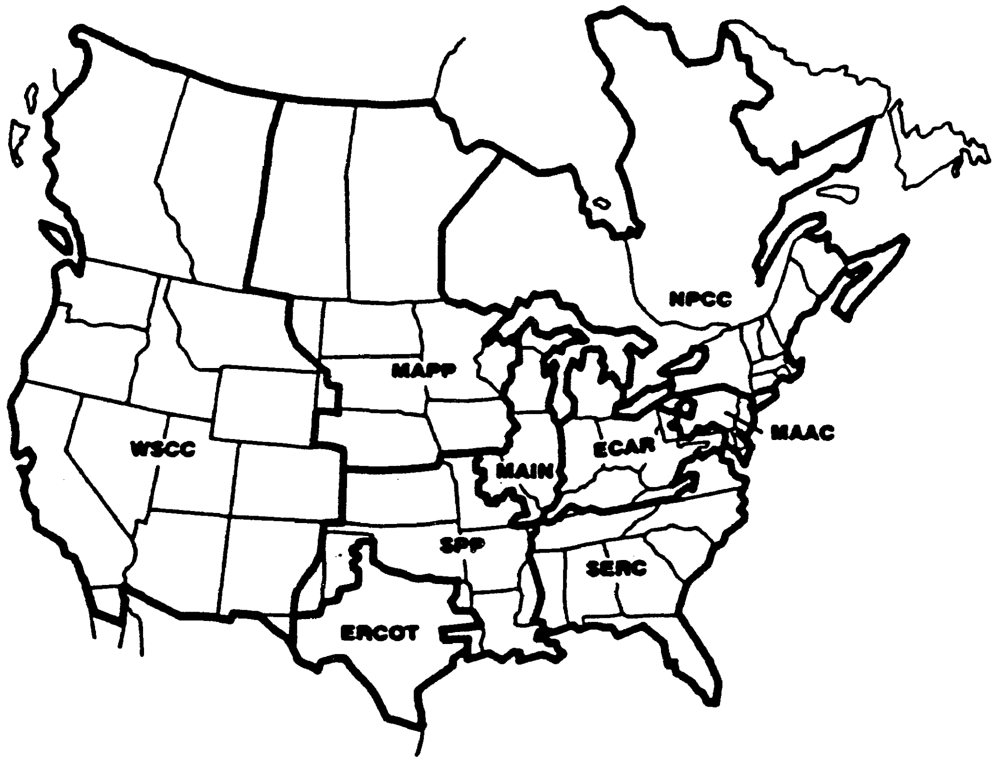
Source: SEC form 10-K filed by Public Service Company of Colorado for the fiscal year ended December 31, 1989, p. 7

2.4 The Interconnection

The interconnection is the network of utilities that sells wholesale power among its members via interconnected transmission lines. It is not a perfect system. To understand why, it is helpful to understand the system of interconnections among electric utilities in the United States and Canada.

2.4.1 NERC

All the electric utility plants in the United States and most of Canada are part of the North American Reliability Council (NERC). NERC is subdivided into nine regional reliability councils (figure 2.3). Certain of these nine regional councils are connected together as interconnections. Utilities in an interconnection can easily share electric power since all the generators in the interconnection are synchronized. Utilities in different interconnections can also exchange power, but not as easily since an intermediate conversion to direct current (DC) is needed to solve the problem of synchronization differences between the two alternating current (AC) systems (Moore 1988). In spite of these limitations, most utilities get plenty of opportunities to purchase wholesale power on the spot market because all the utilities in the United States and Canada are divided into only three interconnections: the Eastern Interconnection (which extends almost to the Rockies), the Texas Interconnection (which includes only Texas utilities, but not all of them), and the Western Systems Coordination Council (named after the NERC subcouncil which has the same geographic boundaries). The interconnections are shown in figure 2.4. PSCO is a member of the Western Systems



ECAR: East Central Area Reliability Coordination Agreement
ERCOT: Electric Reliability Council of Texas
MAAC: Mid-Atlantic Area Council
MAIN: Mid-American Interconnected Network
MAPP: Mid-Continent Area Power Pool
NPCC: Northeast Power Coordinating Council
SERC: Southeastern Electric Reliability Council
SPP: Southwest Power Pool
WSCC: Western Systems Coordinating Council

Figure 2.3 North American Electric Reliability Council

Source: Office of Technology Assessment. Electric Power Wheeling and Dealing: Technological Considerations for Increasing Competition. OTA-E-409. Washington, DC: GPO.

Figure 2.4 Interconnections within NERC

Source: Office of Technology Assessment. Electric Power Wheeling and Dealing: Technological Considerations for Increasing Competition. OTA-E-409. Washington, DC: GPO.

Coordination Council (WSCC).

It should be emphasized that utilities cannot share all their capacity through the interchange since this power is delivered through existing transmission lines. The first priority of the transmission system is to serve utility customers. Transactions between utilities can occur only when transmission lines aren't fully loaded by customer power demands. Utilities can build more transmission lines to take advantage of the savings from wholesale power transactions. Additionally, electric power flows throughout the system of interconnected power lines in amounts proportional to the impedances of the lines. This means that a utility "A" trying to deliver power to a utility "B" would quite likely wind up delivering power to several other utilities as well. These other utilities might agree to transfer the power to utility "B" for a fee (wheeling). In the WSCC power flows in an oval-shaped path known as the "doughnut" with the "hole" located over the state of Nevada (figure 2.5). Power sent to any utility on the doughnut will split with parts going both clockwise and counterclockwise. Part of all power transmitted along the doughnut travels in the opposite direction it was intended for. In practice, complex computer routing and scheduling of power lines is used to move wholesale power over the transmission system of

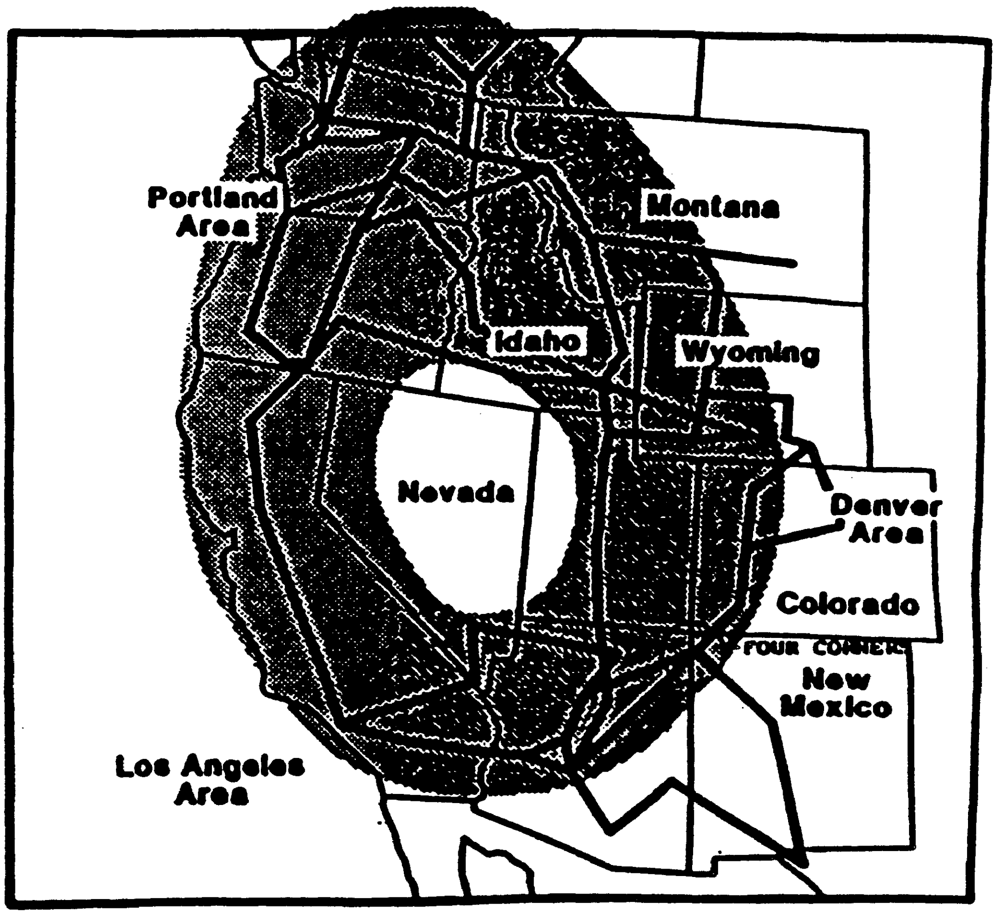


Figure 2.5 Loop Flows in the WSCC Interconnection

Source: Office of Technology Assessment. Electric Power Wheeling and Dealing: Technological Considerations for Increasing Competition. OTA-E-409. Washington, DC: GPO.

an interchange.

2.4.2 WSCC

The WSCC is composed of 19 investor-owned utilities (IOUs), 17 municipal utilities, 16 public power utilities, and 5 government agency generators. The WSCC includes Arizona, California, Colorado, Idaho, Nevada, Oregon, Utah, Washington, Wyoming, parts of New Mexico, Montana, South Dakota, and Texas, and the Canadian provinces of Alberta and British Colombia. The WSCC has an installed capacity of 123,022 megawatts (MW) and a minimum capacity margin of 31.5 percent. This capacity margin is defined as the amount of power available, minus the amount of peak demand, divided by peak demand, and expressed as a percentage. Although the WSCC currently has the highest capacity margin of any of the NERC subcouncils, this capacity margin is not a reliable indicator of the power available to be transferred between utilities. First, in the WSCC, pooling is accomplished on a regional basis, and regional margins may be higher or lower than the WSCC margin. Secondly, the margin represents more of a minimum amount available for wholesale transfer than a maximum, since the figures are taken at peak demand. At off-peak there would be much more capacity available for wholesale transfer. There is a heavy volume of bulk power transfers throughout the WSCC with coal-fired power being sold to Canada to supplement hydropower in the dry seasons and imports of Canadian hydropower in the peak summer months. Coordination and pooling occurs on a sub-regional basis with no central brokering by any one firm. Federal Energy Regulatory Commission (FERC) studies indicate that consolidated pooling could greatly reduce costs in the WSCC, but so far nothing has been done to coordinate pooling on a system wide basis probably due partly to the large number of utilities involved and the large geographic distances within the WSCC and partly to the lack of incentive to minimize costs in a regulated industry.

The WSCC is divided into four separate smaller regions: the Northwest Power Pool, the Rocky Mountain Power Area, the Arizona-New Mexico Power Area, and the California-Southern Nevada Power Area. These regions all have different seasonal fuel usage patterns. The Northwest Power Pool is winter peaking and relies mainly on hydropower. The Rocky Mountain Power Area is summer or winter peaking and relies on coal and hydropower. The Arizona-New Mexico Power Area is summer peaking and uses coal and gas/oil fired generation. The California-Southern Nevada Power Area, also summer peaking, depends heavily on gas and oil fired generation (OTA 1989). The large capacity margin on the interchange and the fact that it serves two time zones indicates that there will be a large amount of capacity available at any given time. The different time zones should mean that there will be two distinct peak demands, and that the utilities that aren't currently facing peak demand should be able to find a market for their capacity among the utilities that are. The large distances involved present a barrier to the exchange of power because longer lines have greater transmission losses (line losses are a linear function of the length of the transmission lines).

2.4.3 Intermediate Capacity: The Area of Contention

The demand for electricity varies over time as shown by a load curve, like an irregular sinusoid (see figure 2.1). The area below the bottom of the through of the sinusoid is referred to as baseload capacity. At PSCO the baseload capacity is provided by coal-fired steam electric generators. Coal is a common choice for baseload capacity since it provides cheap, dependable generation, and baseload is the part of the demand that is the most reliable. Not surprisingly, baseload demand is usually supplied by long-term contacts for coal. The area above the baseload capacity line to about the top third of the sinusoid peak is called intermediate capacity. At PSCO the boundary between intermediate and baseload capacity is the area where coal-fired power competes with wholesale power. When wholesale power becomes cheaper than contract coal, the contract price must be renegotiated or coal will lose some of its market share. In the intermediate region itself, power is provided by burning coal purchased on the spot market or purchasing wholesale power generated by other utilities on the interchange. The decision of whether to generate power or to buy spot power is typically made on an hourly basis. Information is usually available on utilities with power for sale and on the asking price for that power on an hourly basis (Cohen 1982). The area at the top of the sinusoidal load curve is referred to as peak capacity and is usually provided by fuels other than coal. At PSCO this capacity is provided by gas turbine generators. In the peak capacity region, wholesale power competes effectively with power produced from gas turbine generators.

2.5 Observed Market Sharing by Coal and Wholesale Power

In 1988 about 42 percent of the electric output of PSCO was purchased power. Of that, about 37 percent were nonfirm purchases on a short-term basis. Almost all nonfirm purchases were made because they represented a savings to the company compared with company-owned generation. Some of the non-firm purchases were made from qualifying facilities under PURPA, a federal law requiring utilities to purchase available power from qualifying facilities at the avoided cost to the utility. However, according to a recent CPUC ruling, the QFs can provide no more than 20 percent of the net firm peak load. As also approved by the CPUC, the company will initiate a competitive bidding system for qualifying facilities in the future. This will allow PSCO to get a more competitive rate on power purchased from QFs (PSCO 1989b). The bulk of the short-term, interruptable power is purchased through the Inland Power Pool. The pool is a regional system composed of various utilities in the WSCC. The pool provides three categories of energy: immediately accessible, accessible within 10 minutes, or accessible within 12 hours.

Long-term contracts for wholesale power provide a way for PSCO to increase its capacity without building any additional facilities. These capacity contracts are especially helpful since they are arranged to coincide with peak demand periods. This means that PSCO gets the same service out of these contractual agreements that a utility would ordinarily use a gas turbine or oil-fired generator for. So far PSCO has been able to use these contracts for wholesale power as an alternative to building more generating capacity. As demand for electricity grows, PSCO might eventually exhaust the available contracted capacity. In other words, the current "capacity bubble" in electric supply might be used up.

2.5.1 Long-Term Power Contracts

PSCO contracts as of December 1988 for firm peak power with other utilities are shown in table 2.4. These long-term contracts represent about a third of the total purchased power at PSCO. They do not represent displacement of coal by purchased power as much as displacement of physical plant assets by purchased power. Ft. St. Vrain, the nuclear plant in the PSCO system, is listed as a utility from which power is purchased. As a part of the decommissioning process, the plant has been written off PSCO's books and removed from the rate base. Colorado Ute is financially troubled and may be unable to meet the full length of its contract. These are minor losses and PSCO will probably have no trouble finding other sources of long-term contracted wholesale power. Wholesale power provided under contract is an easy and flexible way to bridge the gap between existing and required capacity without committing the utility to build any new facilities.

Table 2.4 PSCO Contracts for Wholesale Power as of December 1988

Utility	KW at 1989 peak	Expires
Basin Electric Power Cooperative	100,000	2016
Colorado-Ute Electric Association	100,000	1993
Pacific Power & Light	108,000	1997
Tri-State Generation and Transmission	100,000	2001
	100,000	2017
Platte River Power Authority	20,000	1994
	250,000	1994
Fort St. Vrain	230,000	1989
Various Qualifying Facilities	177,000	various dates
Total	1,185,000	

Source: SEC form 10-K filed by Public Service Company of Colorado for the fiscal year ended December 31, 1988, p. 1.

Note: Ft. St. Vrain, PSCO's nuclear facility, was shut down permanently in August 1989.

2.5.2 A History of Purchased Power as a Percent of Output

The history of purchased power as a percentage of total electric sales by PSCO is shown graphically in figure 2.6; the numbers contributing to the figure are shown in table 2.5.

Table 2.5 Purchased Power as a Percentage of Sales at PSCO (in gigawatt-hours)

Year	Sales	Purchases	%
1984	17.00	5.51	32
1985	17.54	6.97	40
1986	17.93	7.12	40
1987	18.36	8.36	46
1988	19.19	8.04	42

Source: SEC form 10-K filed by Public Service Company of Colorado for the fiscal year ended December 31, 1988, p. 2.

Purchases include net interchange. Net interchange is the net of electricity gained due the receipt of power at PSCO from a transmission not involving PSCO and lost due to transmission from PSCO not received by the parties it was intended for. All utilities in an interconnected transmission system have these gains and losses; usually they are

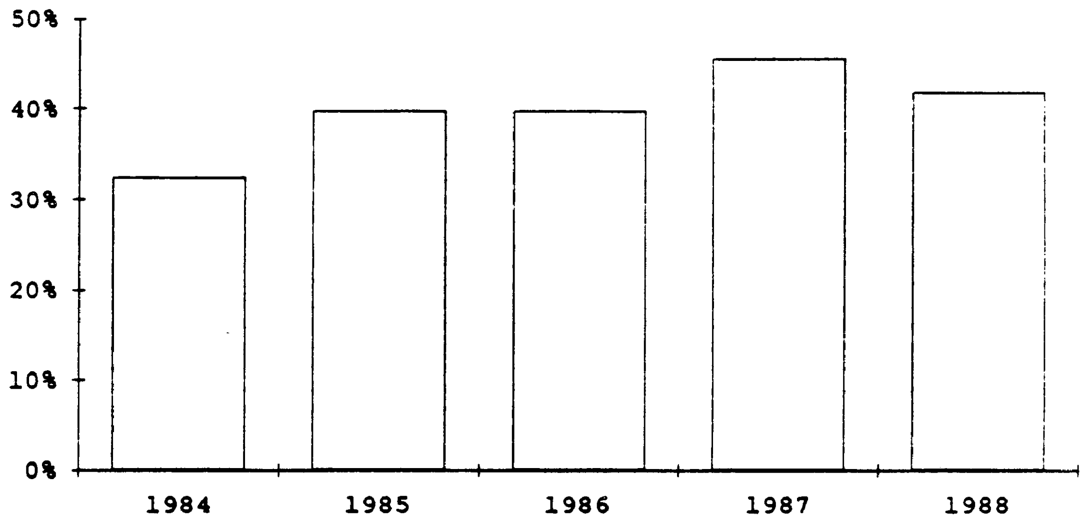


Figure 2.6 Purchased Power as a Percentage of Sales by PSCO

<u>Source</u>: Public Service Company of Colorado. 1989. <u>Securities and Exchange Commision form 10-k</u>.

not a significant portion of the total electric production. The figures suggest a strong trend toward increasing the amount of purchased power, perhaps in response to an increase in electricity demand and the fact that no new capacity has come on line in the period covered by the figures. Another reason for the increase in purchases could simply be that purchased electricity is competing more successfully with electricity purchased through generation.

2.6 Summary

The interconnection allows an imperfect distribution of power between utilities because of the limited availability of power lines and wheeling between utilities. These limitations aside, the interconnection allows for considerable competition between sources of electric power. The most widely vigorous competition is in the area of peak capacity, but competition also extends to intermediate capacity. Although the intermediate capacity range usually sets the backstop for the price of coal, PSCO is so coal intensive that the assumption is made that any power purchases displace coal. The wholesale power market for PSCO is divided between contracts for wholesale power and spot purchases of wholesale power. Contract purchases of wholesale power substitute for building new capacity. PSCO may have to build new capacity eventually as the demand for electricity grows and the amount of capacity available for long-term contracts is used up. Spot purchases of wholesale power are used to provide electricity more cheaply than the utility could generate it. When spot purchases become cheaper than the baseload power source, long-term contracted coal, purchased power exerts a backstop effect on coal by forcing the price of coal to be renegotiated.

Chapter 3

THE SUPPLY MECHANISM FOR WHOLESALE POWER

3.1 Introduction

The supply mechanism for wholesale power is examined using a model of two supplies of power offered to the utility, generated and purchased power. The operations section of the utility must combine these two inputs to produce the lowest cost output. The supply of power from the utility is actually a hybrid of power generated and purchased from other utilities. Rents and costs arising from the two inputs are identified in this model. The model is applied to PSCO, and coal displacement by wholesale power is calculated. Trends in displacement of coal by wholesale power at PSCO are examined. This supply mechanism is applied to the next chapter as the model for the backstop effect of wholesale power on steam coal.

3.2 The Mechanism of Wholesale Power Transactions

A utility on an interconnected transmission system constantly faces the decision to generate or purchase power at any given time. The two supply curves that compete for the utility's resources are the supply of electricity by generation and the supply of electricity by purchase. The utility's supply curve is a composite of purchased and generated power. The mechanism that causes a utility to create this composite supply curve is examined in the following sections.

3.2.1 Stepwise Supply Curves

Wholesale power gives the utility a second supply curve for electricity. This second supply curve is superimposed over the utility's own supply curve for generated electricity (see figure 3.1). Both supply curves have discrete steps. The steps in the supply curve for generated electricity indicate the electricity generated from various plants in the utility system which operate at different costs or the use of different fuels which have different costs. The steps in the supply curve for wholesale power indicate blocks of power sold at different prices. This stepwise effect also assumes that variable costs are constant over the entire range of productive capacity, an assumption that fits the electric utility industry well since costs are mostly constant at any given capacity level.

Figure 3.1 also shows two different levels of demand the utility must meet. These demands are shown as vertical lines to emphasize their inelastic nature. Inelastic demand is relevant to the electric utility industry where the fact

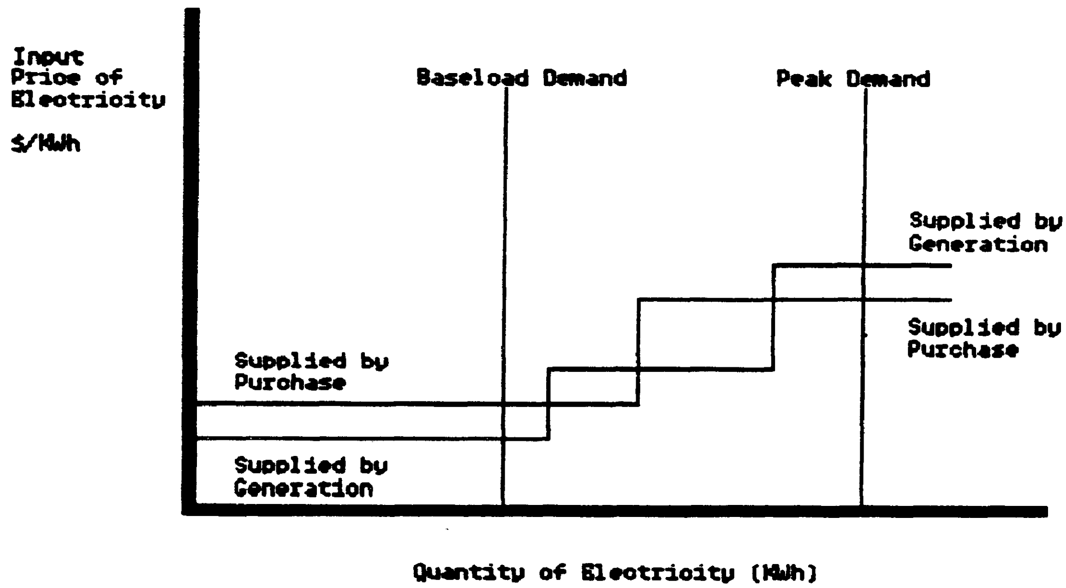


Figure 3.1 Stepwise Supply Curves

that electricity cannot be stored and that there is a long lead time, five to seven years, required to bring more capacity on line make short run modeling the most appropriate. The two levels of demand shown in figure 3.1 represent the demand for baseload power and the demand for peak power. The supply curves are arranged as shown to reflect the fact that purchased power usually competes more successfully against generated power at the peak level of demand.

3.2.2 Composite Supply Curve

Figure 3.2 shows a diagram similar to that in figure 3.1, but here the two supply curves have been combined into a single curve by ranking the available blocks of power according to cost. This is the composite supply curve from the utility. The composite supply curve is the lowest cost electric supply the utility could achieve at any level of power. As the figure shows, this composite includes alternate sections of purchased and generated power to achieve the lowest cost supply. Alternation is not necessary in ranking the blocks of power. The composite curve could be have two or more blocks of purchased or generated power in a row. This composite supply curve is at the heart of the mechanism for wholesale power transactions because it rep

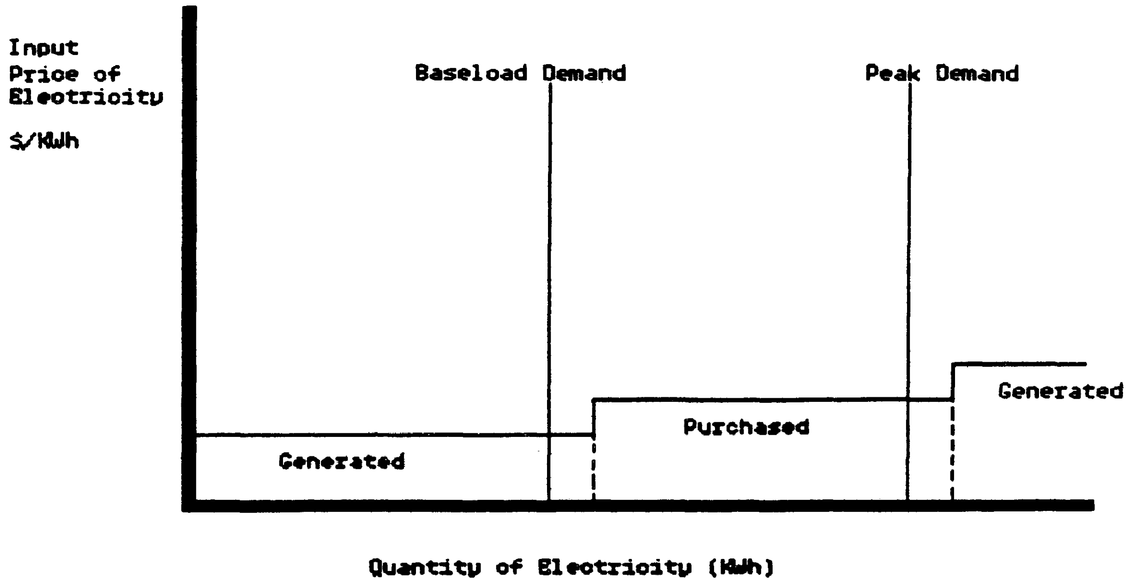


Figure 3.2 Composite Supply Curve From Stepwise Curves

resents what the utility can supply both to its retail and wholesale customers.

The vertical height between the purchased and generated power supply curves represents the savings the utility makes by using the cheaper source of power at that quantity. This savings is also the maximum amount of rent the seller of power could charge the buyer. The vertical distance between the two curves is therefore the room for price negotiation in the wholesale power transaction.

3.3 The Supply Mechanism and PSCO

The supply mechanism described in 3.2 is the model for the supply of wholesale power to PSCO. This supply is composed of a mixture of purchased and generated power from each of the utilities in the power pool. PSCO is a part of the Inland Power Pool, a group of utilities in the region which tries to reduce costs through buying and selling blocks of power to each other. Data on prices and quantities of power available in this pooling system were not available from PSCO, which considers the information proprietary. This discussion, and the model itself, is based largely on Cohen's 1982 study of The Florida Energy Broker, a power pool in southern Florida (Cohen 1982). At any given time, the operations section of PSCO must decide whether to generate or purchase power. They are confronted with a situation similar to that shown in figure 3.1. They are operating between baseload and peak demand and must figure out what the lowest cost method for meeting the demand is at any given time. There is a certain amount of power generated by burning coal which is typically received on a take or pay basis from the coal company and represents the largest, and usually lowest cost generating method, available to the utility. The demand between baseload and peak that cannot be satisfied by contract coal at the upper bound of the production range specified by the contract is filled by spot coal purchases and other higher cost methods of generation. Purchased power usually competes most effectively with these higher cost methods. Occasionally, purchased power competes with the baseload power. When this occurs, the purchased power is acting as an effective backstop to the price of steam coal.

When the price of purchased power is below the cost of generated power in the region of the load curve covered by long-term contract coal, coal prices have to be renegotiated or else coal loses some of the market. If coal loses too much of the market, the coal mine will not be able to continue operations. This is the backstop effect of purchased power on the price of steam coal. If the proportion of electrical power output produced by purchased power at a utility is increasing, then it would follow that this purchased power is displacing generated power. At PSCO, where the principal fuel for generation is coal, this displacement would probably be first to displace spot purchases of coal, then to displace long-term contracted purchases of coal, which would result in the contracts initially being held at the same quantity while the price was reduced, then finally reducing the quantity as well as the price.

3.4 Coal Displacement by Wholesale Power at PSCO

The quantity effect of wholesale power displacement on coal is calculated by determining the amount of coal that would be required to produce the electricity purchased by PSCO. The price effect of displacement is the renegotiation of the coal contract necessary for coal to remain a viable fuel at the utility.

The first requirement in the quantity calculations is a knowledge of the quality of the fuel, i.e., how many Btu are in a ton of coal, as well as the conversion factor of the utility. The conversion factor of the utility is assumed to be 10,500 Btu per net kilowatt hour, this figure was obtained in an interview with PSCO's engineers (Martin 1989). The quality of the fuel is determined from information published in the PSCO's 1988 10-k report. The results of these calculations and the method of calculation are shown in table 3.1.

Table 3.1 Quality of Coal, PSCO

	Avg. Cost		Avg. Quality	
	$/ton	$/MMBtu	MMBtu/ton	KWh/ton
1984	23.81	1.275	18.67	1778.52
1985	23.64	1.254	18.85	1795.40
1986	24.18	1.291	18.73	1783.78
1987	25.05	1.325	18.91	1800.54
1988	22.39	1.200	18.66	1776.98

Note: The information in the first two columns is from PSCO's 1988 10-K p. 7. The information in the second two columns is derived. The fuel quality in MMBtu/ton is calculated by dividing the figure in the $/ton column by the figure in the $/MMBtu column. Fuel quality in KWh/ton is derived by dividing the figure in the MMBtu/ton column by 10,500 Btu/net KWh.

The amount of coal displaced by purchased power is calculated by dividing the amount of power purchased by the quality of the coal. Table 3.2 shows these calcuations.

PSCO's coal requirements with and without wholesale power is presented graphically in figure 3.3. The amount of coal displaced on a yearly basis is shown graphically in figure 3.4. These figures show about 3 to 5 million tons of

Table 3.2 Coal Displacement by Purchased Power at PSCO

	Purchased Power(GWh)	Coal Quality (KWh/ton)	Displaced (Mtons)
1984	5,510.5	1778.52	3,098
1985	6,972.5	1779.40	3,884
1986	7,115.0	1783.78	3,989
1987	8,363.1	1800.54	4,645
1988	8,043.9	1776.98	4,527

Source: SEC form 10-K filed by Public Service Company of Colorado for the fiscal year ended December 31,1988, p. 15.

coal displaced per year at PSCO by wholesale power purchases. The bulk of this wholesale power is obtained on the basis of long-term contract. In 1988 PSCO had contracts for 1,185 megawatts at peak. Unfortunately this information represents only a snapshot, not a yearly amount of power obtained under long-term contract. Using ratio of peak contracted power to peak demand of 1,185/3,362 gives an approximate figure of 35 percent (PSCO uses 37 percent) of the total output that is purchased power under long term contract. The power purchased under contract does not displace coal so much as it displaces new plant assets. The power purchased above the 35 percent figure acts as a backstop to coal. This is mainly the economy power purchased through the power pool. This modeling relies on some key

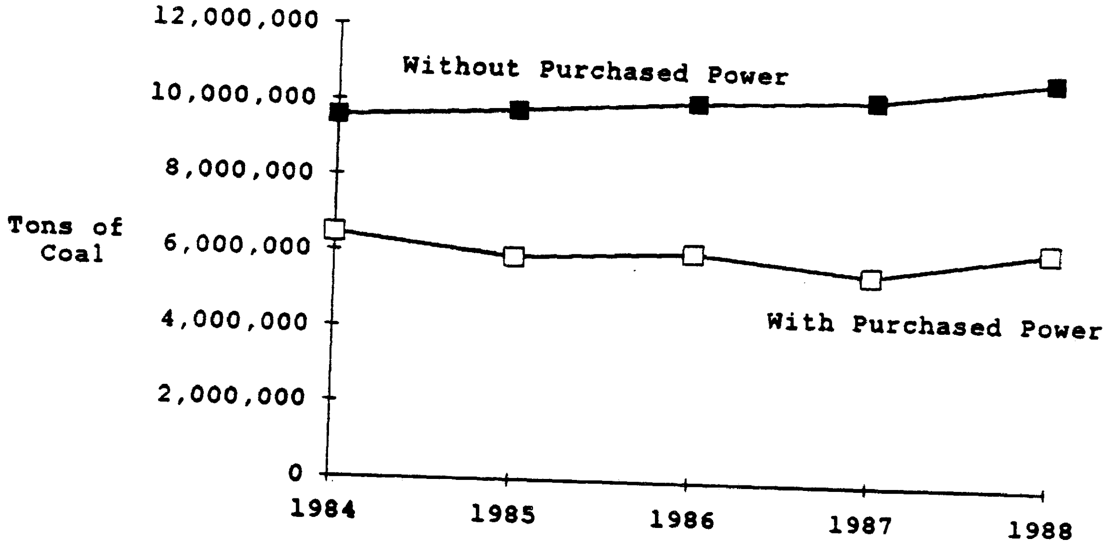


Figure 3.3 PSCO's Coal Displacement by Purchased Power

<u>Source</u>: Public Service Company of Colorado. 1989. <u>Securities and Exchange Commission form 10-k</u>. Denver, CO.

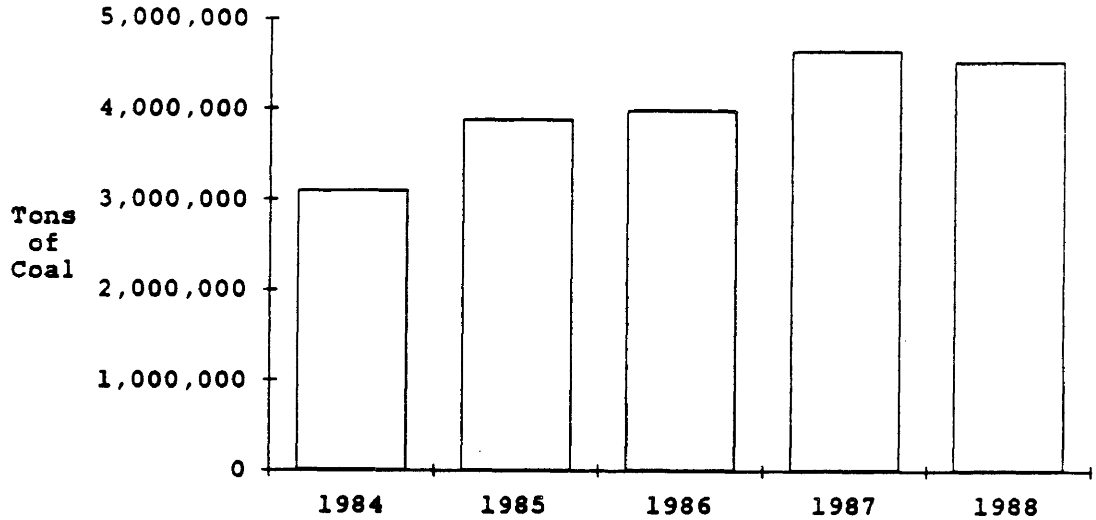


Figure 3.4 PSCO's Coal Displacement by Wholesale Power

Source: Public Service Company of Colorado. 1989. Securities and Exchange Commission Form 10-k.

assumptions. One is the constant use of the conversion factor, 10,500 Btu per net KWh. This factor is actually an average of the various plants that generate electricity at PSCO and may not be constant through time as new, more efficient capacity is added and existing capacity is upgraded. Also, the amount of coal required for both the actual and the theoretical level of generation is calculated. This has the advantage of eliminating inventory effects but has the disadvantage of allowing the conversion factor to mask trends in the actual amount of coal received at PSCO. The average level coal quality to the utility is also variable, as was shown earlier in this chapter. The result of these assumptions is to provide a set of data more useful for trend analysis than for the actual numbers themselves. The numbers are probably only approximations at best of the real amounts of coal displaced but should show an accurate trend in coal displacement.

3.5 Summary

The stepwise supply of power to the utility provides a model for evaluating the mechanism of wholesale power transactions and the possibility of a backstop effect. The steps can be quite arbitrary. PSCO effectively reorders the two curves into a single composite curve and uses this composite curve as its supply of electricity.

The displacement of coal by purchased power at PSCO shows how wholesale power can exert a backstop effect on coal and force the price of coal to be renegotiated. This has the effect of increasing competition among the coal suppliers. This increased competition is the subject of the next chapter.

Chapter 4

LONG-TERM SUPPLY OF COAL AND EVIDENCE OF THE BACKSTOP EFFECT

4.1 Introduction

This chapter examines the supply of coal to PSCO by producers operating under long-term contracts. Under the model of electricity supply developed in chapter 3, the backstop effect is assumed to have made the coal industry much more competitive. This assumption is tested by examining the rents realized by the PSCO's coal suppliers. If the rents realized by the companies have been decreasing, the coal market has become more competitive. Since rents can be absorbed by factor costs, real prices of coal are also examined to see if they support the conclusions reached by the analysis of rents. Decreasing real coal prices would indicate an increasingly competitive coal market.

4.2 Market for Steam Coal Without Wholesale Power Transactions

More than 80 percent of current U.S. coal production is sold to utilities as steam coal. Without the effect of wholesale power purchases, coal mines would compete with each other solely on the basis of which mine provides coal at the lowest delivered price to the utility. This coal also competes with other possible fuels, such as natural gas and fuel oil, but historically, at PSCO, coal has been the lowest-cost fuel. Of the non-fossil fuels the only other fuel that could possibly provide the quantity of energy required at a cost that could compete with coal is nuclear fuel. Natural gas would be another possibility, but the fact that PSCO doesn't use it for a fuel seems to indicate that they can realize greater profits by selling it to their gas utility customers than using it to fuel their boilers. The history of nuclear fuel at PSCO has been one of failure culminating with the shutdown of the only nuclear plant in the system, Ft. St. Vrain, in August 1989. Therefore the only competition for coal in Colorado without wholesale power transactions is from other coal mines.

Coal mines in the same region, producing coals of similar quality compete with each other based on delivered price. Delivered price is the sum of coal production costs, transportation costs, profit margin for the coal producer, and profit margin for the transporter (railroad). Profit margins include not only the normal economic profit but also any rent that is realized. Representing this relationship algebraically:

$$P_d = C_m + M_m + C_r + M_r \tag{4.1}$$

where P_d is the delivered cost of coal, C indicates cost, M indicates margin. The subscripts m and r indicate the mine and the railroad. The production cost is a function of the costs of labor and capital to the mine. These costs are both strong functions of the geology of the mine. The transportation cost is a function of the distance between the railhead at the mine and the unloading point at each specific plant in the utility system. In the simplest analysis the costs for each mine and railroad would be assumed to equal the Cost of Goods sold in their balance sheets, and the margins could be found from the ratio of sales to cost of goods sold. The fact that PSCO uses unit trains would make this cost analysis give a transportation cost figure that would be too high. The model for delivered price given in equation 4.1 could be modified to consolidate the transportation cost and margin terms:

$$P_d = C_m + M_m + P_r \tag{4.2}$$

where P_r indicates the price of rail transport which is the sum of the cost and the margin for transporting coal by rail. P_d is available from Department of Energy/Energy Information Administration publications, C_m is also available from the same sources, and P_r is found by difference. Unfortunately, this method assumes that the mining margin equals zero. The last and simplest technique is to examine profit and loss statements of the coal-producing companies and figure their overall margins as sales divided by cost of sales. The drawback to this technique is that the margin so computed is an average of all the sales of the company, not just those sales of interest in terms of this paper.

The technique used in this paper is a variation on the profit and loss statement technique discussed above. Companies that supply PSCO with coal by contract issue consolidated financial statements but also publish segmented data for their coal divisions. This segmented data provides good trend information but there is some inconsistency in reporting between the companies themselves. The three companies that supply PSCO with coal under long-term contracts are all active in other areas of mineral and energy markets. The coal operations division of each company is a wholly-owned subsidiary of the parent company and does not publish independent financial statements. The data available for computing the margins of each coal company are segmented data from the consolidated financial statements of the parent company. This data is in the form of two items, sales and earnings before tax, for each company for each year. By subtracting earnings from sales for each year, costs for that year can be determined. However, this figure is not the costs of goods sold but rather the costs of goods sold plus the operating expenses of the company. Costs of goods sold would be preferable because it is a more accurate representation of the marginal costs of the company. The cost figures determined here more closely represent the full costs of the company.

In the simplified case of a world without wholesale power, the mines would compete with each other solely by minimizing the delivered price of coal. For PSCO the mines that would be competing with each other are assumed to be the same mines that currently supply PSCO with coal (see table 4.1).

In a region with similar geology, in the absence of an oligopolistic market structure, the real determinant of the outcome of the competition would be how close the mine was to the utility plant site and how much of the coal demanded by the utility could be supplied by any one mine.

4.3 Market for Coal with Wholesale Power Transactions

With wholesale power, competition between coal mines intensifies. Coal now competes with nuclear and hydroelectric facilities, as well. Effectively, all the utility plants and mines in the WSCC area compete with the companies that handle PSCO's long term coal contracts. This competition is imperfect since line loading limits prevent totally free interaction between buyers and sellers of

Table 4.1 PSCO Long-Term Coal Contracts

MINE	1988 PRODUCTION (million tons)	COUNTY	STATE
CYPRUS			
Empire	2.0	Moffatt	CO
Yampa Valley	0.9	Routt	CO
Plateau	1.6	Carbon	UT
Shoshone	1.1	Campbell	WY
ARCO			
Black Thunder	*		
Coal Creek	25.5	Campbell	WY
Mt. Gunnison	**	Gunnison	CO
Gordon Creek	1.4	Carbon	UT
AMAX			
Belle Ayr	13.3	Campbell	WY
Eagle Butte	12.9	Campbell	WY
Castle Gate	0.5	Carbon	UT

Notes: Coal Production is in million tons.
* Production figures for Coal Creek included with Black Thunder.
** Production for Mt. Gunnison is included with Gordon Creek.

Source: 1988 Annual Reports for Cyprus Minerals, ARCO, and Amax.

power. For reasons discussed in chapter 2, this competition is not even as good as it could be since pooling in the WSCC occurs on a volunteer, sub-regional basis only. Coordinated pooling throughout the WSCC could greatly increase the market efficiency for wholesale power.

In spite of market imperfections, coal having the same qualities such as grindability and presence of impurities, now competes on the basis of minimum cost per KWh of energy expressed as

$$C_e = P_d / (H * U) + C_g \tag{4.3}$$

where C represents a cost, H is the heat value of the coal in Btu/ton, and U is the utility conversion factor in net KWh/Btu; the subscripts e,d, and g represent electricity, delivered, and generated. Coal competes with wholesale power available at

$$P_w = C_w + M_w \tag{4.4}$$

where w subscripts indicate prices, costs, and margins to the wholesaler. Margins include rents.

Assuming the heat value of the coal, the conversion factor of the utility, and the costs of generation to be constant, then the basis of competition for coal and electric power is the delivered price of the coal versus the price of wholesale power. Algebraically, coal is competitive with wholesale power when

$$P_d <= (P_w * H * U) - C_g \quad (4.5)$$

In the market with wholesale power transactions, the company producing the lowest cost coal must minimize not only its delivered price of coal with respect to its geographic competitors, but also with respect to wholesale power prices as described by equation 4.5. Since each P_w in equation 4.5 is the cost of electricity at some other utility (as described by equation 4.3) plus a margin, each coal producer competes with every other coal producer for the lowest delivered price to a utility.

4.4 Long-Term Contracts for Coal

PSCO gets its coal primarily through long-term contracts with three suppliers. The amount of coal PSCO has contracted for from each supplier as of December 1988 is shown in table 4.2. Amax produces roughly two-thirds of the coal used by PSCO, and Cyprus just under a third. ARCO's contribution is almost inconsequential.

4.5 Margins of PSCO's Suppliers

Table 4.3 is derived from the 1988 annual reports of Cyprus Minerals, Atlantic Richfield (ARCO), and Amax and the 1988 10-k report of PSCO. The margins realized by the coal

Table 4.2 Contract Coal supply to PSCO

Supplier	Minimum	Maximum	%
Amax			
1988 thru Pawnee 2 completion	3,960		68%
Pawnee 2 compl. thru 2013	3,600		66%
Cyprus			
1988 thru 1997	1,700	1,900	29%
ARCO			
1988 thru 1991	190	210	3%

Notes: Values in thousands of tons per year. Percentage calculations based on Amax's current contract.

Source: SEC form 10-K filed by Public Service Company of Colorado for the fiscal year ended December 31, 1988. p. 8.

suppliers are presented along with the yearly amount of power purchased by PSCO.

As table 4.3 shows, increased purchases of wholesale power by utilities from 1986 to 1988 coincided with lower margins for two of the coal-producing companies that supply PSCO with power. For Amax and Cyprus, the margin data support the idea that wholesale power purchases have the effect of making the coal industry more competitive. ARCO's increasing margins run counter to the trend. This may be

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Table 4.3 PSCO Power Purchases and Margins of PSCO's Coal Suppliers

Year	PSCO	ARCO	AMAX	CYPRUS
1982	2,680	19.11		
1983	3,514	15.58	17.16	
1984	5,811	8.64	21.04	12.03
1985	6,973	15.76	16.49	15.21
1986	7,115	22.03	17.38	9.17
1987	8,363	20.94	15.19	8.67
1988	8,043	28.29	13.66	2.19

Notes: The figures in the PSCO column represent purchased power in gigawatt-hours (GWh). The figures in the other columns are margins companies realized on their coal operations. These margins are segment earnings divided by sales expressed as a percentage.

Sources: 1988 Annual Reports of Amax, ARCO, and Cyprus Minerals Company, SEC form 10-K filed by Public Service Company of Colorado for the fiscal year ended December 31, 1988, p. 15.

attributable to ARCO's extremely low production costs. A time series of power purchases by PSCO from 1982 through 1988 is shown in figure 4.1. This figure shows the total purchases and net interchanges of power over the six-year period. Net interchange results from transmissions by other utilities intended for third-party utilities, which wound up at PSCO due to imperfections in the power transferring system. For the first five years there has been an increase in the amount of purchased power, with a slight decline occurring in the last year. The most vigorous period of growth seems to have occurred during the years 1983-1985.

A comparison of the margins on coal production realized by the three companies are shown in figure 4.2. These margins are computed as described in section 4.2 and so do not represent the true marginal costs of the company. For comparison purposes they should be accurate enough. The data was gained from each company's annual reports. Data is not available for Cyprus before 1984, the year the company went public. Usable data for Atlantic Richfield Company (ARCO) is available starting with 1983. ARCO reports coal earnings as part of their energy segment which included petroleum and natural gas prior to 1983. Amax shows a consistent history of coal segment earnings from 1982 onward. Figure 4.2 shows a decline in margins on coal for

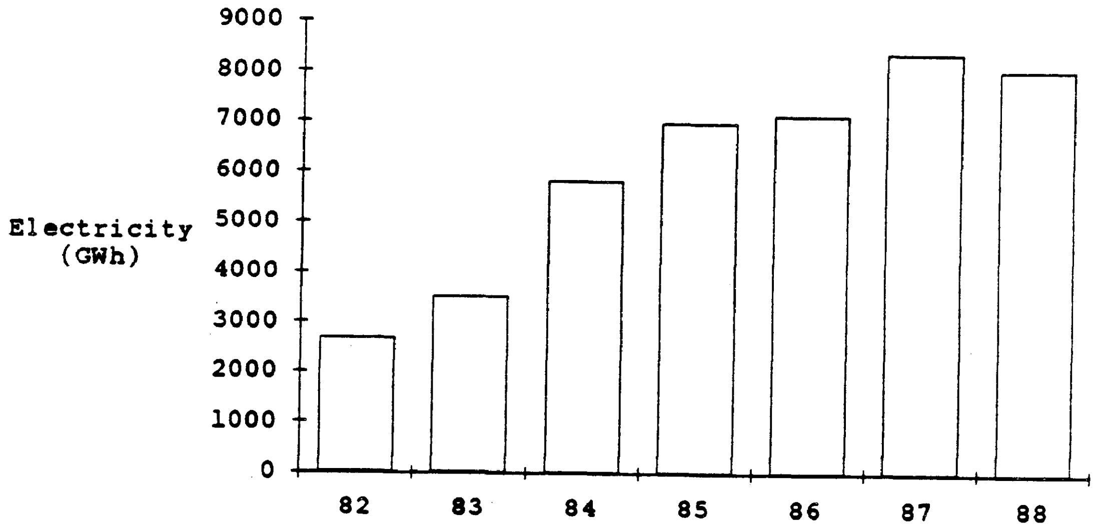

Figure 4.1 Power Purchased by PSCO

Source: Public Service Company of Colorado. 1989. Securities and Exchange Commission form 10-k. Denver, CO.

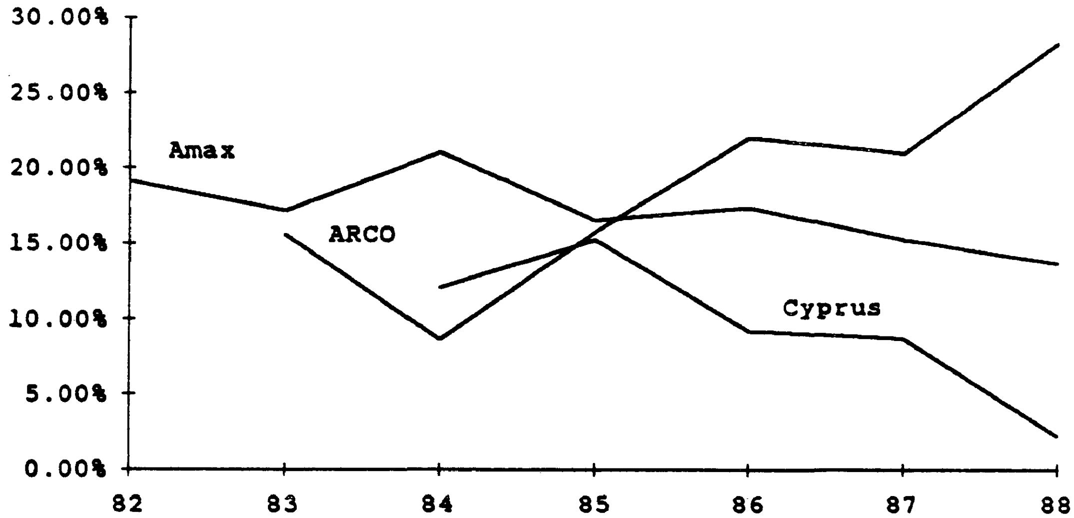

Figure 4.2 Profit Margins on Coal

Source: Amax. 1988 Annual Report.
ARCO. 1988 Annual Report.
Cyprus. 1988 Annual Report.

Amax and Cyprus from 1982 through 1988 and an increase in ARCO's margins over the same period. Two factors may explain ARCO's increasing margins. The first factor is that ARCO has by far the lowest market share in the market to PSCO. ARCO accounts for only 3.25 percent of the coal supplied to PSCO under long-term contract. Amax accounts for 67.7 percent and Cyprus accounts for 29.05 percent. ARCO may not feel the pressure from PSCO's power purchases to reduce their prices, and therefore their rents as much as Cyprus and Amax. The second factor is that ARCO's principle coal company is the Thunder Basin Coal Company which operat-es two of the largest and lowest cost coal mines in the world, the Black Thunder Mine and the Coal Creek Mine, both Wyoming surface mines. Due to its low costs ARCO may not feel any pressure from purchased power.

In figures 4.3, 4.4, and 4.5 the profit margins of Cyprus, Amax, and ARCO superimposed over PSCO's power purchases. Profit margins for Cyprus turned up sharply in 1984 and 1985 and then declined. Cyprus profit margins from 1985 onward support the concept that margins and wholesale power purchases are inversely related but the relationship doesn't appear to be constant or simple and may involve a lagged response in the margin to the wholesale power purchases. Profit margins for Amax declined generally. ARCO's exper

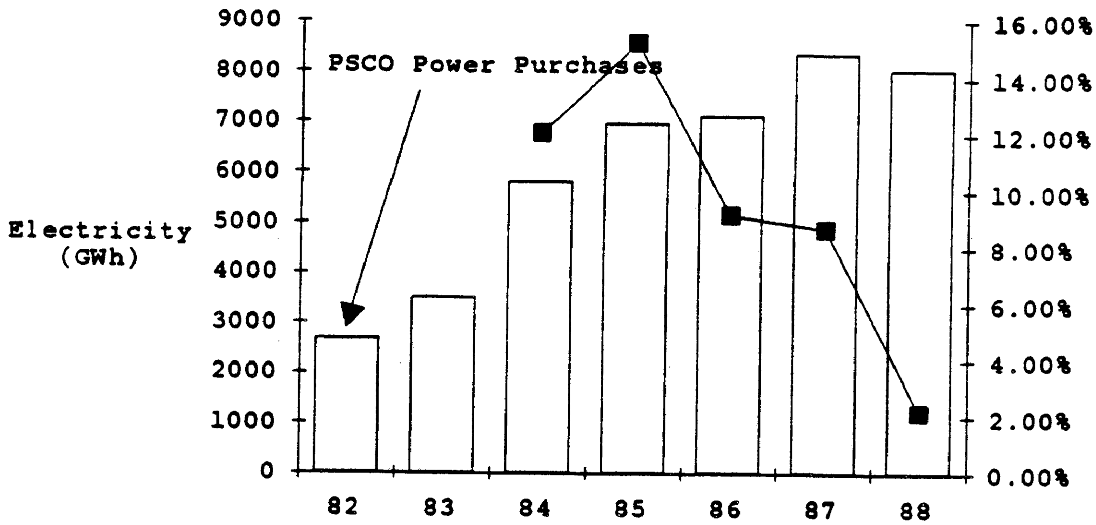

Figure 4.3 Cyprus Profit Margin and PSCO Power Purchases

Source: Cyprus Minerals Company. 1988 Annual Report. Denver, CO.
Public Service Company of Colorado. 1989. Securities and Exchange Commission form 10-k. Denver, CO.

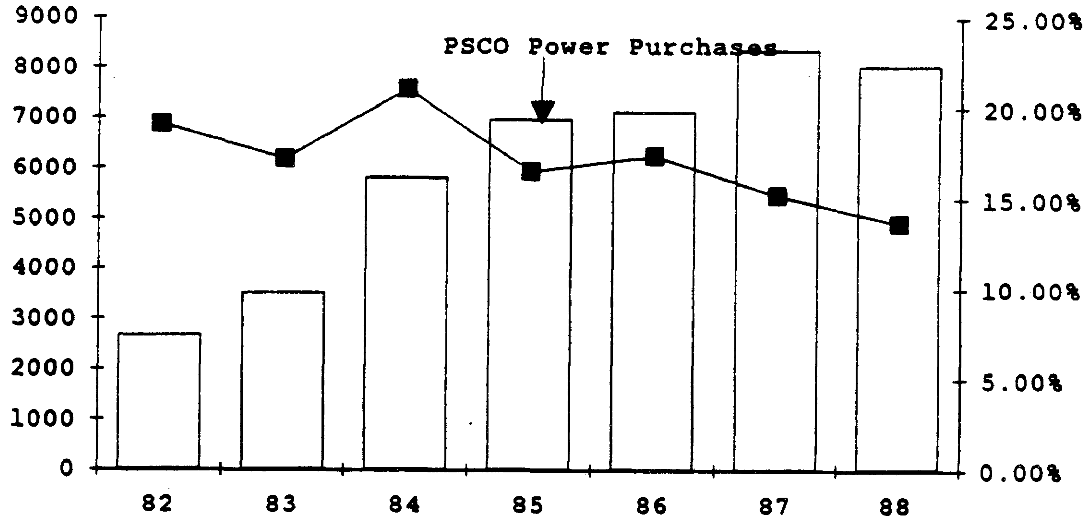

Figure 4.4 Amax Profit Margin and PSCO Power Purchases

Source: Amax. 1988 Annual Report.

Public Service Company of Colorado. 1989. Securities and Exchange Commission form 10-k. Denver, CO.

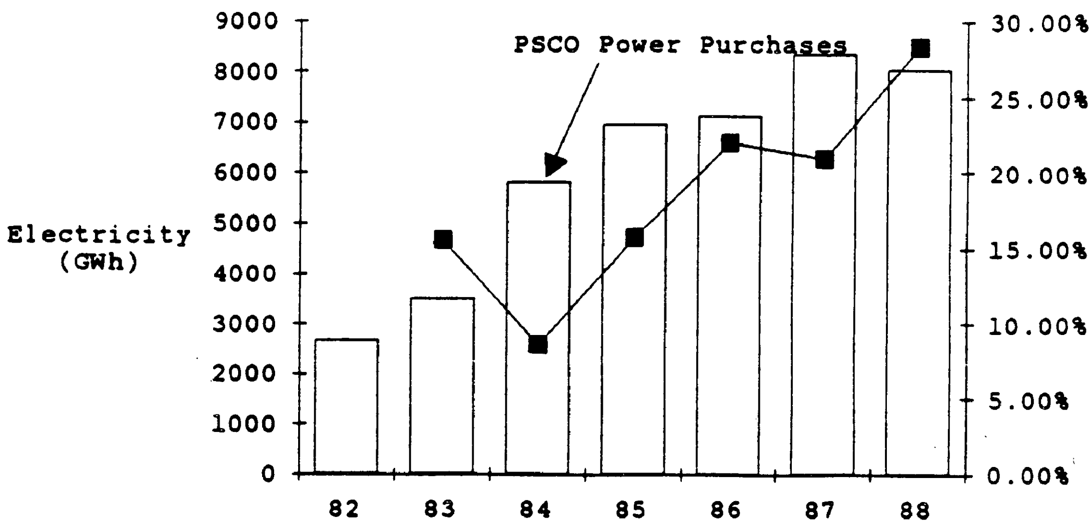

Figure 4.5 ARCO's Profit Margins and PSCO Power Purchases

Source: ARCO. 1988 Annual Report.

Public Service Company of Colorado. 1989. Securities and Exchange Commission form 10-k. Denver, CO.

ience appears to run counter to the trend of margins decreasing with increased PSCO power purchases.

The problem with using margins to determine the amount of competitiveness in an industry is that margins can vary according to the amount of rent absorbed by factor costs which gives a false impression of the level of competition.

The factors that would absorb rent in the case of coal production are labor and rail transportation. Labor unions are experiencing some reverses in the mining industry as many companies, especially in the copper industry are beginning to reject unions. This is not the case with coal. Unions remain a fixture in coal mining and while their power may be diminishing, it's still sufficient to enable the unions to take a large portion of the rent generated by coal mining. A much larger portion of the rent is absorbed by railroads. The railroads have steadily increased rates to absorb rent generated from coal mining. These two factors can take the rent away from the mine, thereby lowering earnings and margins.

4.6 Real Price Trends In Long Term Coal Supply

A history of real prices of coal is given in table 4.4. The prices for Amax, ARCO, and Cyprus are average prices determined from balance sheet data by dividing total coal sales by coal production. These sales include sales to customers other than PSCO and therefore conclusions drawn from these prices assume that the other markets for coal these companies are selling in are behaving similarity to the PSCO market.

Table 4.4 Real Coal Prices from PSCO's Suppliers

Year	AMAX	CYPRUS	ARCO
1982	16.14		
1983	15.57		11.83
1984	14.71	39.77	11.42
1985	15.16	36.25	11.15
1986	16.47	30.17	11.17
1987	14.96	25.60	10.43
1988	14.00	23.36	10.29

Notes: Prices are in 1982 dollars per ton.

Source: Annual Reports for Amax, ARCO, Cyprus Minerals, various years. Economic Indicators December 1989, Washington, DC: GPO.

This information is shown in graphically in figure 4.6. Cyprus real prices have fallen over the period. This would indicate that the low margins for Cyprus were due to an increase in the competitiveness of Cyprus Coal Company, not just adsorption of rent by factor costs. Similarly, The decreases in the real coal prices of Amax indicate that the lowered margins observed for Amax are not due to rent lost to factors of production but are due to increased competi

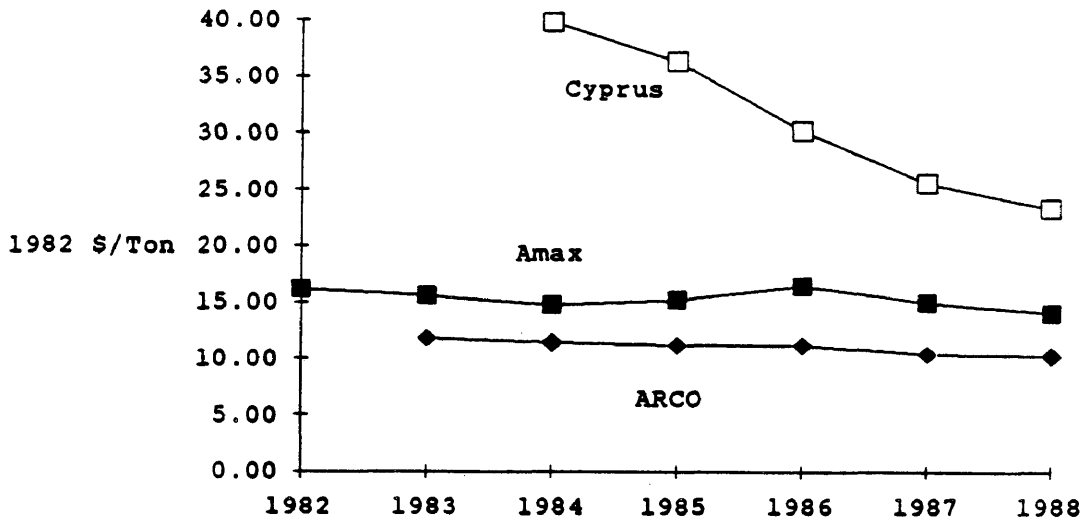

Figure 4.6 Real Coal Prices from PSCO's Suppliers

Source: Annual Reports of Amax, ARCO, Cyprus Minerals, various years.
Economic Indicators December 1989, Washington, DC: GPO.

tiveness. For ARCO the slight decrease in the real price of coal indicates increased competitiveness in spite of increasing rents. The increasing rents realized by ARCO are probably due to ARCO's low production and/or transportation costs.

Real price decreases could also be caused by the increasing productivity in mining methods realized in the period from 1982 to 1988. This would not be inconsistent with increased competitiveness if rents were decreasing. For Amax and Cyprus the idea of increased competitiveness is supported by decreasing real prices and rents. For ARCO the idea is not well supported.

4.7 Statistical Correlation of Rents and PSCO's Power Purchases

Statistical correlation of rents and PSCO's power purchases was attempted. As might be expected with the small amount of data available, the results were not statistically significant. Table 4.5 summarizes the results of an attempt to correlate rents with PSCO power purchases in the form

$$\text{Rent} = a + b * \text{PSCO Power Purchases} \qquad (4.6)$$

This form was selected because it is a very basic form that postulates an autonomous level of rent, independent of PSCO's power purchases given by the a coefficient, and sensitivity to PSCO's power purchases, given by the b coefficient. The sparse data discouraged using any further forms for statistical testing.

Table 4.5 Correlation of Rents as a Function of PSCO's Power Purchases

Company	a(t)	b(t)	adj. r-squared
Amax	21.2(8.41)	-0.000666(-1.69)	23.7%
ARCO	3.4(0.32)	0.00229(1.51)	20.3%
Cyprus	30.9(1.92)	-0.00295(-1.35)	16.9%

A further cautionary note on these statistics is they assume that PSCO has a significant effect on these three companies, an examination of the percent of the coal output of each company over the period is given in table 4.6.

The information in table 4.6 shows that PSCO accounts for about one percent of ARCO's coal output or less. The statistics for ARCO are therefore not very significant. Table 4.6 shows that PSCO has consistently accounted for between 10 and 12 percent of Amax' coal output and 14-19 percent of Cyprus' coal output. Cyprus coal contract started in 1987 when they acquired the Colorado Yampa Coal Com-

Table 4.6 Percentage of Company Coal Output Committed to PSCO

	Amax	ARCO	Cyprus
1982	13.84		
1983	13.08	1.12	
1984	12.22	0.80	
1985	13.22	0.71	
1986	13.48	0.77	
1987	12.53	0.80	18.97
1988	12.90	0.65	14.39

Source: Annual reports for Amax, ARCO, Cyprus, various years. 10-k report for PSCO, various years.

pany which had had a contract with PSCO since prior to 1982. As shown in table 4.6, the statistics for Cyprus are the most significant. The influence of PSCO's power purchases therefore has the greatest effect on Cyprus, since PSCO accounts for so much of Cyprus total production. PSCO's power purchases also have a strong influence on Amax since PSCO has accounted for approximately 10 percent of Amax total coal output during the 1982-1988 period. In contrast, the influence of PSCO's power purchases on ARCO is barely significant since PSCO accounts for less that 1 percent of ARCO's coal output during the same period.

4.8 Evidence of the Backstop Effect

Based on the arguments and data presented in this chapter, the effect of wholesale power purchases on the steam coal market appears to have been to increase competition among the higher cost producers. Since ARCO contributes so little to the market under study here, it's hard to say why their margins seem to run counter to the trend of inverse relationship with the amount of power purchased. On a weak basis at least, the data presented here seems to indicate the effect of purchased power on the coal market has been to increase competitiveness.

Chapter 5

CONCLUSIONS, SENSITIVITIES, AND FURTHER QUESTIONS

5.1 Statement of Conclusions

Results of this study support the thesis that wholesale power purchases by PSCO has had a backstop effect on the price PSCO pays for steam coal. The backstop effect is a result of the mechanism of wholesale power transfer which allows all the coal mines in an interconnected power transmission system to compete with each other and with all the other fuel sources in the same system for the lowest cost of generated power from each utility. Support for this conclusion is found by examining the rents realized and the real price of coal charged by each of PSCO's contact coal suppliers during a period of increasing purchases of wholesale power by PSCO. Real coal prices of the three coal suppliers decreased and the rents decreased for two of the three. Another observation is that PSCO has apparently been using long-term wholesale power contracts to augment existing capacity. Coal will be even more vulnerable to the backstop effect until electricity demand within Colorado grows enough to use up this "capacity bubble".

5.2 Assumptions

There were several assumptions behind these conclusions. The first was that wholesale power is the backstop commodity for coal. While this was the case at PSCO, it would not necessarily be the case at a utility with nuclear or natural gas fired capacity. PSCO had no real working nuclear capacity to speak of and did not use natural gas to fire the steam boilers, probably because they could realize greater profits by selling the gas to their gas utility customers. The relative costs of various fuels at various locations in the country would determine the backstops for coal, or may even cause another fuel to be used for the primary fuel, while coal acted as the secondary.

The second major assumption was the nature of the wholesale power supply curve faced by PSCO. This data was not available from PSCO. The discussion of the subject in chapter 3 was largely theoretical. A related issue is the imperfect nature of the market for wholesale electricity. Because of technical and legislative constraints discussed in chapter 2 the wholesale power market is not used to the optimum amount.

The assumption that demand for electricity would remain constant if all the electricity were generated from the higher cost fuel, in this case coal, is not valid in the long run. Thus the amount of coal displacement calculated in chapter three is overstated.

The calculation of the decreasing trend in rents among the suppliers of coal to PSCO during a period of increasing power purchases as a percent of total power output at PSCO may have pointed to a general economic trend among coal companies. The decreasing rents may be due to a downturn in the business cycle for the coal industry as much as the increased use of wholesale power at utilities.

The rent realized by coal mines is due to some specific barriers to entry; the location of the mine relative to the utility and the presence of transportation to the utility, the geology of the mine, the type (grade) of coal at the mine and the amount of harmful impurities (sulfur, ash, nitrogen) in the coal, and the prevailing legal structure. These rents are contested by two other monopolies in the coal mining process. The first is the labor union. Coal miners have remained unionized during a period when other miners have been de-unionizing. The unions try to capture the rents realized by the mine through higher wages and benefits. The most effective tool the union has is the threat of strike. In times of economic downturn, strikes are less likely since opportunities for other employment are scarce. The second monopoly is the railroad company that transports the coal. The railroad company tries to absorb the rent through higher rail rates. The decrease in the rents realized by the mines could simply represent a transferring of the rent to the two other factors of production.

5.3 Limits in the Data

Data limitations included a lack of price and quantity data on wholesale power transactions, market regulations and imperfections that prevented the most efficient solutions from being reached, the presence of rents and the lack of data on their distribution, use of consolidated financial data, and the assumptions of constant operating parameters in the electric utility plants being considered.

Because only a few years of data were available trends could not be subjected to statistical analysis. This may not be bad since interutility power sales are still a fairly recent phenomenon and the market is still recovering from the OPEC shocks of the 1970s when the previously stable pattern of electricity demand in the United States and U.S. energy policy were reshaped. The utilities still feel the effect of these shocks because of the 5-10 year delay for new capacity to come on line. Capacity ordered in the 1970s under the assumption of constant yearly growth in energy demand came on line in the 1980s when it was no longer required. Thus the supply of wholesale power was greatly expanded in the 1980s. As the 1990s progress and electricity demand catches up to the installed capacity, the patterns of interutility power sales may be much different.

5.3.1 Lack of Wholesale Price and Quantity Data

PSCO would not disclose data on its transactions within the Inland Power Pool. This data would have been quite helpful in constructing the stepwise supply curve model and could have led to a thorough analysis of the market mechanism as utilities choose between purchased and generated power. Therefore the section on the supply mechanism was theoretical.

5.3.2 Market Imperfections

The wholesale power market has several built-in imperfections. The foremost is regulation. Regulation causes the decision makers at the utility to optimize only to a certain level. They maximize profits only up to their regulated rate of return. Although, from a welfare-maximizing point of view, regulation is preferable to the monopolistic situation where less quantities would be offered for sale at a higher price, it discourages the utilities from achieving the lowest possible costs. Other market imperfections revolve around the problems of line losses and wheeling and capacity constraints. These all represent barriers to widespread pooling.

5.3.3 Consolidated Financial Statistics

Consolidated financial statements were used for the coal supply companies to determine whether competition had increased in the coal industry. Consolidated financial data suffers from the fact that overheads are often allocated arbitrarily and companies have little uniformity in the items they report.

5.4 Limits of Scope

The data in this case study is representative of the western United States. The coal is relatively low cost with low sulfur, there is no nuclear capacity on the system, and wheeling and line losses are high due to the widely separated population centers and large amount of shared transmission lines. The terrain is an obstacle for the coal suppliers since the coal mines are on the eastern side of the Rocky Mountains and the utilities are on the western side. This allows the one railroad with access to the Moffat Tunnel, the only passage for rail cars through the Rocky Mountains, to realize monopolistic rents.

The conclusions are also a product of the prevailing economic conditions. During a time when energy intensive manufacturing is widely used and demand for coal is high the sensitivity to the price of wholesale power will be much less. The changing legislative conditions could either help or hurt coal drastically as a fuel of choice. this is especially true of PSCO which suffers from being located in Denver, a city with an acute air pollution problem. Although a recent study has confirmed that the coal burning at PSCO is an insignificant contributor to the air pollution problem in Denver, PSCO is still the largest single target for public frustration with the problem and presents a deceptively appealing "quick fix" to the problem.

5.5 Further Issues

Several issues for further study are raised in this thesis. The first concerns the actual prices of spot power to PSCO. Information on this would provide much greater insight into the backstop effect. A related issue would be the construction of the electricity supply curve for PSCO from data.

The second issue is the division of the rent from the mining operations. How much is the mine able to retain? How much is lost to unions? How much to the railroad? The issue of rent would be difficult to track but would provide fascinating insights to the mining industry and the negotiations between the key players in the industry.

The third issue involves the concept of PSCO using contract wholesale power in lieu of building additional capacity. How much capacity is available for this purpose? What is the critical level of demand for building new capacity? When will the capacity bubble burst? What will be the effect on the price of coal?

The issues mentioned above are only some of the more significant issues raised in the course of this thesis.

5.6 Summary

The backstop effect of purchased power on the price of coal at PSCO appears to be a result of increased competition between PSCO's coal suppliers caused by increased wholesale power purchases from other utilities. This effect is part of a larger effect and may be obscured by such things as higher operating costs and therefore is difficult to isolate.

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