NRRI-88-9

THE EVALUATION OF TRANSACTIONS IN INTERCONNECTED SYSTEMS

by

Narayan S. Rau

Research Scientist

THE NATIONAL REGULATORY RESEARCH INSTITUTE
1080 Carmack Road
Columbus, Ohio 43210

August 1988

This report was prepared by The National Regulatory Research Institute (NRRI) with funding provided by participating member commissions of the National Association of Regulatory Utility Commissioners (NARUC). The views and opinions of the author do not necessarily state or reflect the views, opinions or policies of the NRRI, the NARUC, or NARUC member commissions.

EXECUTIVE SUMMARY

Since the liquid fuel crisis of 1974, there has been a general trend of increase in fuel prices. A greater difference among the prices of fuels used for the production of electricity has ensued. Therefore, there is an incentive to displace generation by higher priced fuels by the generation from lower cost fuels. Such transactions are termed economy energy interchange. The term interchange or exchange signifies that the energy flows can change direction frequently to exploit the benefits arising from the differences in the incremental costs of production of electricity. The cost of production varies due to differences in fuel prices, changes in loads, and machine outages. In addition to the economy energy interchanges, interconnected utilities indulge in transactions of longer term purchases and sales of firm power and energy, energy banking, reserve sharing, peaking energy, etc. Such firm transactions, ranging from about a month to several years, exploit not only the advantages due to the difference between the fuel prices among the transacting parties but also other advantages like capacity deferment by importing from a utility having surplus generation.

The exchanges of energy are neither new nor a result of the 1974 liquid fuel crisis. The power pools, a collection of member utilities to exploit economic gains, have indulged in energy exchange transactions and other coordinating activities to maximize the gains since the early part of this century. However, the increasing difference between the prices of fuels resulted in exchanging greater quantities of energy between utilities and, in some cases, stretching the transfer capacity between utilities to its limit.

The Experiments

It is commonly believed that the electric utilities are not trading in electrical energy and power to the full extent that is feasible. Concerns have been expressed that the intermediate utilities are exercising powers of monopoly in regard to the provision of wheeling service.

There are two broad categories of transactions in the wheeling debate. The first is where a requirements customer or industry in a utility's service territory would like to buy from sources outside or from a private generator from within the utility's service territory. This would require the provision of transmission or wheeling service by the utility. The second is when two regulated utilities want to use the transmission service of an intermediate utility to exchange power and energy.

The latter category of wheeling raises the question as to whether all the efficiency gains realizable by exchanging power and energy among utilities are being realized.

The Federal Energy Regulatory Commission (FERC) regulates transactions in bulk and interstate power and energy. The utilities hold that certain requirements of FERC in regard to the filing requirements of prices of transactions impede the attainment of maximum efficiency. In response to a request by the utilities in the southwestern states, FERC authorized an experiment in 1984 called the Southwest Experiment.

For the duration of the experiment, FERC modified its regulation over coordination sales by permitting utilities wide latitude in setting prices and by permitting a specific percentage of profits to be retained by the utilities, if they chose to do so. It also required that participating utilities not employ their control of the transmission system to frustrate transactions involving other participants.

In 1987, in response to a request from participants in the Western System Coordinating Council (WSCC) area, FERC approved the WSPP Experiment for a period of one and a half years, commencing in May 1987. For the duration of the Experiment, FERC has preapproved a band of prices for the four commodities to be transacted. The commodities are: Economy Energy, Firm Power, Firm Energy, and Transmission Service. The twenty-two participants in the experiment are allowed to retain 25 percent of the incremental benefits arising from the experiment. The object of the experiment is to ascertain if the preapproval of the band of prices for the commodities and the retention of 25 percent of the incremental benefits result in increased efficiency and competition in the bulk power market.

Evaluation of Experiment

The assessment of the incremental gains in efficiency and competition stemming from an experiment is not an easy task. The evaluation of the SW experiment by The Rand Corporation uses statistical significance tests and other methods. Certain tests have been proposed in this report to measure the increase in production efficiency during such an experiment.

The term production efficiency has been used in this report to imply that only the costs of fuels for the production of electricity are considered. Whether the costs are true costs to society and if they take into account social costs due to environmental damage, loss of employment due to displacement of certain fuels, etc., is not addressed. Such further considerations lead to the assessment economic efficiency.

Three categories of tests are proposed. They include general tests, tests to evaluate the functioning of the bulk power market, and tests to evaluate the functioning of the transmission market.

Under the category of general tests to measure the incremental benefits due to an experiment, the first test is based on the assertion that surplus hydro energy would always be absorbed by the parties, even in the absence of an experiment. The simulation of joint dispatch to calculate the maximum gains in production efficiency and the examination of the differences in the hourly incremental costs of production between the Participants are suggested as additional tests under the general category.

Under the second category, six tests are suggested. The tests analyze the statistics collected during the experiment in terms of the difference between the buy and sell quotes, the sizes of blocks of power, and their statistical frequency.

Under the category of transmission, six tests are suggested. The first three, statistical in nature, examine the frequency of price for transmission service, the number of times access is granted or denied, and the number of transactions curtailed due to the nonavailability of transmission. The fourth test attempts to examine the sharing of the benefits due to improved production efficiency between the buyer and seller, while the fifth test examines the effect of exercising transfer capacity entitlements on production efficiency. The sixth test examines the consistency in the pricing of transmission service.

It must be noted that these tests are neither unique nor eternal in their usefulness. Presumably, one could suggest similar or additional tests which may be more suited to a particular region conducting an experiment. On the other hand, the proposed tests are not ephemeral. Tentative as they might be, they point to appropriate areas of further inquiry and questioning.

Aspects of Transmission

Copious literature exists proposing methods for pricing transmission service. The main approaches appear to be those of pricing based on embedded costs and on the incremental cost of providing the service. However, the spot market for economy energy is dynamic and changes character hour-to-hour. Therefore, not only is it logical to assume that the pricing principles could change to suit the market condition, but other considerations also could enter into the picture. This aspect is elucidated further in the following.

Consider three utilities, A, B, and C, connected radially, i.e., A to B and B to C with B being the utility in the middle. If the utilities with the highest hourly incremental cost of production and the lowest hourly cost are adjacent to each other and if the transmission between these two adjacent utilities is owned by either one or both of them, no dichotomies arise. The lowest cost producer would displace the generation of the highest, thereby attaining maximum production efficiency. As examples, if B is the highest cost producer and C is the lowest, C would transmit to B. Similarly, if B is the lowest cost producer and A the highest in any hour, B would sell to A.

Problems could arise if there is one or more intervening utilities between the highest cost producer and the lowest cost producer. For instance, consider the mid utility B to have an incremental cost of production between that of A and C, C being the lowest cost producer and A the highest. It is clear that maximum gains in production efficiency would result if the highest priced energy is displaced from the lowest cost production. In this case, C would have to sell to A. The attainment of maximum production efficiency may not be possible under all circumstances because of the following. B has three options open to it. The first is that of displacing the higher cost generation in A by its own generation. Instead of doing so, if B allows C to use its transmission to sell to A, it would have lost the opportunity to sell to A from its own generation. Therefore, it may implicitly price the transmission service to at least result in a gain equal to that had B sold to A. This is termed the Franchise Attitude (FA).

Utility B has an obligation to its customers to reduce the cost of electricity. Since it owns the transmission between it and C (or has an entitlement to certain transfer capacity in it), B might choose to purchase energy from C and displace its higher cost generation instead of allowing C to sell to A. This has been termed Entitlement Attitude or EA.

The third option open to B is that of simultaneously buying energy from C and reselling it to A. The formula for the price of transactions may be based on actual costs and splitting the benefits equally between the buyer and seller or could be determined arbitrarily. This option has been termed the Simultaneous Purchase and Sale (SPS) attitude.

When B provides transmission, it might choose to implicitly price the service to correspond to the gains by any of the above attitudes. Depending on the quantities of cheaper energy available and the dynamic nature of the market, B might indulge in more than one of the transactions listed above.

The report examines the gains from each of the above attitudes for various ratios of incremental costs of the three parties. The fluctuations of the market are taken into account by the different ratios of incremental cost. The analysis of the idealized three interconnected systems may not, of course, be applicable to all practical situations.

A comparison of the three attitudes indicates that the maximum gains to the intermediate utility result from the SPS attitude for all ratios of incremental costs of production of the three parties with one exception. If the lowest cost producer is selling energy in the market at a fixed price (as in the case of surplus Bonneville Power Authority energy in the WSCC), the gains to the middle utility could be more under the EA attitude than SPS for certain ratios of its cost of production to that of the highest cost producer.

The WSCC Region

Due to the national interest in the WSPP Experiment, the major transmission and its owners in the WSCC region are shown in Figure ES-1. Several contracts in regard to the sharing of the transfer capacities in the major NW-SW AC and DC interties are summarized in the report. Figure ES-2 depicts the share of the parties to the agreements.

Some major contracts between certain entities in the WSCC region were reviewed and summarized. When BPA is in a spill or a near surplus situation, all the parties would like to utilize their transmission entitlements to the fullest extent possible. However, the highest production efficiency could be achieved in the region if the cheapest energy from BPA displaced the energies with the highest incremental costs of production. Such may not be the case due to the parties utilizing their entitlements. The intertie access policy of BPA is that of granting other PNW utilities a percentage of the transmission capacity to the southern markets. The percentage allocation is based on the surplus declared by the utility in relation to the total surplus in the PNW region. Therefore, the cheapest production in the PNW region would not necessarily be sold to the southern markets resulting in a loss of production efficiency. In practice, since the generation mix of the PNW utilities are somewhat similar, particularly during surplus seasons, the loss of production efficiency may not be significant.

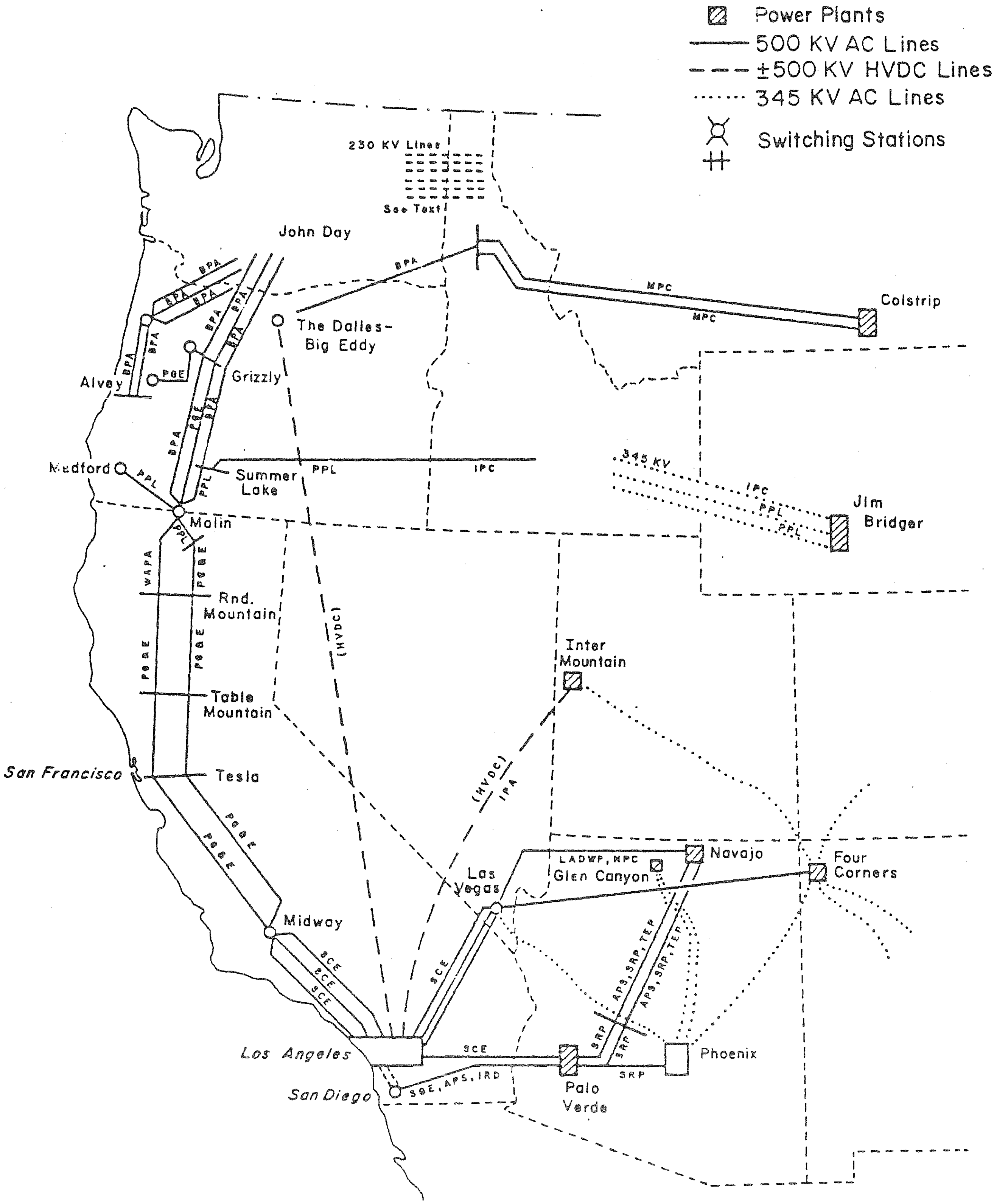


Figure ES1 Major transmission in WSCC region

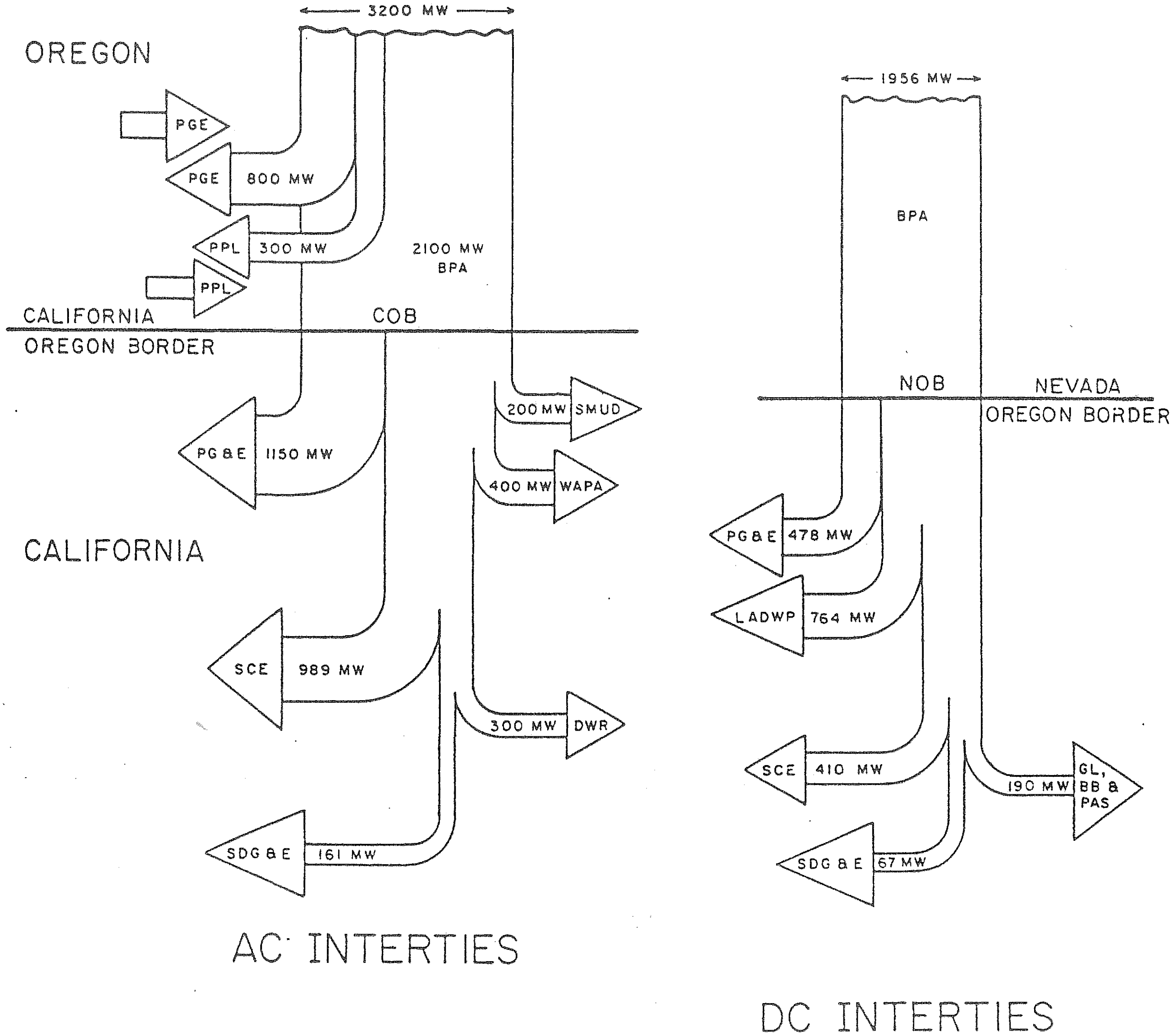


Figure ES2 Transfer capacity entitlements in the Pacific interties

It is important to note, however, that the parties have invested money in the transmission and that the contracts were entered into with their interests in mind. Several contracts have evolved over a period of time, each one of them furthering the interests of the signatories. Therefore, it is unrealistic to expect that the contracts, as a collection, necessarily serve the interests of the region or maximize the efficiency of the region as a whole.

Of particular interest is the contract between the three California IOUs called the California Power Pool Agreement. It is unclear if the definition of incremental cost in this agreement will produce the maximum production efficiency attainable by displacing the highest cost generation in SW by the cheaper NW energy.

Applicability of Tests and Data Requirements

It is seminal to determine the degree of loss of production efficiency, if any. The tests are designed with this as our goal. However, the tests designed for the idealized three systems are not directly applicable to the WSPP region due to the contractual obligations and transmission entitlements.

The data to be collected during idealized experiments have been listed. The data are no more than the usual hourly cost data, buy and sell quotations, price of consummated deals, number of transactions not possible due to the absence of transmission service, etc. However, several manipulations of the data to portray them in certain ways and to make them amenable to the application of particular tests would be required. The details of this are found in the report.

Conduct of Idealized Experiments

Idealized experiments can be conducted by a voluntary suspension of certain legal and contractual obligations regarding transmission entitlements for the duration of the experiment. The generation from the highest priced fuel would be displaced by the lowest one, subject to technical limitations. The providers of transmission service would collect a tariff to result in the same benefit as under normal operating practice. Such calculations may require the use of mathematical models to simulate the normal operating conditions, a relatively simple exercise in the present day of electronic computing. The incremental benefit due to the experiment would then be the difference between the actual benefits that accrue in the region and those calculated by the computer under normal operating circumstances. There would be some questions regarding the sharing of any additional benefits among the providers of transmission service and the receivers.

Appendices to the report include a summary of the document by FERC authorizing the WSPP Experiment and a short explanation of an energy brokerage system.

Conclusions

The main thrust of the report is the measurement of maximum production efficiency. The primary tests, therefore, are those that measure or suggest the lack of production efficiency. If in the application of these tests serious concerns come to light, questions regarding the availability or otherwise of transmission service and if the pricing of transmission service impeded efficiency gains could become important. Often, in the debate on transmission and wheeling, the pricing of transmission takes the center stage before ascertaining if there was any loss of production efficiency. The tests proposed put the debate in what we think to be the right order and that is that of keeping the production efficiency issue as the nucleus.

TABLE OF CONTENTS

		Page
LIST OF FIGURES		xi
LIST OF TABLES		xiii
LIST OF ABBREVIATIONS		xv
FOREWORD		xvii
ACKNOWLEDGEMENTS		xix
Chapter		
1	INTRODUCTION	1
	Historical Sketch	1
	Aspects of Transmission	2
	The Experiments	3
	Scope of the Report	5
2	TRANSACTIONS AND WHEELING IN IDEALIZED INTERCONNECTED SYSTEMS	9
	General	9
	Wheeling, Firm Power and Energy, and Economy Energy	10
	Recapitulation	44
3	EVALUATION OF INTERCHANGES	47
	Category 1: General Tests	48
	Category 2: Tests to Evaluate the Functioning of the Bulk Power Market	53
	Category 3: Tests to Evaluate the Transmission Market	63
4	THE TRANSMISSION AND OPERATION OF SYSTEMS IN THE WSCC AREA	77
	Generation in the WSCC Area	77
	The Transmission System in the WSCC Area	83
	Ownerships and Entitlements	86
	Contractual Obligations	89
5	APPLICATIONS OF TESTS FOR THE EVALUATION OF INTERCHANGES	105
	Intent	105
	WSPP Situation	105
	Production Efficiency	107
	Comments Regarding the WSPP Experiment	110
	Applicability of Tests Proposed in Chapter 3	114
	Required Data	116
	Conduct of Idealized Experiments	117
6	CONCLUSIONS	123
	Epilogue	124

TABLE OF CONTENTS - (cont'd)

Page

Appendix

A BROKERAGE SYSTEMS 127
Resolution of Bids and Quotes 130
Benefits and Their Division 131
Division of Benefits 134
Summary 135

B THE WESTERN SYSTEMS POWER POOL EXPERIMENTS 137
Background 137
List of Participants 146

REFERENCES 149

LIST OF FIGURES

Figure		Page
2-1	Illustrative Three Radially Interconnected Systems	16
2-2	Benefits to A, B, and C under FA	24
2-3	Benefits to A, B, and C under SPS	29
2-4	Illustration of Incremental Cost of Transmission	32
2-5	Effect of Sale from C to B and A	35
2-6	Effect of Sale to B and then to A	36
2-7a	Benefits to A, B, and C under EA	38
2-7b	Benefits to A, B, and C under EA, Fixed Energy Price by C	40
2-8	Comparison of Benefits under Different Attitudes	42
3-1	Frequency of Maximum Differences between λ	52
3-2	Frequency of Quotes	55
3-3	Frequency of Consummated Deals	57
3-4	Effect of Differences between Quotes on the Probability of Consummation	57
3-5a	Scatter Diagram of Consummated Deals	60
3-5b	Bivariate Distribution of ΔC_h and the Cost of Lower Quote	60
3-6	Effect of Hydro Energy on the Price of Transactions	61
3-7	Frequency of Transmission Service Prices	65
3-8	Two Illustrative Frequencies of Curtailed Transactions	66
3-9	Frequency of Granting or Denial of Transmission Access	66
3-10	Deviation in Transaction Price from Mean Cost	69
3-11	Deviation in Transaction Price from Mean of Posted Prices	69
3-12	Ratio of Lambdas and Available Transmission to A	71
4-1	Demand and Resource Shares	80

LIST OF FIGURES - (cont'd)

Figure		Page
4-2	Major Transmission in the WSCC Region	84
4-3	Transfer Capacity Entitlements in the Pacific Interties	88
A-1	Block Representations of Incremental Costs of Production	129
A-2	Effects of Sales and Purchases	132

LIST OF TABLES

Table		Page
2-1	Scenarios	17
2-2	Table of Benefits Under SPS	30
4-1	Capacity and Energy Generation by Major Participants in the WSPP Experiment	78
5-1	Data Requirements for the Application of Tests	118
A-1	Buy Bids and Sell Quotes	130
A-2	Sorted Sell Quotes and Buy Bids	131
A-3	Transactions	133
A-4	Division of Benefits	134

LIST OF ABBREVIATIONS

AC	Alternating Current
APS	Arizona Public Service Co.
BPA	Bonneville Power Authority
BURB	Burbank Public Service Dept.
COB	California Oregon Border
CTU	Combustion Turbine Unit
DSI	Direct Service Industries
DWR	Department of Water Resources of the State of California
EPE	El Paso Electric
EA	Entitlement Attitude
FA	Franchise Attitude
FERC	Federal Energy Regulatory Commission
GLEN	Glendale Public Service Dept.
HVDC	High Voltage Direct Current
IID	Imperial Irrigation District
IOU	Investor-owned utilities
IPC	Idaho Power Co.
LADWP	Los Angeles Department of Water & Power
MWD	Metropolitan Water District/Southern California
MPC	Montana Power Co.
NPC	Nevada Power Co.
NOB	Nevada Oregon Border
NRRI	National Regulatory Research Institute
NW	Northwest
PGE	Portland General Electric
PG&E	Pacific Gas & Electric
PNM	Public Service Co. of New Mexico
PPL	Pacific Power & Light
PNW	Pacific Northwest
PSW	Pacific Southwest
SDGE	San Diego Gas & Electric Co.
SMUD	Sacramento Municipal Utility District
SRP	Salt River Project
SCE	Southern California Edison Co.

LIST OF ABBREVIATIONS - (cont'd)

TEP	Tucson Electric Power Co.
UPLC	Utah Power & Light Co.
WWPC	Washington Power & Light Co.
WAPA	Western Area Power Administration
WSCC	Western System Coordinating Council
WSPP	Western System Power Pool

FOREWORD

The focus of this report is the measurement of gains in production efficiency resulting from electricity interchanges. A conceptual basis for doing so is provided, through the development of tests that may be applied generally to interchanges and experiments. Where possible and appropriate, the FERC approved Western System Power Pool Experiment with electricity interchanges is commented upon against this backdrop. Data requirements necessary for the application of these tests are enumerated. Data from the WSPP Experiment itself were unavailable to us.

Douglas N. Jones
Director, NRRI
Columbus, Ohio

August 1988

ACKNOWLEDGEMENTS

During the course of this project, the assistance rendered by M. Harunuzzaman and Y. Hegazy of NRRI was invaluable. Dr. Kevin Kelly's (NRRI) helpful critique and editorial suggestions improved the final product immensely. The painstaking preparation of this manuscript by Pat Brower, Evelyn Shacklett, and Joan Marino is gratefully appreciated.

CHAPTER 1

INTRODUCTION

Purchases of electrical energy from lower cost production areas to displace energy in higher cost production areas improves production efficiency. Such exchanges on an hour-to-hour basis in power pools and bokerages and firm sale commitments for a longer duration result in gains to the consumer. This report attempts to examine electrical interchanges for their effectiveness in terms of the maximum production efficiency achievable. Some allied aspects of access to and price of transmission service have also been analyzed. It is intended that the analysis be useful for the evaluation of electricity exchange experiments such as the WSPP Experiment.

Historical Sketch

The interconnection of generating units and the interconnection of areas of generation had an interesting evolution. In the early 40s and 50s, after the initial technical problems of the 20s with regard to the parallel operation of generating units were solved, interconnections were commonplace and were justified on the basis of reliability and stability. The interconnections were generally of a rather small transfer capacity compared to the production capabilities of either of the interconnected systems. The interconnections enhanced system reliability since a system in the event of generation difficiency (due to outages of generation or transmission) could be aided by power flows from the other systems.

Due to increasing demand for electrical energy, larger interconnections were planned and built during the 60s, not for reasons of reliability alone but, in addition, with the intention of transferring larger blocks of energy from one area to another. During this and earlier decades, power pools were formed in which increasing production efficiency was achieved by joint planning and operations. Moving energy from cheaper production areas to more expensive areas on an hour-to-hour basis has been a common practice in pools. In interconnected systems, a cheaper production area in any particular hour or season may find itself to be a more expensive production area in another hour or season. Trading of energy from one area to the other may therefore change direction from hour-to-hour or season-to-season. Such movements of energy is called Interchanges or Exchanges. Transactions of a longer duration, either for interruptible or firm energy, are termed sales or purchases. Examples of such transactions of short-term firm power or assured energy sales and interruptible energy purchases for a period of, say, five years. There are several other categories of transactions that take place among interconnected systems. They are too numerous to list here.

After the liquid fuel crisis of 1974, there was a rising trend in the prices of fuel. A greater difference between the prices of fuels used to produce electricity ensued. Therefore, the interconnections were increasingly used to transfer "Economy Energy" to displace the more expensive fuel by the generation from a lesser expensive fuel on an hour-to-hour basis. In addition, longer term firm transactions involving larger blocks of power from areas using cheaper or non-oil fuels to displace oil based generation were possible. The increasing number and quantity of energy of the transactions placed a greater demand on the existing transmission systems stretching them, at times, to their limit. In certain areas, plans for interconnections or increasing transfer capacities are still being made to realize additional economies due to enhanced interchanges. Since the early seventies, there has been a growing concern among the regulators regarding the maximum efficiencies that could be realized and regarding the transmission-related or other impediments to the achievement of such efficiency gains.

Aspects of Transmission

The debate about the improvement of efficiency and the introduction of competition in the electricity market has spanned many areas. In the bulk power and interstate markets, the pros and cons of unimpeded wheeling of electricity between entities, forced if necessary, are being debated. Some hold the view that the utilities may be exercising monopoly power by not granting access to transmission. Others have expressed concern about forced wheeling by stressing the utilities' "obligation to serve", the undesirable effects of "bypass" on the utilities and their retail customers, and the effect on the reliability of the system. Yet another concern regarding the transmission service has been that of proper compensation to the owners of transmission. The subject of pricing transmission service based on embedded costs, incremental costs, or on other factors has been a matter of considerable discussion.

The proponents of deregulation of the electricity industry have argued that more reliance should be placed on market forces to determine and set the prices for transactions in capacity, energy, and transmission of energy, and that by such a reliance more efficiency would be achieved. The introduction of market based flexible prices for energy transactions to enhance competition in the bulk power market has been proposed. Some other methods and mechanisms to increase competition have also been suggested. Under one of the scenarios advocating deregulation, the breakdown of the industry to unregulated Generators, Transmission Utilities, and fully regulated Distribution Entities has been suggested.

From the industry's point of view, certain filings and the procedures to obtain approvals from FERC for electricity transactions and their prices have been somewhat onerous. In particular, it has been suggested, such procedures to obtain the approval of FERC may jeopardize the hour-to-hour efficiency gains possible in the spot market. It would therefore be advantageous to introduce and accept a certain degree of flexibility in pricing transactions. In view of such concerns, on two occasions in the past, utilities requested FERC to preapprove price bands to permit flexibility in pricing for certain transactions in order that "experiments" could be performed. The experiments would determine if the market and production efficiencies would improve and if competition would be enhanced by such preapproval. Devising these experiments, the utilities were allowed to retain a specific percentage of profit resulting from the enhanced trade.

The Experiments

In the existing power pools, coordination and transactions to improve the production efficiency are commonplace. In the day-to-day operation, the participants' resources are either centrally dispatched or the participants voluntarily agree to dispatch their units for the common good of all to minimize the production cost of the pool viewed as a whole. The resulting savings are shared among the participants according to a pre-agreed formula. In addition to the joint dispatching of the units, other efficiency improvement measures such as joint planning, maintenance, coordination, and energy banking are utilized in the pools.

As in the operation of power pools, in the energy brokerage systems, the parties are aware of the buy and sell prices and quantities of each participant through the medium of a central computer on an hour to hour basis. But, in contrast with the power pools, the participants' units are not jointly dispatched but the participants are free to buy any of the bid blocks of power. Generally, the central computer suggests the "best" strategy of hourly reconciliation of bids matching the highest remaining buy quote to the lowest remaining sell quote. Thus, the hourly operating efficiency is improved by reconciling or consummating the bids to buy and sell power in the spot market. There need be no other agreements, such as joint planning, maintenance coordination etc., although the parties to the brokerage might voluntarily undertake such activities and may engage in transactions of longer duration.

Yet another way of capturing the gains of trading in the spot market is by the so called experiments. In essence, for the duration of the experiments, the market works, more or less, as a brokerage system. The reason for the conduct of an experiment is to quantify additional efficiency gains realizable.

In the past, FERC has approved and authorized two experiments. The first, called the Southwest Experiment, was conducted during 1984 and 1985. The details of the experiment and its evaluation can be found in reference [1].

The second, called the Western States Power Pool (WSPP) Experiment, is now being conducted by twenty two participants in the Western Systems Coordinating Council (WSCC) area. One of the objects of the experiment is to see if, by FERC preapproving a band of flexible prices for some transactions and by allowing the participants to retain a portion of the enhanced savings, market efficiency and competition would be improved. The FERC document authorizing this experiment is summarized in appendix B of this report.

Several concerns have been expressed about the experiment. Some fear that FERC might use the results of this experiment to deregulate the bulk power market. Another concern has been that the WSCC is a well coordinated area where large quantities of energy are already being exchanged, and therefore it is difficult to see how an experiment might further improve market efficiency significantly. Appendix B outlines other concerns regarding the experiment expressed by some entities.

Against this backdrop of unfolding events, NRRI has conducted two major studies on transmission related projects [4, 5]. The first project [4] addressed the economic principles of pricing wheeled power and the second [5] examined certain non-technical impediments to power transfers. With a view to extend the above studies and in view of the current WSPP Experiment, the Board of Directors of NRRI authorized this project to identify a consistent set of data that should be collected and would be collectible in any experiment and could be used with suitable methods to measure (a) quantifiable benefits, (b) competition among participants, (c) incremental benefits due to the experiment, and (d) the restriction to trading imposed by transmission. This report outlines the results of our investigations into these and other allied matters.

The goals listed above translate to the determination of data and methods to measure the benefits, efficiency, competition, restriction imposed by transmission, and the incremental benefits due to an experiment.

Scope of the Report

For the measurement of incremental benefits, it is evident that any method proposed should be capable of measuring the benefits either with or without the conduct of an experiment. The quest, inexorably, is for methods to measure the performance of any electricity market or power pool with respect to efficiency gains, competition, and transmission restriction. The analyses conducted with these aspects in view are presented as follows.

In chapter 2, the transmission aspects of idealized interconnected systems and the economic incentives to engage in power and energy transactions are examined. This analysis applies either during the conduct of an experiment or otherwise.

In chapter 3, certain tests to evaluate the functioning of a power market are proposed. These tests evaluate the improvements in production efficiency, transmission restrictions, and competition among the participants under idealized circumstances. The underlying assumptions in proposing these tests are that the required data (including data regarding costs of production) are either available in the pools or are collected and collated during an experiment. The tests are not intended to reveal the costs of any participant nor is it intended to identify participants who might impede the efficiency gains. They are intended to quantify (subjectively in some tests) the performance of the market. They could be applied to any pool or to any operating interconnected system.

In chapter 4 and 5, because of widespread interest in the current WSPP Experiment, we consider the applicability of the tests to that experiment. In chapter 4, the major generation and transmission systems in the WSCC area are outlined. A summary of some major contractual obligations in regard to transmission access in this area is also included.

In chapter 5, an attempt to apply the tests proposed in chapter 3 to the WSPP area is made. Due to the nonavailability of actual data from the participants in the experiment, such applications of tests had to be conceptual in nature. However, the existing contractual obligations and other factors make the experiment far from the idealized situation envisioned in chapter 3. Certain steps that might have to be taken to make an area fit the idealized description in any future experiment or investigation are also outlined in chapter 5. Only under such idealized circumstances can the tests be applied to evaluate efficiency and competition. The data that has to be collected to measure efficiency and competition (either during or outside of an experiment) has been identified.

Concluding remarks have been incorporated in chapter 6. Two appendices, one on the Brokerage system and the other on the WSPP Experiment, have been added to aid the uninitiated in these areas.

It is necessary that our terminology is clearly understood. The first is regarding the terms Exchanges or Interchanges. By these terms, it is meant that the transactions last a relatively short time and can change directions frequently. The tests proposed in this report can measure the gains due to interchanges. The measurement of gains over a longer term would involve several other considerations such as the availability and price of extra-regional energy, existing load-resource balance, and the effect on generation and transmission expansion plans. In other words, an assessment of benefits due to sales/purchases of a longer duration are not as simplistic as the proposed tests and would require a detailed knowledge of the utility and its planning process. Hence, due to our primary concern with short-term exchanges, we have chosen the word Interchanges in the title of this report.

The second clarification involves the term production efficiency. The term production efficiency has been used to indicate the relative costs of production of electricity in a region of interest. Exchange of electricity between utilities displaces fuels. For instance, sale of coal-fired energy might displace oil or gas-fired energy. The cost of coal, gas, or oil has been taken as given data. But, one could question the principles used in pricing these commodities. In addition, one might hold the view that displacing imported fuels is advantageous. Further, one might argue that the cost of certain fuels may not include appropriate environmental and clean up costs. When one addresses economic efficiency in a region, all these factors have to be considered. For example, it may be that the displacement of certain types of generation, while improving production efficiency, might not improve the economic efficiency of a region. For instance, one might argue that the cost of displacement of coal-fired energy should include the potential loss of jobs in mines. If such a consideration were given to the loss of jobs, the economic efficiency might not show an improvement while the production efficiency, based on given costs, might show an improvement. The report does not address the above aspects of global efficiency. Since our analysis uses the costs of fuels as the starting point, the term production efficiency has been used instead of the term economic efficiency.

CHAPTER 2

TRANSACTIONS AND WHEELING IN IDEALIZED INTERCONNECTED SYSTEMS

General

In this section, aspects of transmission service as they bear on the major transactions that take place in the interconnected operation of systems are discussed. An idealized situation of three interconnected systems is considered. Some aspects of wheeling are revisited and the economic incentives to provide transmission service to move blocks of firm power and economy energy are examined. A normalized analysis of the economics of wheeling is portrayed.

In interconnected system operation many commodities are traded or exchanged to improve production efficiency. The commodities such as firm power, short term power, reserve capacity, diversity exchange, and economy energy are negotiated for purchase between systems at a suitable price and are exchanged if there is adequate transfer capacity between the systems without jeopardising the technical integrity or the reliability of the system. There may be more than one utility in the path of a particular energy flow between two entities and such intermediate utilities provide the transmission service for a fee.

While utilities in North America have a record of success in such exchanges to improve the production efficiency, questions are being raised as to whether utilities could do more. Are commodities traded at a "fair" price? Is the transmission service being provided by the intervening utilities, or are there monopoly powers that are being exercised? Is there adequate transmission capacity between systems, or should additional capacity be built to realize longer term economic gains? These and many allied questions frequently arise in the regulatory community.

FERC authorized an experiment during 1985-85, the Southwest Experiment, to evaluate some of the above aspects. Currently, another experiment, the WSPP Experiment, has been authorized by FERC to attempt to answer some of these questions. The WSPP Experiment deals with four commodities: firm power, firm energy, economy energy, and transmission service. It is our intent here to focus on these four commodities instead of discussing all the transactions that take place in interconnected systems. As discussed in the introductory chapter, the goal of our research has been the identification of data that has to be collected and its application to the evaluation of experiments (including the WSPP) and the performance of interconnected systems.

We shall start by examining idealized experiments. Therefore, even though frequent references may be made in the following to the WSPP Experiment, it is important to remember that we are analyzing an idealized situation of three interconnected systems with one intervening utility. The analysis would enable us to identify the data that need to be collected in energy exchange experiments. In a later chapter, we shall examine the "real world" situation of the WSPP Experiment and the possibilities of breaking down such large systems to constituent elements consisting of the idealized three interconnected systems.

Wheeling, Firm Power and Energy, and Economy Energy

Wheeling

For transactions in power and energy, the availability of transmission service is a prerequisite. If one or more utilities are in the path of energy flow between two transacting utilities, the provision of transmission service by the intervening utilities is termed "wheeling" service.

A considerable amount of literature exists on various aspects of wheeling and its economic implications have been documented. Two previous efforts by NRRI on the subject have been listed under references [4, 5]. Certain technical aspects as they impinge on the trading of commodities in idealized experiments will be discussed here. How these aspects will bear on the measurements of market efficiency, production efficiency during such experiments is also addressed.

Reference [5] classifies wheeling into four types and categorizes the policy issues into three broad areas. They are as follows.

Type I Wheeling: Regulated utility to regulated utility

Type II Wheeling: A requirement customer or a private user such as an industrial customer purchases energy from a regulated utility that does not service the customer's geographic location. To consummate such a purchase, transmission service by the intervening utilities would be required.

Type III Wheeling: Private generator to regulated utility: this is the reverse of type II because of a private generator sells to a regulated utility whose service territory does not cover the geographic location of the generator.

Type IV Wheeling: Private generator to private user: It is assumed here that both the generator and the user are located in a single utility's service territory.

Issue I: What costs should be recovered by the wheeling utility?

Issue II: How should the profits (economic rents) of wheeling be shared?

Issue III: What rate structure should be used?

In view of our interest in idealized experiments (and the WSPP Experiment in a peripheral way) we shall address only wheelings of type I and type II in this report. The thrust of this chapter contrasts with the earlier work [4] in that no attempt will be made to suggest what costs should be recovered, how they should be shared and what the rate structure should be. However, the ensuing analysis considers the dynamic aspects of the market. The price to be charged for transmission service depends on the incremental costs of generation of different entities, the obligation to serve, the holding of franchise, profit motives etc. The incremental costs of generation change from hour-to-hour. Therefore, instead of focusing on any particular principle for pricing transmission service, different principles in pricing the wheeling service in a dynamic market place are examined. We shall examine the effect of such pricing principles on the production efficiency in a region where exchanges take place.

Firm Power and Energy

Firm power and energy are two commodities offered for sale in interconnected systems. A certain block of power and energy and the duration of its sale will be made known to the others or will be posted on a central computer or the bulletin board as in the WSPP experiment. The prospective purchaser of firm power and energy has to examine various alternatives and technical aspects before making a decision to buy such blocks of power and energy. They are:

1. Relative prices, duration and quality of supply of the offers from sellers, if there is more than one possible source of purchase.

2. The relative durations of the offers and their effect on the resource expansion of the purchaser, i.e. deferability of generation installation (for contracts of very long duration) and the effect of such a purchase on facilitating maintenance and other operational aspects.

3. Availability of transmission service and its cost in transacting with different intending sellers.

4. The effect of committing transfer capacity to purchase firm power on the loss of opportunity to realize economies by participating in the spot market (economy energy exchanges) for the duration of the firm transfers.

These considerations are elaborated in the following paragraphs.

The system operator has to weigh the above elements in accepting any particular offer. The operator attempts to realize the maximum economies possible in the day-to-day operation of the system, balancing it against the integrity and reliability of the system. The achievement record of the operators in the North American scene speaks for itself reflecting the efficient use of resources and reliability of operation. Therefore, the role of the operator and the importance of "smart" operators for proper systems operation is ineffable.

However, the operator may not have a knowledge of certain longer term strategies. Decisions involving long term implication have to be made at the corporate level. Therefore, the trust in the operators' abilities to realize economies in transactions of shorter term may not be directly extrapolatable to longer term dealings. The purchase contract between SCE and SDG&E [2] on a longer term is an example of corporate decisions. The management has to weigh the probable risks associated with the uncertain price and availability in a shorter term future spot market against the option of committing to purchase firm power now. Decisions regarding firm purchase for a short term are not associated with the same amount of risks and dichotomies of decisions involving commitments for a longer term.

In attempting to evaluate an experiment for the improvement of production efficiency by firm transactions, several questions have to be addressed. They are listed below.

> Was there any refusal of transmission service to consummate a firm deal? Was there any monopoly power exercised due to the holding of a franchise? (This aspect is similar to the next section on economy energy.) Did the refuser of transmission have his own firm power to sell because of a surplus? What was the refuser's price for the sale of his firm power and its other attributes in relation to the ones that would have been consummated if transmission were to be provided? However, how does one examine the equivalency between two offers? Is one firm power offer better than another firm power offer? Should there be a posting of the delivery schedule, load factor, etc., on the bulletin board to which all parties have access? How does one handle return of energy for power offers and diversity sales?

It is not readily obvious as to how one can answer all these questions either during or outside an experiment. It is essential, however, to recognize that a great degree of co-ordination exists between and among utilities. The operators and the corporate employees are frequently in contact with one another and do realize most of the economies possible. Our intent is to develop tests to examine the degree of production efficiency achieved. If such tests reveal serious problems, the above questions are directed to examining the reasons for the problems.

It is apparent from the above that the evaluation of shorter and longer term firm sales would be site specific and would involve the collection of a large amount of data. For firm transactions of very long durations, one may have to examine the generation expansion alternative of the transacting parties. Therefore, any attempt to suggest universal tests applicable to all situations of firm transactions would be meaningless. Accordingly, this report does not address transactions of longer terms.

We propose data collection and tests to examine the production efficiency in a region mainly due to exchanges over a shorter term. If the tests reveal serious loss of production efficiency or transmission constraints to the improvement of production efficiency, one should embark on an examination of longer term strategies for the utilities.

Economy Energy

It is well understood that when there is a difference in the incremental costs of production between two interconnected systems, purchasing energy from the lower cost producer to displace the higher cost production improves production efficiency. Such exchanges, termed economy energy interchanges, take place all the time in interconnected systems. Such exchanges between directly interconnected systems pose no special problems, particularly when there is adequate transfer capacity between the two. However, when the transmission of intervening utilities have to be used to exchange economy energy between two systems, the debate about the availability of wheeling service and its pricing can become intense. Therefore, the examination of economy energy interchanges is intertwined with that of wheeling service. An examination of some concepts in regard to wheeling will be undertaken in the following. Our task, at first, is to examine the various positions an intermediate utility may take in regard to providing and pricing the transmission service. In a subsequent chapter, we shall develop tests to analyse the types of services provided and their implications on production efficiency.

Towards this end, consider three idealized interconnected utilities as in Figure 2-1. In reality, of course, there would be a complex interconnection between many systems. But, the idealized representation of three utilities in Figure 2-1 will aid in the examination of certain principles. One could apply the principles obtained thus to larger and more complex situations. An attempt might be made to break down larger networks into modules as in Figure 2-1 in order to examine economic efficiency and monopoly power. In the representation of Figure 2-1, flow of power from A to C or vice versa is only possible through the network of B which holds the franchise to serve its territory and has the obligation to serve it.

In Figure 2-1, λ_a, λ_b, and λ_c represent the incremental cost of production of the three utilities in any particular hour. This cost includes the fuel cost, incremental cost of operation, maintenance, and other costs that can be directly related to the production of an additional quantum of energy. For generation from hydro sources, the cost would include the cost of water rights, reservoir management costs and other water related costs instead of the fuel cost.

Obviously, to make a transaction attractive, the buying price has to be some what less than the λ, the actual incremental fuel cost of the buyer, and has to take into account any costs associated with additional losses due to changes in the flow of energy in the network, costs of shutting down or off loading machines and other such factors. Similarly, the selling price has to be somewhat higher than the λ of the seller. In the following discussion, it is implicit that such adjustments to λ have been incorporated. We have also made the assumption that the prices posted on the computer during an experiment or a bidding process reflect the λs, as in the Florida Brokerage System. The postings in the WSPP Experiment need not be the λ values of producers. The participants are free to post any price they deem fit under the circumstances. This aspect does not hinder or affect the relevance of our analysis but is a matter of precision to be borne in mind in later discussions.

Table 2-1 lists all the possible scenarios that may arise over a period of time. By scenarios we mean the different ratios and relations between costs that may arise in a dynamic market and influence the incentives to trade in energy and transmission service. These incentives or attitudes

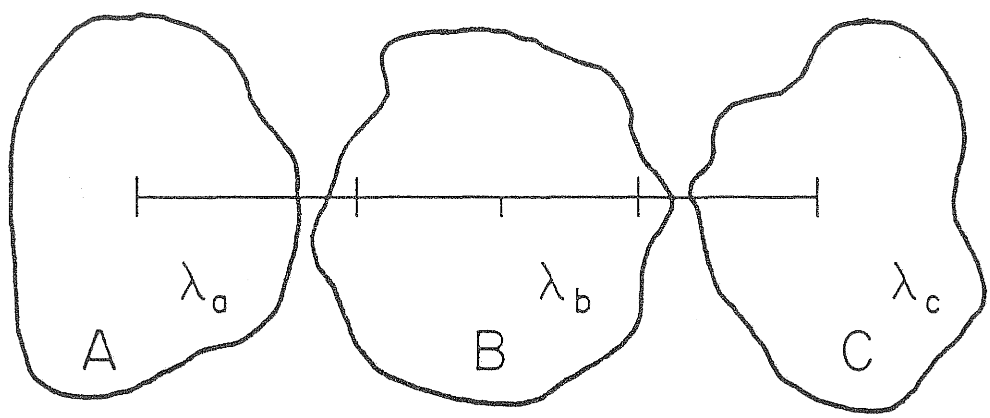


Fig. 2-1 Three illustrative radially interconnected systems

TABLE 2-1: Scenarios

Scenario No.	Network Conditions		Comments
1a	$\lambda_c < \lambda_a < \lambda_b$	$Q_b$buy ≤ $Q_c$sell	C sells to B. No wheeling.
1b		$Q_b$buy > $Q_c$sell	A and C sell to B. No wheeling
2a	$\lambda_a < \lambda_c < \lambda_b$	$Q_b$buy ≤ $Q_a$sell	A sells to B. No wheeling
2b		$Q_b$buy > $Q_a$sell	A and C sell to B. No wheeling
3a	$\lambda_c < \lambda_b < \lambda_a$	$Q_a$buy ≤ $Q_c$sell	C sells to A. B provides wheeling (see text)
3b		$Q_a$buy > $Q_c$sell	C and B sell to A. B provides wheeling (see text)
4	$\lambda_a < \lambda_b < \lambda_c$	Identical to scenario 3 but with A and C interchanged	
5a	$\lambda_b < \lambda_c < \lambda_a$	$Q_a$buy < $Q_b$sell	
5b		$Q_a$buy > Q_b sell	
6	$\lambda_b < \lambda_a < \lambda_c$	Identical to scenario 5 but with A and C interchanged	

will be elaborated later. The Qs in the scenarios refer to quantities made available by the parties to buy or sell. In all, there are six possible combinations of λs. We have omitted cases where the λs of any two parties are equal since the sale from or to either party with equal λs do not result in an increase of total production efficiency. We shall first enumerate some of the scenarios that create neither conflict nor debate before embarking on a discussion of more controversial scenarios. During an experiment, the participants may agree apriori to divide the benefits from exchanges in any manner. They may even negotiate a price of transaction between the buy and sell bids as in the WSPP Experiment. In our analysis, however, the division of benefits from the deals that are consummated will be calculated on an equal sharing (split savings) basis. In addition, we have assumed that adequate transmission capability to transfer the required amounts of energy is available to enhance production efficiency.

Scenarios 1 and 2

In scenarios 1 and 2, λ_b is the highest of the three lambdas. Therefore, either A or C or both A and C sell to B depending on the quantities and transmission capability that are available at that particular hour. For example, if Q_b buy, the quantity B is willing to buy, is less than or equal to Q_c sell, the quantity C is willing to sell, a sale from C to B precipitates the maximum production efficiency achievable. No intermediate party would be involved in moving the transacted power. In scenarios 1b and 2b, where B is willing to buy more than what the lowest cost producer is willing to sell, both A and C would sell to B.

Scenario 3a, Market Behavior When Q_a buy $\leq Q_c$ sell

This scenario is worthy of a thorough examination because of the requirement of transmission service. Therefore, we shall scrutinize all the aspects of this scenario before discussing scenarios 3b, 4, 5 and 6. Such a scrutiny would enable the reader to identify situations under scenarios 3b to 6 that are identical to those under 3a. Therefore, a lengthy discussion of scenario 3a is undertaken in the following.

Scenario 3 is a case when λ_b is at a value between the λs of A and C. This case would require the provision of transmission service by B to achieve the maximum production efficiency. The same is true in scenario 4 as well. Our assumption in the following has been that the transfer capacity in B's system to move energy from A to C and vice versa is available and that such transfers do not jeopardize the integrity of the systems involved.

Since C and A are the lowest and highest cost producers respectively, it is evident that the flow of energy from C to A via B's network would achieve the maximum production efficiency. Such a transfer of energy leads to questions on access to transmission, cost of wheeling and other important matters.

Extensive literature exists debating the principles of pricing the transmission service to be provided by B. The pros and cons of charging a rate based on embedded cost, short run marginal cost, and long term marginal cost have been documented in the literature. Our intent is to examine the dynamic nature of the market and the incentives and attitudes that might prevail among the traders of commodities under different scenarios. In the case of the three idealized utilities under consideration the position taken by the intervening utility and its regulators would directly affect the enhancement of efficiency.

Utility B and its regulators may take the position that B has the obligation to serve the customers in its territory. Since it holds the franchise to serve the customers in this area, it should minimize the cost of service to them. Therefore, the following three major alternatives are open to B:

1. B's cost is lower than that of A. Hence, B could refuse transmission access to C and try to sell energy to A from its own generation.
2. Alternatively, since B's cost is higher than that of C, B may choose to purchase energy from C to benefit its customers and then, if any further transfer capacity and energy from C is available, may consider making transmission service available to transfer power from C to A.
3. B, as an intermediary, could buy energy from C and resell it to A.

It is well known that the highest priced energy should displace the lowest priced energy in order to realize the maximum benefits. The total gain in production efficiency, if C sold to A through B's network, would be $(\lambda_a - \lambda_c)$ per MWh as against a lower value of $(\lambda_a - \lambda_b)$ if B alone were to sell to A. If B simultaneously buys from C and resells it to A, the total gain in efficiency would be the same as in the case of C selling to A via B's network. However, the portion of the total efficiency gains accruing to B would be different in the two cases under comparison. Our intent is to examine the positions B might take and its effect on the percent of total gains that accrue to B.

If B were to wheel energy between A and C, it might choose to price transmission service at a value which is the greater of the following at any particular hour: (a) Price for transmission service based on embedded costs, long or short run marginal costs depending on its and the regulator's principles on pricing wheeling service; (b) transmission priced to produce a benefit to B to the same degree if B were to have sold energy to A; (c) the transmission price set at a value which would result in a benefit to B not less than the benefit that would accrue to B if it purchased energy from C, and (d) B would simultaneously purchase from C and sell it to A according to a suitable pricing formula.

We shall not attempt to debate the merits of either one of the above. It will be shown that the benefits to B from any of the above attitudes would depend on the values of λs of the three utilities. The pricing principle and the gains to B under any alternative chosen by it would depend on the actual values of λs which could vary from one hour to the other in the dynamic market. Therefore, the pricing principle could vary from hour-to-hour. Our goal, therefore, is to examine the circumstances under which Utility B is likely to prefer either of the above pricing schemes. In a later chapter, we shall discuss what data could be collected during the WSPP Experiment and other experiments in order to analyze and to identify which pricing scheme was adopted by the participants. To account for the dynamic nature of the market, we shall develop a normalized or a nondimensional analysis involving the ratios of λs.

Definition of Attitudes

Before embarking on the analysis, three possibilities have to be defined and catagorized. We have chosen to call the possibilities "attitudes." There are no aspersions to a mind set or a dogmatic position in regard to pricing transmission by this choice of term. The reasons for our choice of this term are as follows.

In the dynamic market of electricity interchanges, the hour-to-hour decisions are made by the system operators. The operator, being the employee of a particular utility has the natural reaction to maximize the benefits to his employer. He/she probably will not concern himself/herself with the attainment of maximum production efficiency in the whole region. Furthermore, since decisions to grant or deny transmission service have to be made in a very short time frame (usually within the hour), the operator may not have the luxury of time to make an analysis of the region's interest. Therefore, when a request for transmission service is made, his/her immediate reaction would be to take any of the following attitudes in pricing the transmission service. We have not chosen the term "pricing principles" because of the probable absence of a planned corporate objective in establishing the hour-to-hour prices to maximize the region's production efficiency. Surely, the attitudes discussed below could be used as pricing principles to design any on line computer method to reflect the corporate objectives and to display the hour-to-hour price for transmission service.

Any movement of energy from C to A can be viewed as, and is indistinguishable from, the case of a simultaneous purchase and resale of energy from B. However, the attitudes adopted in pricing the purchases and sales by B distinguish the following transactions.

The first attitude of B, of pricing transmission service to produce a benefit to the same degree if B were to have sold to A, is defined to be the "franchise attitude" or FA. The second attitude is that of B purchasing energy from C to minimize the cost to its consumer. With such an action by B, either no additional transfer capacity to move energy from C to A could remain or, B might forego purchases from C and price transmission to result in benefits at least equal to that that would result had B purchased from C. This attitude based on its obligation to serve is termed the "entitlement attitude" or EA. The situation in some states of the WSCC region is similar to this. The third possibility is that of B simultaneously buying from C and selling to A. This has been termed "simultaneous purchase and sell" or SPS attitude.

To a casual observer, the EA and FA might appear to be similar. Under certain circumstances there may be some similarities between the two attitudes. However, it is important to note the difference between the two. Likewise, the similarities between EA and SPS should be understood.

The EA represents situations, as in the WSCC, where parties have some rights or entitlements to scheduling capacity on the transmission system. Then, if C is the cheapest producer, B would buy from C up to its entitlement. A would also buy from C up to its entitlement if it has some entitlement to the transfer capacity from C via B. Subsequently, B might make a sale to A (in addition A's purchase from C) under a pool or a transactions agreement.

Under the FA, A would not have any entitlement to the transfer capacity between C and B. The lines between C & B would be owned by themselves. Therefore C and B would schedule any amount of power between themselves as they deem fit, subject to technical restrictions. Therefore, any sale from C to A would require the provision of transmission service by B. The pricing of such a service under FA would be guided by the lost opportunity of B making sales to A.

In regard to the similarities and differences between EA and SPS, note that purchases and sales could be according to any preset or preagreed methods under SPS. For instance, both the purchase and sale price might be based on a split savings formula. Another example is when the purchase could be on a split savings basis, and the sale could be priced at 80% of the cost of displaced fuel.

The case of EA, however, can be viewed as a simultaneous purchase and sale by B with the transmission service priced to result in benefits equal to that that would result if B purchased from C.

The following is an analysis of the economic implications of these attitudes. The analysis will clarify the assumed formulas for purchases and sales. The analysis does not account for the fact that the incremental cost of generation of a purchaser reduces due to the displacement of his generation while that of the seller increases due to the opposite. In other words, the relation between λ and load has been assumed to be constant for the amount of power purchased or sold implying a stepped relation between them. In reality, the relation between λ and load is continuous, non linear, and site specific. Therefore, accounting for such a relationship would make the analysis complex and unrelated to any specific utility. In spite of this approximation, conclusions arising from the following analyses point to some interesting investigations. While considering the operation of power pools and experiments in chapters 2 and 4, however, the effect of the actual relationship between λ and load on the definition of incremental and decremental costs is addressed.

Case 1. The Franchise Attitude (FA)

In the Franchise attitude, it was mentioned that B's share of benefits would be at least equal to the lost opportunity of making sales to A. B allows C to sell to A utilizing its network. In spite of λ_b being less than λ_a, B has lost an opportunity to make a profit, in the interest of maximum production efficiency (sale from the highest λ to the lowest λ), by making available the network in its franchise territory to C and A.

The total gain in production efficiency by C selling to A (the implicit unit for gains is \$ per MW•h) is $(\lambda_a - \lambda_c)$.

If B had sold to A instead of making the network available for sale between C and A, gain in production efficiency would have been $\lambda_a - \lambda_b$ and B's share (assuming equal split) would have been

$$\$_b = (\lambda_a - \lambda_b)/2, \tag{2.1}$$

Where $\$_b$ is in \$/MWh.

If B decides to collect this amount (in providing transmission from C to A) as his share of the gain due to the trade between C and A (the franchise attitude), the remaining benefit to be split equally between C and A would be

$$\$_{c+a} = (\lambda_a - \lambda_c) - \left(\frac{\lambda_a}{2} - \frac{\lambda_b}{2}\right)$$

$$= \frac{\lambda_a}{2} - \lambda_c + \frac{\lambda_b}{2}. \tag{2.2}$$

Hence, this benefit split equally between to A and C would be

$$\$_a = \$_c = \frac{\lambda_a}{4} - \frac{\lambda_c}{2} + \frac{\lambda_b}{4}. \tag{2.3}$$

Normalizing (2.1) and (2.3) with respect to λ_a, one gets

$$\$_b/\lambda_a = 0.5 - 0.5\frac{\lambda_b}{\lambda_a}. \tag{2.1a}$$

and

$$\$_a/\lambda_a = \$_c/\lambda_a = 0.25 - 0.5\frac{\lambda_c}{\lambda_a} + 0.25\frac{\lambda_b}{\lambda_a}. \tag{2.3a}$$

Equations (2.1a) and (2.3a) can be portrayed graphically as in Figure 2-2. In the figure, the Y axis represents the benefits to the three participants

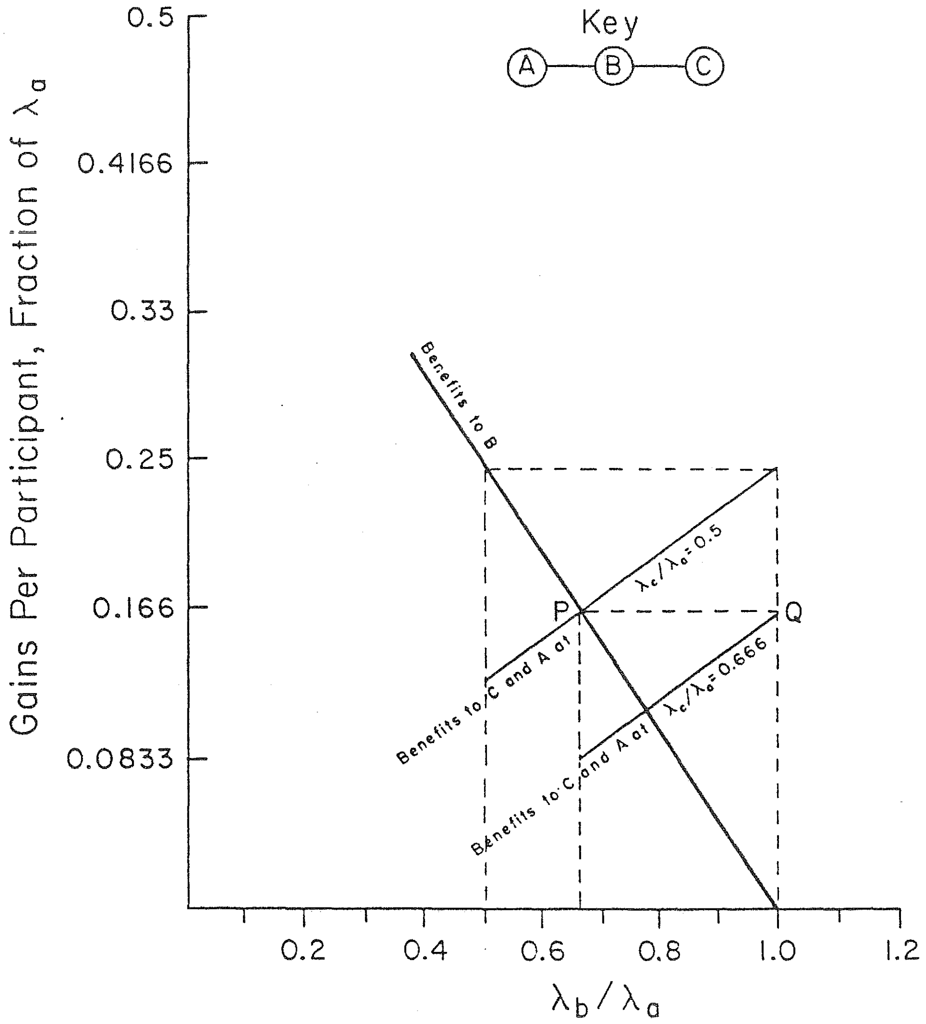


Fig. 2-2 Benefits to A, B, and C under FA

as a fraction of λ_a, the highest of the three lambdas. The horizontal axis is nondimensional and represents the ratio of λ_b/λ_a.

Discussion of Figure 2-2.

The line marked Benefit to B represents the relation of (2.1a). If $\lambda_b = \lambda_a$, then $\lambda_b/\lambda_a = 1$ and B, in theory, would not require any share of the trade between B and C due to lost opportunity, for at this point in the graph, there is no lost opportunity. Under such situations, it will be shown that B may choose to collect a revenue based on the incremental cost of providing the transmission service or might adopt other attitudes to maximize his benefits. As the line indicates, lower the λ_b in relation to λ_a (smaller the ratio λ_b/λ_a) higher is the share of benefits required by B.

In regard to the shares of C and A, note in the figure that they are equal and are dependent on the ratio of λ_c/λ_a. Their share decreases with the decrease of λ_b (hence the ratio λ_b/λ_a). The share of C and A has been shown for two ratios, viz. $\lambda_c/\lambda_a = 0.666$ and $\lambda_c/\lambda_a = 0.5$.

Consider the shares of C and A when $\lambda_c/\lambda_a = 0.666$. It is easy to see that for this ratio of λ_c/λ_a, the graph of the benefits is valid only in the domain $\lambda_b/\lambda_a = 0.666$ to 1 because of the following. If $\lambda_b/\lambda_a \leq 0.666$, since $\lambda_c/\lambda_a = 0.666$, we get $\lambda_b / \lambda_c < 1$ implying $\lambda_b < \lambda_c$. The scenario under examination implies $\lambda_c < \lambda_b$. Therefore, the graph of benefits is invalid in the domain $\lambda_b/\lambda_a < .666$. Similarly, when $\lambda_b/\lambda_a = 0.5$, the graphs are valid in the region $0.5 \leq \lambda_b/\lambda_a \leq 1.0$.

Due to the linear nature of the relations, it can be proven that the region of validity of the graph in Figure 2-2 can be obtained by drawing horizontal and vertical lines shown dotted in Figure 2-2. For instance, if one wants to find the benefits for $\lambda_b/\lambda_a = 0.666$, first a vertical line would be drawn from 0.666 on the x axis. A horizontal line is drawn from P to Q. A line drawn form Q to a point where $\lambda_b/\lambda_a = 2\frac{\lambda_c}{\lambda_a} - 1$ gives the benefits to C and A.

If this attitude (FA) in regard to pricing transmission is taken by B, it can be shown from (2-1) to (2-3) that the benefits to all the participants (A, B, and C) are equal when

$$\frac{\lambda_b}{\lambda_a} = 0.333 + 0.666\frac{\lambda_c}{\lambda_a} \tag{2-4}$$

Examples:

It is important to gain a good understanding of the above and to gain an insight into it in order to analyze the pricing of transmission for interchanges and in experiments. Therefore, a few numerical examples are presented below.

Example 1.

Let $\lambda_b = 5$, $\lambda_c = 4$, $\lambda_a = 6$; hence $\lambda_c < \lambda_b < \lambda_a$.

Then, $\lambda_b/\lambda_a = 0.8333$,

$\lambda_c/\lambda_a = 0.6666$.

B's share of benefits from (2.1a) and figure 2-2 is

$$\frac{\$_b}{\lambda_a} = 0.5 - 0.5 \times 0.833 = 0.08333.$$

Since $\lambda_a = 6$, benefit to B works out to

$$\$_b = 0.5 \text{ \$/MWh}.$$

C and A's share of benefits for this ratio of $\lambda_b/\lambda_a = 0.833$ from Figure 2-2 and (2-3.a) is

$$\frac{\$_a}{\lambda_a} = \frac{\$_c}{\lambda_a} = 0.25 + 0.25 \times 0.833 - 0.5 \times 0.666 = 0.125,$$

or, since $\lambda_a = 6$

$$\$_a = \$_c = 0.125 \times 6 = 0.75 \text{ \$/MWh}.$$

Total increase in production efficiency is the sum of the shares of A, B and C. This value is equal to 2.0 which in turn is equal to $(\lambda_a - \lambda_c)$, as it should be.

Note that at this value of λs, B has a lower benefit than A or C. The value of λ_b (assuming λ_a and λ_c are fixed) at which the share of the three would be equal can be obtained from (2-4) as

$$\frac{\lambda_b}{\lambda_a} = 0.333 + 0.666 \times 0.666.$$

This gives a value for $\frac{\lambda_b}{\lambda_a} = 0.7777$ and since $\lambda_a = 6$, at $\lambda_b = 4.666$ the benefits to the three parties are equal.

Example 2.

Let $\lambda_b = 3.6$, $\lambda_c = 3$, $\lambda_a = 6$:

Then, $\frac{\lambda_b}{\lambda_a} = 0.6$ and $\frac{\lambda_c}{\lambda_a} = 0.5$.

Reading the ordinates of Figure 2-2 for these values of λ_b/λ_a and λ_c/λ_a, one obtains

$$\$_b = 0.2\lambda_a, \ \$_c = \$_a = 0.15\lambda_a.$$

Note in this instance that the gains to B is more than the gains to A or C.

The share of the three parties is equal when

$$\frac{\lambda_b}{\lambda_a} = 0.333 + 0.6666 \times 0.5 = 0.666,$$

or

since $\lambda_a = 6$, in the above equation, the three parties' benefits would be equal when $\lambda_b = 4.0$

Case 2: Simultaneous Purchase and Sale. (SPS)

In this scenario, B can indulge in a simultaneous buy and sell procedure rather than providing transmission access for a fee. The purchase from C and subsequent sale to A can be priced arbitrarily. We shall assume in the following development that the purchases and sales under the SPS policy are based on incremental costs, splitting the benefits equally. Benefits resulting from other policies of sharing can be worked out by the reader.

In this case under discussion, B buys energy from C on a split savings basis and simultaneously sells energy to A based on an equal sharing of the gains. The distribution of the gain in production efficiency amidst the participants is calculated in the Table 2-2.

The table shows a well known aspect under SPS in regard to the benefits. That is, B's share of benefits, being the "middle man", is independent of its own λ but the shares of C and A are influenced by B's lambda.

Normalizing the shares shown in Table 2-2 with respect to λ_a, as was done earlier, one gets for the total benefits to each participant to be

$$\frac{\$_b}{\lambda_a} = 0.5(1 - \frac{\lambda_c}{\lambda_a}), \tag{2.5}$$

$$\frac{\$_c}{\lambda_a} = 0.5(\frac{\lambda_b}{\lambda_a} - \frac{\lambda_c}{\lambda_a}), \tag{2.6}$$

and

$$\frac{\$_a}{\lambda_a} = 0.5(1 - \frac{\lambda_b}{\lambda_a}). \tag{2.7}$$

Figure 2-3 portrays these results in a graphical fashion for two illustrative ratios of λ_c/λ_a that are identical to the ratios used in Figure 2-2, viz: $\lambda_c/\lambda_a = 0.666$ and $\lambda_c/\lambda_a = 0.5$.

Observations.

I. Note that in this instance, the share of C and A are unequal while in the FA case they were equal. As the incremental cost of B (the

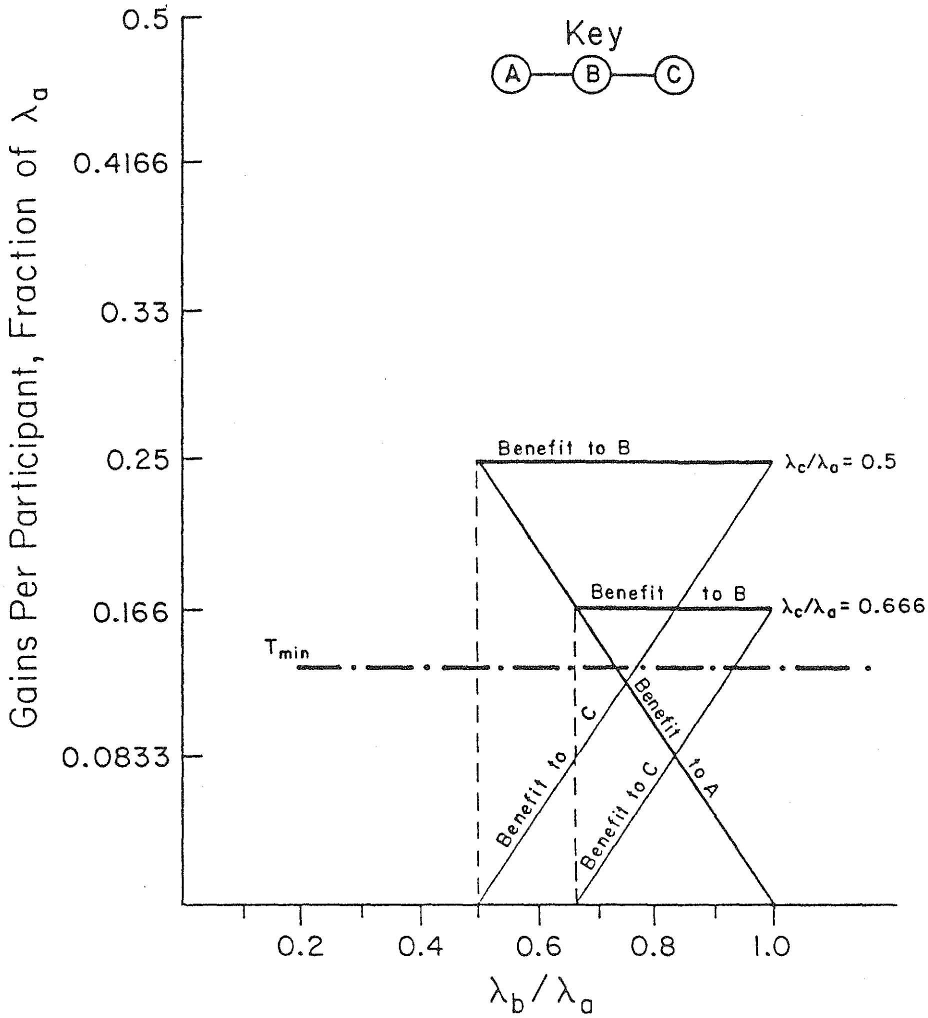


Fig. 2-3 Benefits to A, B, and C under SPS

TABLE 2-2 Table of benefits under SPS

Transaction	Share of benefits to		
	A	B	C
1. B's purchase from C		$0.5(\lambda_b-\lambda_c)$	$0.5(\lambda_b-\lambda_c)$
2. Sale from B to A	$0.5(\lambda_a-\lambda_b)$	$0.5(\lambda_a-\lambda_b)$	
Total	$0.5(\lambda_a-\lambda_b)$	$0.5(\lambda_a-\lambda_c)$	$0.5(\lambda_b-\lambda_c)$

"middle man") decreases in relation to C, the share of the least efficient producer, A, increases and that of the most efficient producer, C, decreases. Observe that for a given ratio of λ_c/λ_a, the share of B is constant and is not dependent on the actual value of λ_b. Hence, it is influenced only by λ_a and λ_c. As in the earlier case, the graphs are valid in the region where $\lambda_b/\lambda_a \geq \lambda_c/\lambda_a$. These regions of validity are shown by dotted lines, as in the case of FA.

II. Note that the benefits to C is higher for lower values of λ_c/λ_a, i.e. for lower values of λ_c. The benefits to A, however, are unaffected by λ_c but is influenced only by changes in λ_b. These relationships can be seen from Table 2-2 as well.

III. The shares of C and A are equal when $\lambda_b/\lambda_a = 0.5 + 0.5\frac{\lambda_c}{\lambda_a}$. The proof of this is obvious from the equations and is omitted.

IV. The benefit to C, the most efficient producer is <u>lower than the previous case for all values of λ_b</u>. (We shall examine the effect of this observation in a subsequent chapter). The benefits to A could be higher than the previous case of FA for certain ratios of λ_b/λ_a.

V. The share of A, the least efficient producer, is identical to its share in the previous case (FA) if

$$\lambda_b = (0.333 + 0.666 \frac{\lambda_c}{\lambda_a}). \qquad (2.8)$$

Its share is lower than the previous case for values of $\lambda_b/\lambda_a >$ the righthand side (RHS) of (2.8) and is higher for values of $\frac{\lambda_b}{\lambda_a} <$ the RHS of (2.8).

VI. Observe that by adopting the policy of SPS, B's share of benefits is greater than in the previous case under any circumstance.

VII. As in the previous case, B may not provide transmission service for a value less than its marginal cost (long run or short run) of providing transmission shown by the horizontal chain line at T_{min} in Figure 2-3. B may exercise its right to obtain this minimum if $\lambda_b/\lambda_a > 1$ as well. Further, as is depicted in Figure 2-4, the share of B's benefit by simultaneous purchase and sale may be less than T_{min}, particularly for values of λ_c/λ_a near 1.0. Then B may choose to charge T_{min} for transmission service rather than to adopt the SPS or FA attitude. Another possibility is that B may pursue SPS policy not necessarily related to λs. Then, B, might purchase energy from C on, say, split savings basis, but may not agree to split the savings in his simultaneous transaction with A. Figure 2-4 is a plot of the benefits under SPS to A, B and C. The figure is identical to Figure 2-3 but has been drawn for a higher ratio of λ_c/λ_a. The assumed values of $T_{min} = 0.133\ \lambda_a$ and $\lambda_c/\lambda_a = 0.8$ have been used in plotting this figure. As shown in the figure, in order to obtain an amount at least equal to the incremental costs of providing transmission service, B requires an additional revenue of $\Delta\$$ over that obtainable from SPS policy.

If one assumes that A pays this additional transmission tariff, its benefits would be reduced to the extent that there would be no

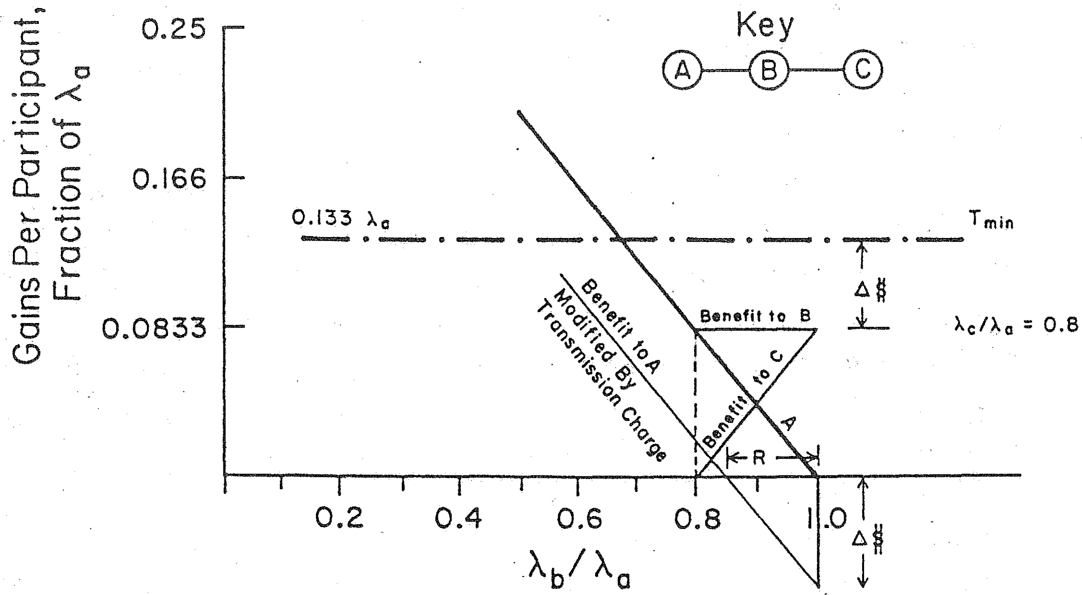


Fig. 2-4 Illustration of incremental cost of transmission

incentive to indulge in a transaction unless λ_b/λ_a is below a value R shown in Figure 2-4.

Under the circumstances considered, although an unattained efficiency would be noted in the region $R < \lambda_b/\lambda_a < 1.0$, it would be unwarranted to move C's energy to A due to the actual cost of providing transmission being what it is in Figure 2-4. Therefore, it is important to note that the value of T_{min}, the incremental cost of providing transmission, should be determined correctly. Distortions in T_{min} could lead to the loss of production efficiency. Furthermore, such losses in production efficiency are harder to assess due to the ratio of λ_b/λ_a being necessarily close to 1.0 and due to the difficulties associated with the definition and the determination of the actual incremental cost of providing transmission.

VIII. From observation III and by observing the share of benefits in Figure 2-3, we can conclude that concerns that their share of total gains is small due to the SPS could be expected from purchasers (A in our e.g.) when $\frac{\lambda_b}{\lambda_a} > 0.5 + 0.5\frac{\lambda_c}{\lambda_a}$ and from the sellers (C in our e.g.) when λ_b/λ_a is less than the above value.

In later sections, we shall utilize the above concepts in designing tests to measure the efficiency of markets, either in an interconnected system or during an experiment.

Case 3. The Entitlement Attitude (EA)

This situation arises due to contractual obligations that exist amidst utilities. To illustrate this situation, recall that λ_c is less that λ_a and λ_b in the scenario under discussion.

The cheaper surplus energy from C may be made available to A and B. Further, since $\lambda_b < \lambda_a$, it is obvious that the energy from C should ultimately displace A's generation (since it is the most expensive one) in order to maximize production efficiency. In reality, however, the incremental cost of production in a system changes with the amount of energy purchased or sold. To account for this aspect, consider Figure 2-5. Here, it has been assumed that λ_c has a fixed price (as BPA, in a surplus situation, fixes the price of energy sold at, say, 22 mills). Then let A and B represent two utilities (say, California utilities) with the idealized load-λ relationship as shown in Figure 2-5.

In Figure 2-5, let L_a and L_b be the loads of A and B with the associated lambdas before transacting. If A purchases a quantity equal to Q_{ca} from C, its local generation drops from L_a to a lower value with an associated lambda.

The strategy to realize the maximum possible production efficiency should proceed as follows. If the energy available from C is less than or equal to that A is willing to buy, Q_{ca}, the generation in A should be displaced first. Then, the lambda of A would come closer to that of system B and in the ideal case would equal that of system B. In this depiction, it has been assumed that the quantity available Q_{ca} is not enough to equalize the lambda of B and A.

If the energy available from C is greater than Q_{ca}, the generation of A and B in the ratios illustrated in Figure 2-5 should be displaced. In this instance, the total energy available is $Q'_{ca} + Q'_{cb}$ and the systems A and B have been shown to attain a common λ after purchases of Q'_{ca} and Q'_{cb} from C.

Under the EA scenario, B might own the transmission from C to B or might have a right or entitlement to a certain transfer capacity in the transmission between C and B. Therefore, B might hold that it has the obligation to serve its customers at a minimum cost and, thus, is first entitled to exercise its right to transmission and purchase all the amount of energy $Q'_{ca} + Q'_{cb}$ as shown in Figure 2-6. The illustration in the left of Figure 2-6 shows this situation where the load L_b and the associated lambda before the transaction has been reduced to a lower value after the purchase of $Q'_{ca} + Q'_{cb}$ into system B. This illustration, in contrast with the illustration in Figure 2-5 which showed the purchase of Q'_{ca} by A and Q'_{cb} by B, shows the effect of system B buying all the energy.

Subsequently, to increase the production efficiency in the region, B may sell a quantity Q_{ba} to system A attempting to reduce the difference in λs between it and system A. The purchase of Q_{ba} and the resulting reductions in load and lambda in system A (with corresponding increase in B) are shown in the illustrations of Figure 2-6.

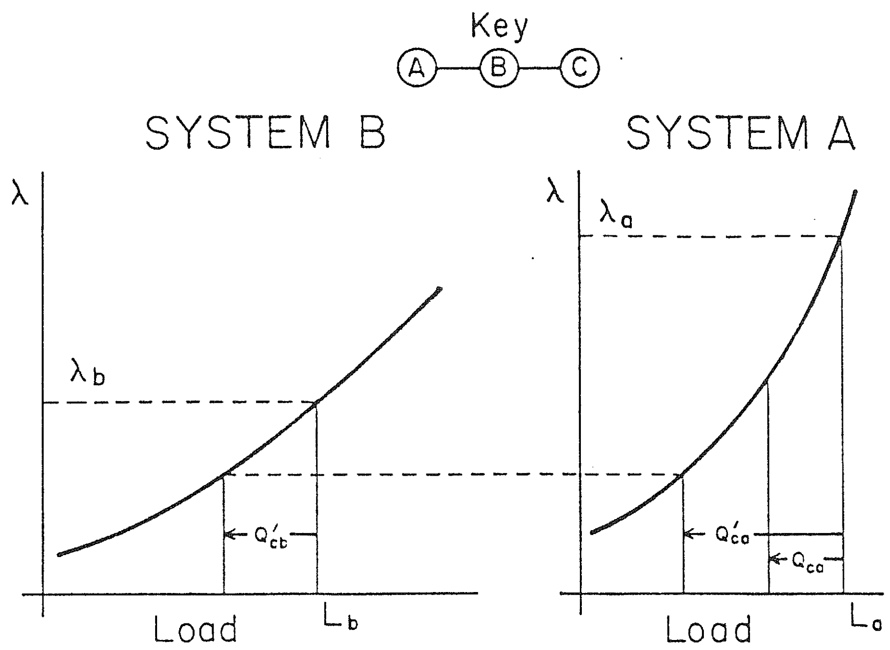


Fig. 2-5 Effect of sale from C to B and A

This procedure shown in Figure 2-6, so far, is similar to a simultaneous purchase and sale situation. Since the λs of systems A and B are equalized after all the exchanges, the same total efficiency gains as under the situation described in Figure 2-5 would result. However, the EA could differ from the SPS in a subtle but vitally important aspect if the following were to be true. In its secondary sale of energy (Q_{ba}) to A, B may hold that its incremental cost is not that shown by the λ curve in the left hand side of Figure 2-6. Instead, B might hold the position that the energy $Q'_{ca} + Q'_{cb}$ was purchased from C for "its own use" and, therefore, the subsequent resale to A would be according to, say, its cost before purchasing from C. B's cost before purchasing from C was λ_b. Hence, in pricing its sale to system A, the characteristic to be used would be according to the dashed curve shown in the left illustration of Figure 2-6, or even according to some other curve perhaps higher in value than the dashed curve. Under such circumstances, the sale from B to A to equalize imputed λs between the two would be Q'_{ba} and the λ of system A will not drop to the value it had when B sold Q_{ba} to it. In other words, since Q'_{ba} is less than Q_{ba}, system A's λ will not reduce to a value as when optimum quantities of Q'_{ca} and Q'_{cb} were purchased from C (Figure 2-5). It is evident, therefore, that the maximum production efficiency would not be realized under these circumstances.

Graphical Representation of EA is shown in Figure 2-7. It has been assumed that B has an entitlement of 100 percent of transfer capacity from C into its system. Then, if the transaction between B and C is on a split savings basis, benefits to B and C would be

$$\$_b = \$_c = 0.5\ \lambda_b - 0.5\ \lambda_c\ . \qquad (2.9)$$

Normalizing with respect to λ_a, we get

$$\$_b/\lambda_a = \$_c/\lambda_a = 0.5\ \frac{\lambda_b}{\lambda_a} - 0.5\ \frac{\lambda_c}{\lambda_a}\ . \qquad (2.10)$$

This equation is plotted for one ratio of λ_c/λ_a in Figure 2-7 and has been identified as benefits to B.

If B implicitly prices transmission to be at least equal to the

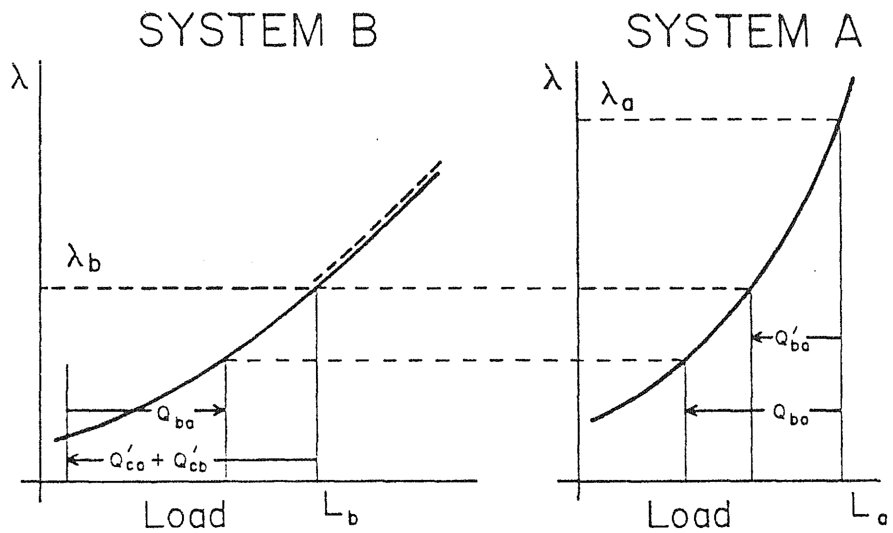


Fig. 2-6 Effect of sale to B and then to A

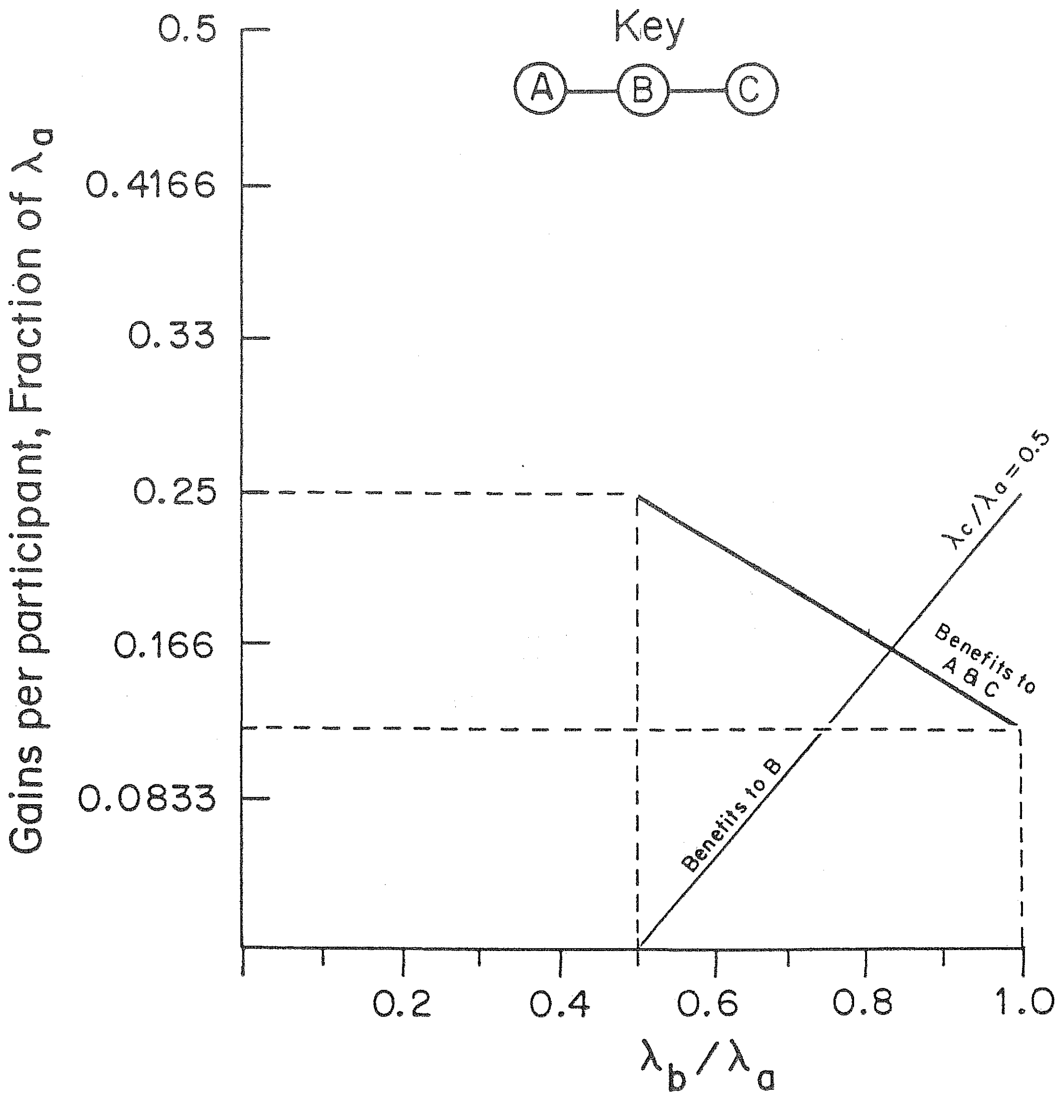


Fig. 2-7a Benefits to A, B, and C under EA

benefits had it exercised the option to buy from C, the remaining benefit when C sells to A via B's network is

$$\$_a + \$_b = \lambda_a - \lambda_c - 0.5\ (\lambda_b - \lambda_c)\ . \qquad (2\text{-}11)$$

Dividing this equally between A and C and normalizing with respect to λ_a, one gets

$$\frac{\$_c}{\lambda_a} = \frac{\$_a}{\lambda_a} = 0.5 - 0.25\ \lambda_c/\lambda_a - 0.25\ \lambda_b/\lambda_a\ . \qquad (2\text{-}12)$$

This line is also shown in Figure 2-7a for one ratio of λ_c/λ_a identified as the benefits to A and C. Observe that the benefits to A and C are equal (as in the case of FA) and that the benefit to B is less than that under SPS.

Consider the case when C sells energy at a fixed price, Z_c. Note that $Z_c > \lambda_c$. The benefit to C is $Z_c - \lambda_c$ and to B is given by

$$\$_b = \lambda_b - Z_c\ , \qquad (2\text{-}13)$$

Which when normalized with respect to λ_a becomes

$$\$_b = \lambda_b/\lambda_a - Z_c/\lambda_a \qquad (2\text{-}13a)$$

As in the earlier cases, if B prices transmission to recover this benefit and permits C to sell A, benefit to A is

$$\$_a = \lambda_a - Z_c - (\lambda_b - Z_c)\ ,\ = \lambda_a - \lambda_b\ . \qquad (2\text{-}14)$$

Normalizing with respect to λ_a, one obtains

$$\$_a/\lambda_a = 1 - \lambda_b/\lambda_a\ . \qquad (2\text{-}14a)$$

These relationships, (2-13) and (2-14), are shown in Figure 2-7b. Note that the benefit to A is independent of Z_c and is only dependent on the ratio λ_b/λ_a. The benefits to B, however, depend on Z_c. For certain values of Z_c, the benefits to B under EA could be higher than under SPS. For instance,

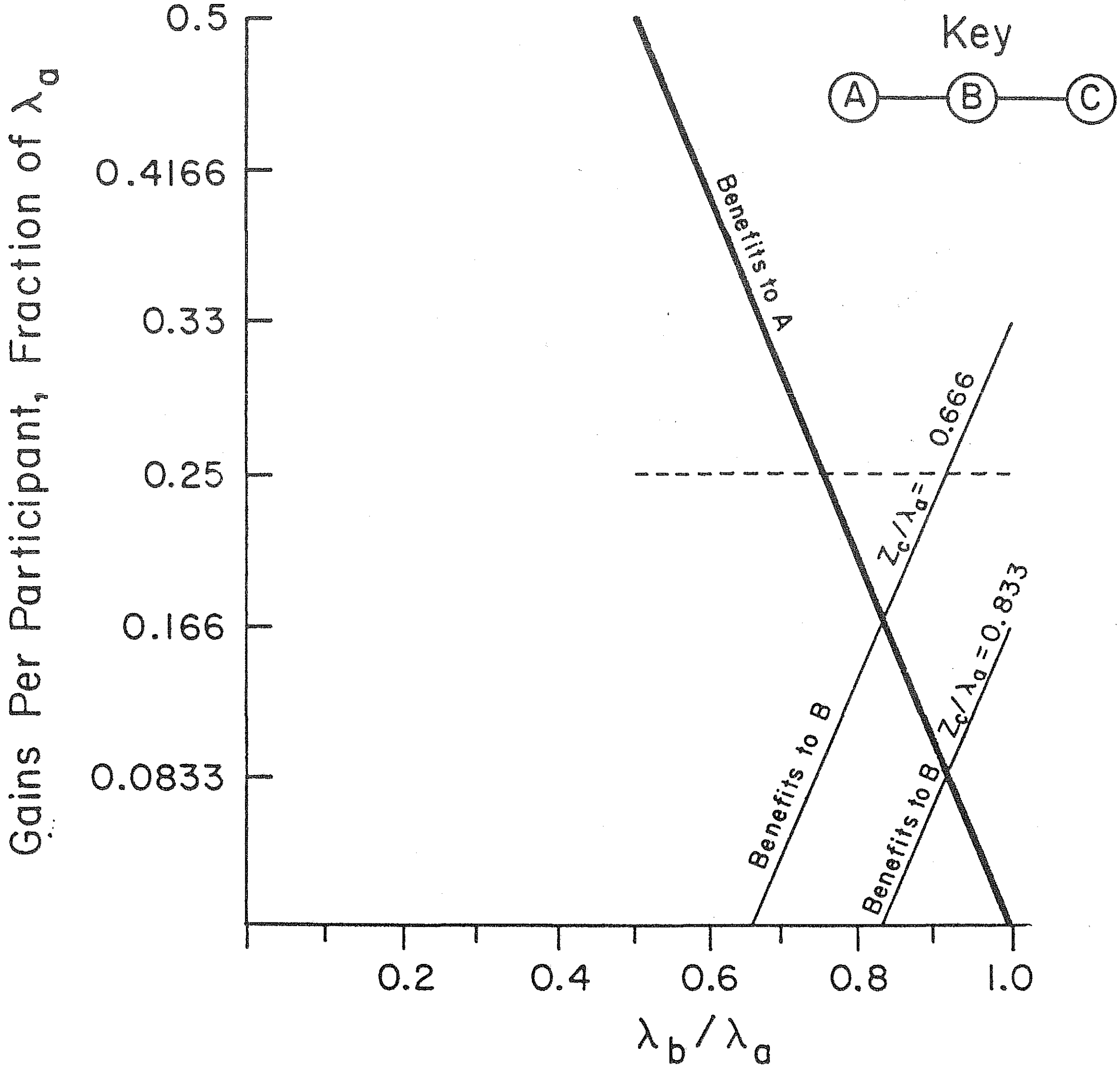


Fig. 2-7b Benefits to A, B and C under EA, fixed energy price by C

consider that $\lambda_c/\lambda_a = 0.5$ as depicted in Figure 2-3. The benefits to B is equal to $0.25\lambda_a$ under SPS. If C declares its fixed price for energy to be such that $Z_c/\lambda_a = 0.666$, say, the benefits to B under EA can be seen from Figure 2-7b to be higher than under SPS for ratios of λ_b/λ_a exceeding about 0.9. If C declares its fixed price to be even higher at $Z_c/\lambda_a = 0.833$, the benefits to B under EA would be lower than under SPS. It is understandable that C would prefer not to fix the price of its energy to result in greater benefits to B than under SPS.

Comparison of Attitudes

Comparison of gains to the intermediate Utility B under different scenarios, FA, EA and SPS have been the depicted Figure 2-8. In the figure, the plots have been shown for one ratio of $\lambda_c/\lambda_a = 0.5$ in order to highlight certain conclusions. The conclusions would, of course, be valid for other ratios with proper adjustments.

Note from the figure that SPS produces more revenue to B than FA for all ratios of λ. The EA, with a split savings transactions between B and C, cannot produce more revenues than SPS for any ratio of λ_b/λ_a. However, EA when C is selling energy at a fixed price, could produce more revenues to B than SPS at certain ratios of λ_b/λ_a for certain fixed prices by C. Therefore, from a maximization of benefits view, it behooves B to adopt the SPS attitude if C is selling energy on a split saving basis. If C is selling energy at a fixed price, B may be better off adopting EA for higher values of λ_b/λ_a and by pricing transmission service according to the SPS attitude for lower ratios of λ_b/λ_a for certain values of C's price for energy.

Note from observation IV under SPS that C's benefit would be lower under SPS than under FA. Note from a comparison of Figures 2-7, 2-2, and 2-3 that: (1) the benefits to A are lower under EA than under SPS for all ratios of lambda and (2) the benefits to C could be higher under EA than under SPS of FA for certain ratios of λ_b/λ_a. To avoid the uncertainties due to changing market conditions, it may be advantageous to C to price its energy at some fixed price to maximize its benefits. This appears to be the practice by BPA in the WSCC under surplus situations. Note that under some circumstances, the benefits to B from the pricing of transmission service

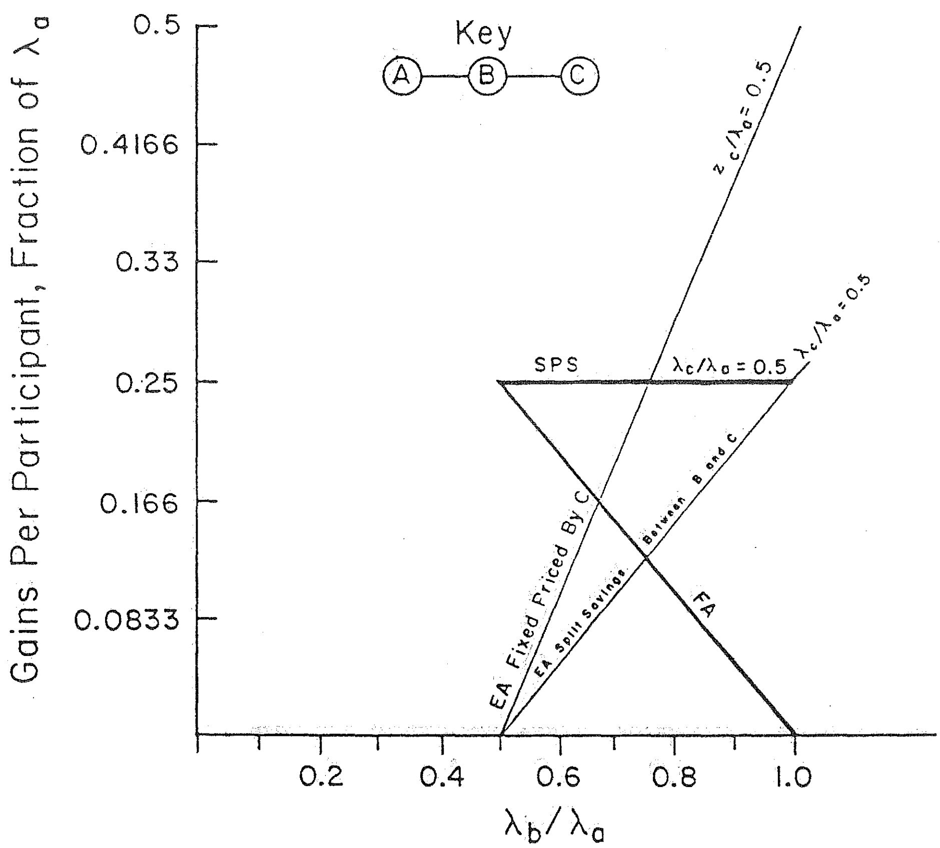


Fig. 2-8 Comparison of benefits under different attitudes

according to any of the above attitudes might be less than the embedded cost or the incremental cost of providing the service.

Note also that the gains depend on the actual value of λ_a.

Scenario 3b, Q_a buy > Q_c sell

Under this scenario, B would provide wheeling service according to any of the considerations outlined under scenario 3a. In addition, B would sell additional energy to A to realize the maximum production efficiency possible from such additional sale. The assumption, of course, is that B's network is capable of transporting the whole quantity of energy required by A and itself. In the absence of such a capability in B's network, B might adopt FA or SPS to maximize its gains.

Scenario 4, $\lambda_a < \lambda_b < \lambda_c$

This is identical to scenario 3 but the λs of A and C have been interchanged. Hence, all the arguments outlined above are valid with the exception that the subscripts A and C would be interchanged. Then, the buyer A in the previous scenario becomes the seller and the seller C of the previous scenario would be the buyer.

Scenario 5a, $\lambda_b < \lambda_c < \lambda_a$, Q_a buy < Q_b sell

Since B is the cheapest producer, B sells to A thereby achieving production efficiency. Since Q_a buy < Q_b sell, B would also sell to C. There would be no wheeling by an intermediate party. It has been assumed that B has adequate entitlement in his transmission to A to transact this sale.

Scenario 5b, $\lambda_b < \lambda_c < \lambda_a$, Q_a buy > Q_b sell

In addition to B's sale of energy to A, wheeling through B's network would be required in order that C can also sell to A. B may choose to simultaneously buy and sell C's energy or it may impose a charge for providing that service to recover the incremental cost of providing transmission facilities. If B's network would be overloaded or would operate at reduced reliability due to the provision of wheeling service, B may refuse to wheel C's energy to A. In the operation of an interconnected network, therefore, one would like to know if wheeling was provided or refused. In case of the latter, one would like to know if the refusal was transmission limit related, related to lack of entitlements in transmission, or if it was due to B exercising a monopoly power of ownership of transmission by imposing a high wheeling tariff.

Scenario 6, $\lambda_b < \lambda_a < \lambda_c$

This is identical to scenario 5 but with A and C interchanged (mirror image). Hence the arguments under scenario 1 are equally valid for this scenario.

Recapitulation

It has been shown that:

1. The intermediate utility may adopt the FA, SPS or EA to maximize its gains. SPS and EA are the more attractive options.
2. The benefit to the most efficient producer is lower when the intermediate utility adopts SPS than when the intermediate utility adopts the FA. Therefore, the most efficient producer may like to maximize its gains by setting a market clearing price for its energy.
3. The SPS attitude produces more benefits to the wheeling utility compared to those produced by FA.
4. For certain ratios of lambdas, the benefits to the wheeling utility by any attitude may be less than the incremental cost of providing transmission.
5. Dissatifaction regarding SPS can be expected from purchasers when $\frac{\lambda_b}{\lambda_a} > 0.5 + 0.5\frac{\lambda_c}{\lambda_a}$ and from sellers when $\frac{\lambda_b}{\lambda_a} < 0.5 + 0.5\frac{\lambda_c}{\lambda_a}$

In the above, all the combinations of λs and scenarios that can arise have been examined. We have refrained from commenting on the fairness or otherwise of the policies in regard to wheeling. It is important to recognize that the market is a dynamic one and therefore any single pricing principle or practice may not be acceptable for every hour. The pricing criterion might jump from one attitude to another as the market conditions change. The vital concern is that any criterion chosen for pricing transmission should be consistent with market conditions and should not hamper production efficiency.

Our agenda in the subsequent chapters is to devise tests to identify the production efficiency and the scenario under which a market would be operating. To this, we shall turn our attention.

CHAPTER 3

EVALUATION OF INTERCHANGES

In the following, we shall develop some methods for the evaluation of energy interchanges under idealized operation of systems or experiments. The methods of evaluation involve the application of certain tests. Not all the tests to be discussed may be applicable to situations in which a full set of data is not collected. Although some of the tests to be proposed are conceptual in nature, most of them are applicable to practical situations. The application of other tests may require collection of additional data. The participants in any experiment and its regulators may choose some from the proposed array of tests that are applicable to their systems to address the concerns of a particular area.

Our agenda is to develop three categories of tests. The first is a set of tests to obtain a general or a global assesment of the market. The second is statistical in nature and is intended to assess the functioning of the bulk power market. The third category of tests is designed to evaluate the transmission service market.

In designing these tests, one important assumption in regard to data collection has been made. It has been assumed that the participants have access to their hourly incremental costs of production and the hourly quoted value for the sale and purchase of commodities. In the WSPP Experiment, we believe that the bid values posted on the computer can be in a band above the actual incremental cost. In the Florida Broker or other pools where the bids reflect the incremental costs, energy exchanges are generally made at the average of the buy bid and sell quotes resulting in the benefits to buyer and sellers being equal. In contrast, in the WSPP experiment, the price for the transaction is negotiated between the buyer and the seller and is, one would expect, entered into the computer data base. In the power pools, as in the WSPP, the hourly incremental costs are tracked by central computers. This data, which is proprietory to the utilities, is assumed to be available to the party/parties evaluating the efficiency of interchanges.

It is further assumed that the data regarding the buy and sell quotes and the consummation price is entered into the computer database.

In the following, the symbol λ refers to the actual incremental cost of production from the least efficient unit on line. It is not the cost of production from the unit that would have been on line if particular amounts of power were not bought or sold. This aspect will be elaborated in a subsequent section. The terms "quotes" or "bids" refer to the actual quotations of price (not the costs) for the commodities while λ refers to the incremental costs. The consumation price refers to the negotiated or a preagreed price at which the commodities would be sold.

Category 1: General Tests

We now make an assertion that any generation from hydro resources would be absorbed in power systems. Hydro energy is seldom spilled in a well planned system such as the WSCC. It is evident that hydro energy plays a prominent part in the WSCC, particularly in the Northwest, with BPA as a major hydro producer. The hydro electric installations are capable of producing more energy under above average flow conditions. Therefore, any seasonal variations in hydro electric generation would be traded either as short-term firm or economy energy. With the above in mind, it is possible to devise some general tests to evaluate the functioning of the market. The tests vary in their degree of complexity.

Test GT1: Enhancement of trade due to an Experiment.

This test is intended to evaluate the benefits due to an experiment by considering what the benefits would have been, had there been no experiment.

For each month in the year, it is possible to calculate the surplus energy balance for each of the participants. Such a calculation is possible for the previous year and the experimental year by using the statistics of energy generated and sold under different types of transactions. We define surplus to be,

$$SU = G_h + G_n - DL + P - S - L - t \, , \qquad (3.1)$$

Where

SU is the surplus

G_h is the hydro generation in GWh

G_n is the non-hydro generation in GWh

DL is the domestic load in GWh including requirement and firm customers

P is the firm and other purchase contracts (in GWh) entered into before the experiment and would have been renewed even in the absence of the experiment,

S is for sales and is identical to P in formulation,

L is the losses in GWh

and

t is any energy spilled

Note that the surplus SU in the previous years was marketed as economy energy, short term firm energy and other arrangements in the spot market.

The first variation in surplus balance for each participant during the year of the experiment in comparison with a previous period is given by

$$\Delta SU = \Delta G_h + \Delta G_n - \Delta DL + \Delta P - \Delta S - \Delta L, \qquad (3.2)$$

where ΔG_n and ΔG_h are the changes in non-hydro and hydro generation, ΔDL is the change in domestic load and ΔP and ΔS are changes in purchases and sales anticipated due to contractual obligations and would have taken place even in the absence of the experiment. ΔL, the change in losses, can be assumed to be small to start with.

During the years of the experiment, we examine the component ΔG_h in (3.2), the change in hydro generation. We assert that any excess hydro generation (if ΔG_h is positive) would have found a market due to its low incremental cost even without the experiment. Therefore, the total exported economy energy and short term energy during the experiment of all the participants minus the sum of historical exchanges and ΔSU (the sum of ΔG_h of all participants plus the sum of all load changes and change of firm purchases and sales) signifies the transactions in the market due to the experiment. Expressed mathematically, we have

$$E_c = \Sigma_r(EX_r - SU_r) - [\Sigma_r(\Delta G_{h,r} - \Delta DL_r) + \Sigma_j(\Delta P_j - \Delta S_j)], \quad (3.3)$$

where E_c is the exchange due to the experiment, r is the number of participants in the experiment and j is the sum of participants and the transacting parties from outside the region where the experiment is conducted ($j > r$), EX is the exports of economy and short term firm energy during the experiment, SU is the quantity calculated for the pre-experiment year as in (3.1), ΔG_h is the change in hydro energy from the year before the experiment, ΔDL is the change in domestic load and ΔP and ΔS refer to the changes contacted and anticipated firm and energy purchases and sales.

Equation (3.3) makes a correction to the difference in economy energies traded before and during the experiment to account for the increase or decrease of hydro-energy and the loads during the experiment. In addition, a correction for any import from or export to extra-regional entities has also been incorporated. If extra-regional entities are not considered, the sum of differences between purchases and sales, i.e., $\Sigma(\Delta P-\Delta S)$, would be zero (neglecting losses). However, during an experiment, there may be large purchases from or sales to extra-regional entities. These sales or purchases cannot be attributed to the experiment. Therefore, the last summation term involving j incorporates a correction to account for this. Tests involving only the comparisons of the energy exchanged without the above correction and tests comparing the number of transactions would be faulty and do not portray the whole picture.

Therefore, the evaluation of E_c from equation (3.3) would indicate the incremental energy sales due to the experiment.

Test GT2: Global Measures of Market and Quotations.

It is important to ascertain what opportunities exist to improve efficiencies and the degree to which utilities are realizing it.

One way of ascertaining this by a "joint dispatch" calculation. In such a calculation, all the machines in the interconnected system are loaded in their increasing order of cost of production to meet the total demand.

In its simplest form, such a simulation ignores, inter alia, transmission limitations between interconnected parties and other engineering limitations such as the minimum load and cycling capabilities of machines. In spite of these limitations, a "joint dispatch" simulation gives a bench mark indication of the global benefits that can be achieved against which the actual benefits obtained can be compared. Many mathematical models to simulate the joint dispatch production costing are available from the utilities, consultants, and other sources.

Test GT3: Frequency of Differences in λ

A method of examining the "degree of awareness" and trading amidst the interconnected parties is by keeping track of the differences between the incremental costs of production. Almost all the utilities have computerized systems which keep a log of hourly costs. Therefore, by a coordinated effort between the utilities, it should be possible to calculate the differences between their λs and the possible improvement in production efficiency if there were to be unrestricted and unimpeded trading between them. Such a calculation could be used as a bench mark figure against which actual efficiencies realized could be compared.

However, the above activity would entail a considerable effort by the participants which may not be warranted unless tests reveal that there are too many restrictions to trading. All the same, to get an indication regarding the functioning of the market and the degree of transmission bottlenecks, the following test which requires much less effort is suggested.

The participants can obtain the data in regard to the λ of each system at each hour based on their actual cost of fuel. A plot of just the maximum hourly difference in λ is shown in Figure 3-1. The figure shows the maximum difference in the λs (between any two participants) in each hour plotted against the frequency or the number of occurrences of that difference over a period of time, say an year. One may choose to omit small differences in λ, say in a dead band of 0.5¢KWh, since it is neither practical nor necessarily economical to consummate such trades. We expect the plot to be a Wibull or a Log-normal distribution.

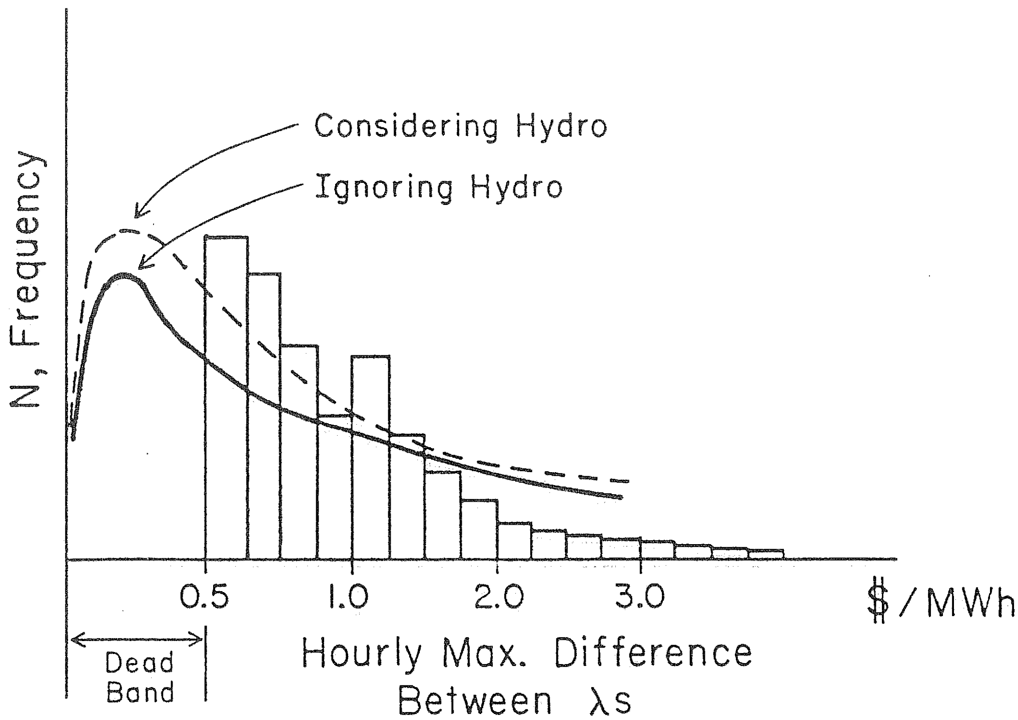


Fig. 3-1 Frequency of maximum differences between λ

A comparison of such a plot before the experiment and after the experiment would be valuable. If the frequency of occurrence of high differences is found to be large, one would conclude either that there is a transmission related restriction (due to technical or monopoly reasons) or that there are other impediments to trading.

A cautionary note is that the existence of a high frequency count of large differences in λ does not necessarily indicate opportunities to improve production efficiency. The fallacy in the plot of Figure 3-1 is that there are no quantities indicated therein. Information regarding production efficiency can be obtained only from the earlier mentioned joint dispatch simulation. To elucidate this further, if the λ difference were to be 10¢/KW•h and the opportunity was to trade only 10MW over a distance of several hundred miles, it would hardly be worth consummating such a deal. However, if the quantity involved is a 1000 MW, say, it would be worth transacting. In spite of the weakness of not showing this information, Figure 3-1 will reveal useful information. Only if Figure 3-1 shows major concerns, additional analysis to probe the matter further be undertaken.

<u>Category 2: Tests to Evaluate the Functioning of the Bulk Power Market</u>

The following tests have been designed to evaluate the efficiency of performance of the bulk power market during an experiment. The tests are also intended to measure the competitive forces during the functioning of the market.

First, a set of six tests that are mostly statistical in nature will be suggested. Any large deviation of the results from the expected, under each test, could lead to further areas of inquiry regarding the interchanges in terms of production efficiency.

This set of tests is applicable to the exchanges of firm power and economy energy. Their applicability to economy energy is straightforward. However, their application to blocks of firm power and energy cannot be specified with precision without a knowledge of the actual process of posting quotes. It is assumed that quotations for firm power blocks (both buy bids and sell quotes) will be entered into the computer and that the price at which a transaction is made will also be stored in the computer.

If that were to be the case, these tests would be directly applicable to firm transactions as well as economy energy exchanges.

Test BP1: Number of transactions.

Figure 3-2 depicts a statistical frequency of the difference between the buy bids and sell quotes, ΔC, valid during any period of time. The first Figure 3-2a is a frequency of difference between quotations on a central computer, ΔC_h. The second in 3-2b is a distribution of actual costs ΔC rather than the posted prices on the computer. In both these figures, the frequency count includes the transactions that are and are not consummated.

For the calculation of ΔC or ΔC_h in the above plot, the following procedure is suggested. A digital computer simulates the consummation of all quotes matching the highest to the lowest assuming unimpeded trade. The difference between the costs of simulated trades gives ΔC or ΔC_h with the trade lasting an hour being counted as one. Thus, a trade lasting for five hours, say, at a particular ΔC would have a frequency count of five.

Figure 3-2c shows ΔC against the product of the block size, and duration. Here, instead of plotting the frequency on the vertical axis (number of hours) as in the previous case, the product of the frequency and the block size (MW traded) is plotted. It is evident that the area under such a plot represents the total efficiency gains attainable if all the quotes could be consummated. In Figure 3-2d, only transactions that are consummated are considered. The number of actual transactions and the difference between the buy and sell prices are portrayed in this figure. It reveals the number of opportunities exploited by the participants to improve production efficiency. Comparison of the results of Figure 3-2c with the joint dispatch simulation indicates the degree of effectiveness of an experiment.

Clearly, if the participants are disinterested in the experiment, or do not want to participate by entering quotations, the area under 3-2c would be very small while a joint dispatch simulation might indicate substantially greater gains. Note that the maximum area possible under the curve, in the limit, is equal to the benefits calculated in the joint dispatch simulation.

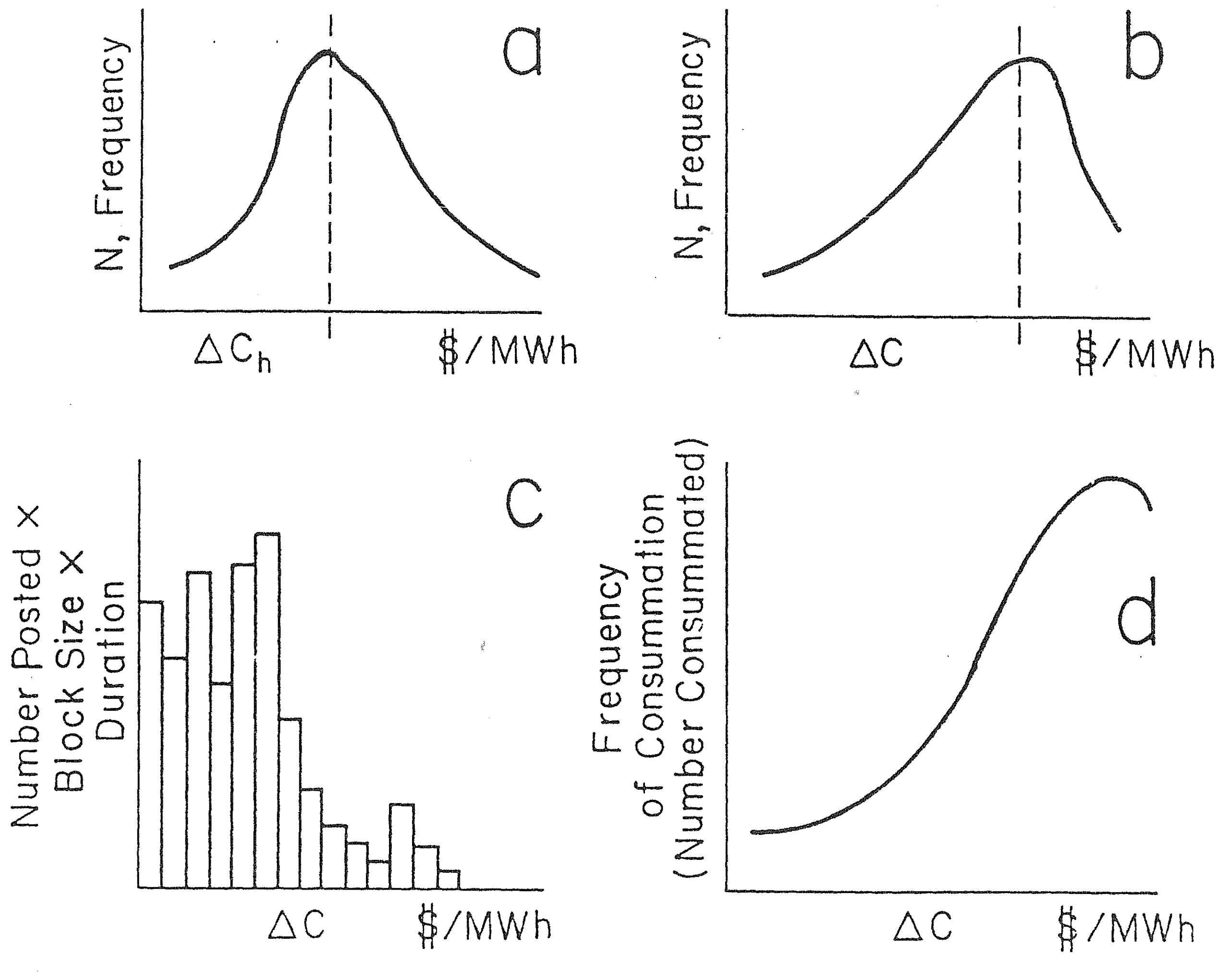


Fig. 3-2 Frequency of quotes

Test BP2: Gain in Production Efficiency

It is well known that when all the systems are jointly dispatched with no transmission constraints, one achieves maximum production efficiency by minimizing the hourly differences in incremental production cost in the systems (optimal solution). This is only possible in very tight pools spread over a smaller geographical area. The WSCC extends over a large area and the WSPP Experiment is intended to enhance economic and production efficiency. The brokerage system of posting buy and sell quotations is one step towards minimizing the incremental hourly cost of production in different systems and regions and is but a suboptimal solution. In a joint dispatch situation (optimal solution), all the systems will be operating either at a common λ, the incremental hourly cost of production or at a minimum difference between their λs.

During the WSPP Experiment, as in any interconnected power pool, all the systems will not be working at the same λ. However, it is logical to assume that the differences between the λs of the systems will be reduced due to enhanced trading. A measure of the differences between λs of systems, is, therefore, a proxy to the measure of the efficiency in trading. Figure 3-3 proposes a test, similar to the one shown in Figure 3-2c, to assess the gains in production efficiency due to interchanges.

Figure 3-3 is a plot of the difference between the λs (cost related data) of the deals consummated against the number of hours of such transactions multiplied by the block size (MW). It is evident that this statistical portrayal is useful in that the area under the curve represents the total increase in production efficiency. To separate the efficiency gains due to the experiment, one has to compare such plots before and during the experiment with proper corrections to hydro energy as in Test GT1.

Test BP3: Number of Transactions.

This test shown in Figure 3-4 indicates the percentage of quotations that are consummated for different values of ΔC_h, the difference in costs entered on a central computer (the hub in the WSPP). The motivation for the test arises from the search for a relation between the difference in the costs of quotes and the probability of their consummation.

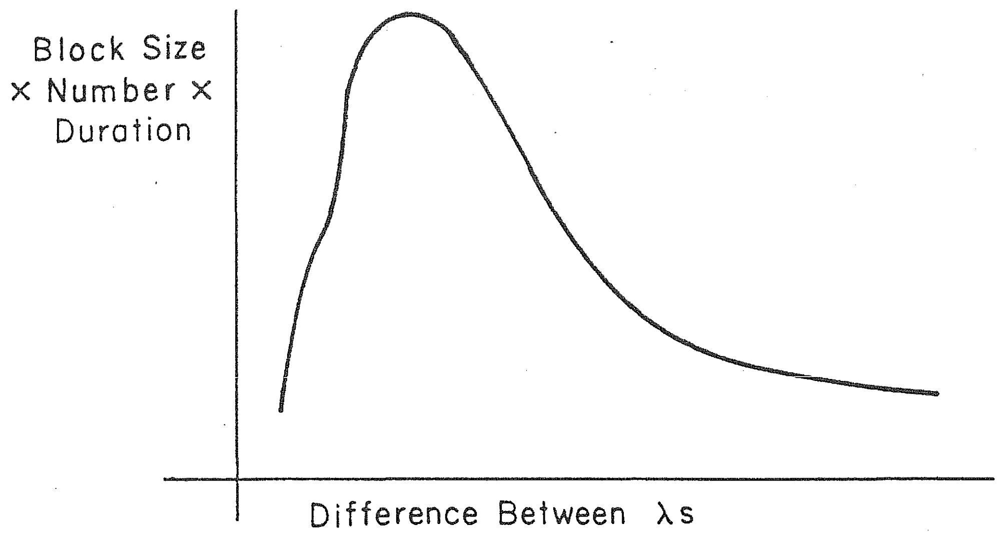


Fig. 3-3 Frequency of consummated deals

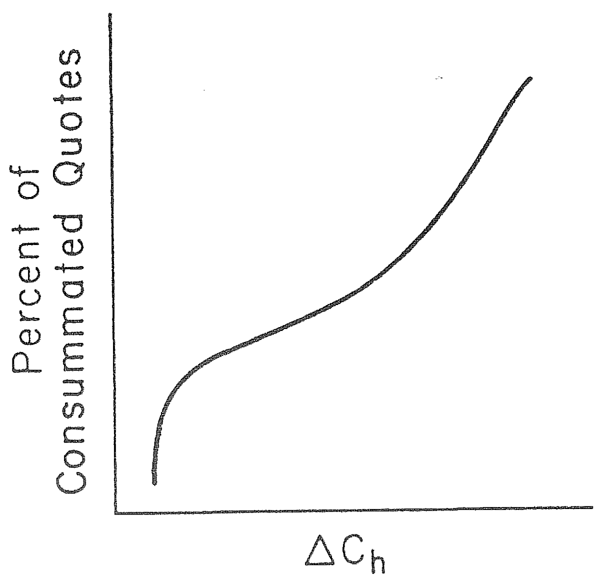


Fig. 3-4 Effect of differences between quotes on the probability of consummation

The details of obtaining this relationship are as follows. To calculate ΔC_h, all combinations of the sell quotes and buy bids are considered. For example, if there are three sell quotes at 20, 30, and 40$/MWh and two buy bids at 35 and 50$/MWh, there are six possible combinations of transactions. They are 20-35, 30-35, 40-35, 20-50, 30-50, and 40-50. Of these combinations the sell quote of 40$/MWh with the buy bid of 35$/MWh is inconceivable resulting in a net of five possible transactions. Some of the five transactions may be consummated. To obtain Figure 3-4, the computer would keep track of all the possible consummations and the difference between their buy and sell bids (ΔC_h). Then, from the number of consummated deals, the percent of deals consummated within a class interval of ΔC_h can be calculated.

Note that in the interest of maximizing production efficiency, the transactions with the greatest difference between the buy and sell bids should be consummated first. Therefore, one would expect to see a higher percentage of consummated deals for larger values of ΔC_h. If this test reveals the opposite to be true, loss of production efficiency would be noted. Such observed loss could be due to the absence of quotes to sell transmission service or, unlikely as it might be, due to improper participation and negotiations during the experiment.

Test BP4: Effect of the Cost of Lower Quotation.

This test attempts to evaluate the effect of the cost of the lower quotation. The assumption here is that the quotations are based on the actual incremental costs of production. For instance, a difference in buy and sell quotes, ΔC, of 2 $/MWh can be obtained either from quotations at 10$/MWh and 8$/MWh or from 4$/MWh and 2$/MWh. It is likely that the smaller the value of the lower of the two quotation, the greater are the chances of a deal. For example, surplus hydro energy (at a low cost, presumably) will always be absorbed. In general, smaller values of the lower quotation stem from renewable resources.

If the test indicates that more transaction with a smaller cost of lower quotes were resolved, apathy on the part of participants to exploit the differences in prices of higher priced generation would be noted. Such apathy may arise from "minimum buy" or "take or pay" clauses associated with the utilities' purchase of fuels.

In Figure 3-5a, the number of incidences of a transaction (consummated deals) are shown in the fashion of a scatter diagram. As an alternative, a three dimensional plot signifying a bivariate frequency can be made. In the bivariate case the two random variables would be ΔC and the cost of lower quotation as shown in Figure 3-5b. We have chosen ΔC, the cost entered in the central computers. However, it would be desirable to examine the plots using ΔC, the actual costs, as one of the variables.

This test and the previous one, therefore, permit the examination of restrictions imposed by transmission and the effectiveness of the participants in improving production efficiency.

Test BP5: Effect of hydro energy on the transaction price.

This test is designed to ascertain the effect of the availability of hydro energy on the relation between the quotes of production from non-hydro sources. Figure 3-6 indicates the portrayal of data for this test in a band of maximum to minimum and the average value of the ratio of quotations to cost.

The motivation is to test any correlation between surplus hydro energy and the price quoted for non-hydro energy. Is the price quoted for non-hydro energy dependent on its costs of production or is it based on the market value related to the supply of surplus hydro energy? This may be an important issue in some regions and can be addressed by this test.

In a region of interest, an increase in hydro generation would result in a reduction in non-hydro generation if the total demand for energy were to remain constant. The most expensive non-hydro generation would be displaced first, and hence the average cost of energy in the region would fall. Therefore, it stands to reason that the price of transactions should fall with increasing hydro generation.

However, since the quotations in some experiments may not reflect the cost of production, another aspect in regard to competition among intending sellers enters the picture. The intending sellers would post sell quotes closer to their costs of production when large quantities of surplus hydro energy are available in the market. If there is no competition from the

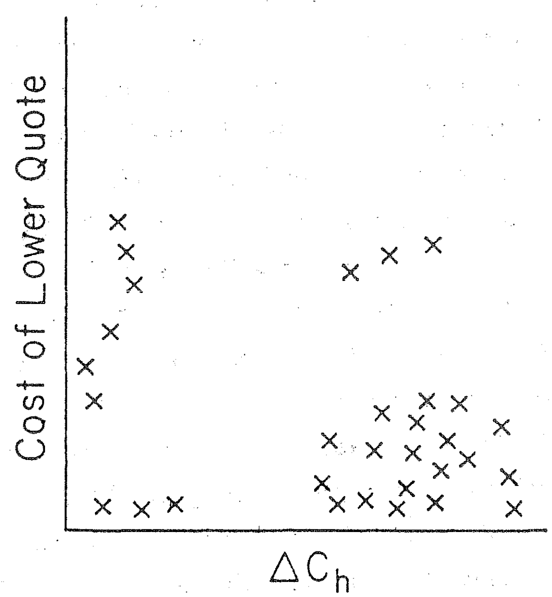


Fig. 3-5a Scatter diagram of consummated deals

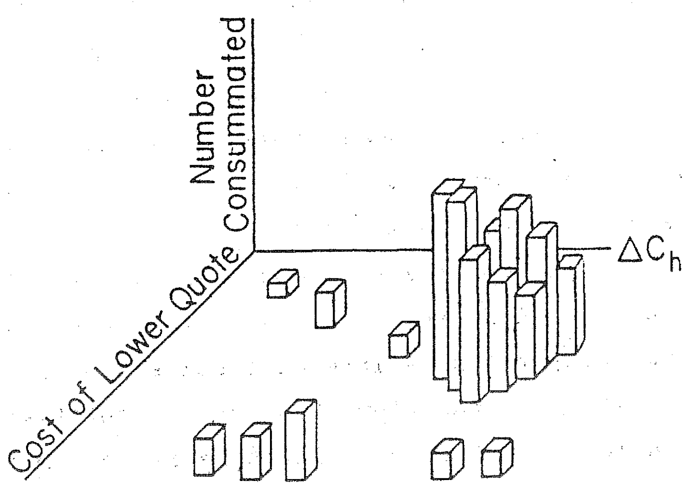


Fig. 3-5b Bivariate distribution of ΔC and the cost of lower quote

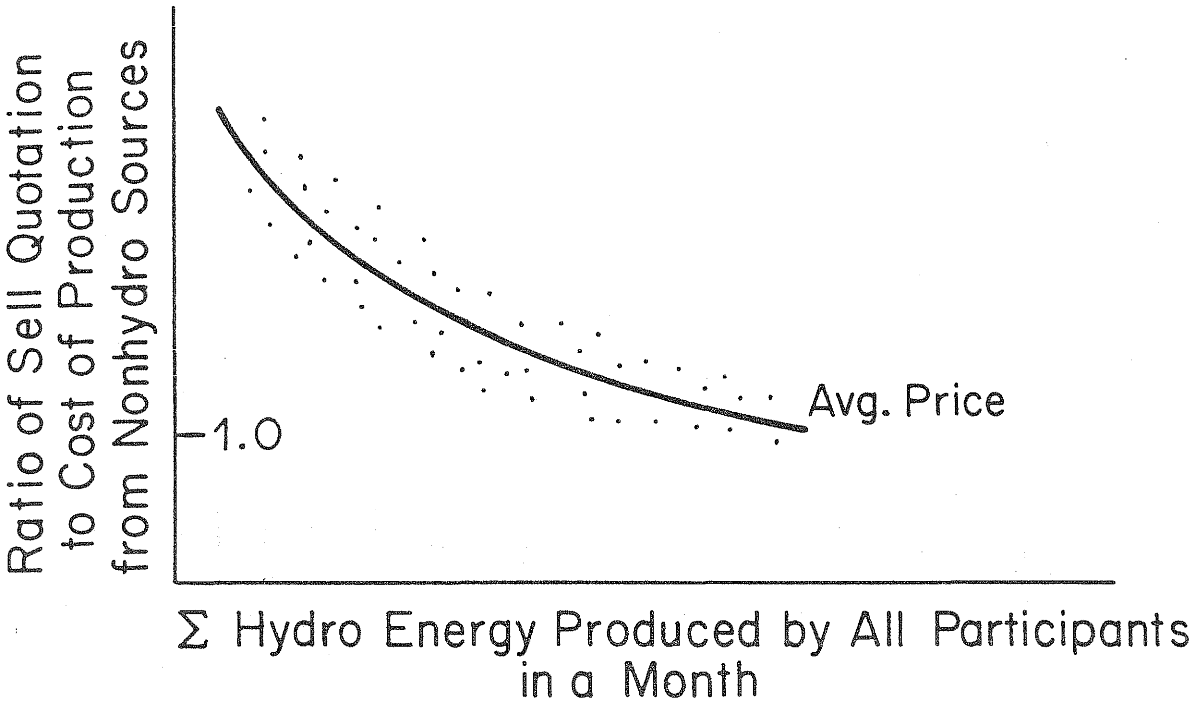


Fig. 3-6 Effect of hydro energy on the price of transactions

sellers of surplus hydro energy, the non-hydro sellers may post a price above their costs of production depending on the value of the energy to the prospective buyers.

Figure 3-6 depicts the ratio of the quoted sell price to the cost of production for non-hydro sell quotes. The figure reveals the effect of hydro energy production on the cost of sell quotes. If the sellers post prices well above their costs when smaller quantities of hydro energy are being generated, the pattern shown in Figure 3-6 would be obtained. A similar figure drawn for the ratio of posted buy quotes to the actual cost of energy to be displaced by such purchases will reveal the effect of hydro generation on the buyers.

If the demand for lower priced energy is large in relation to the quantity of hydro energy available, the market for hydro and non-hydro energy could function independently. That is, hydro energy would be sold at some fixed price, say, and the selling price of energy from non-hydro sources would depend on the demand for it and its value in the market place. In such a situation, a declining relationship between the variables shown in Figure 3-6 would not be observed.

Test BP6: Measure of the degree to which power and energy were offered for exchange.

Previously, the method of evaluating the maximum production efficiency achievable by joint dispatch has been alluded to. Further, it was pointed out that models exist for the calculation of these benefits, the simplest ones being those that do not consider any transmission constraints.

It is evident that vendors and purchasers do not necessarily post quotations when they believe that the quotations do not have a chance of consummation either due to transmission limitations or due to other aspects of the market.

The area under Figure 3-2c, it was pointed out earlier, signifies the production efficiency that could have been achieved if all the quotes were consummated. The maximum achievable in a trade with no transmission or other restrictions can be calculated from a joint dispatch simulation. The difference between these two values (i.e., area under Figure 3-2c and the maximum gain obtained from a simulation of joint dispatch) indicates the degree of participation by the participants. If the difference between the two is small (as a percent of total gains achievable), one can conclude that the participants are posting all possible transactions that may improve the production efficiency. If, on the other hand, the difference is rather large, one might suspect that offers that could result in an improvement in production efficiency were not being posted on the computer, perhaps because of real or imagined perceptions regarding transmission bottleneck or other reasons.

This test, therefore, involves a comparison of the area under Figure 3-2c with the joint dispatch simulation.

Category 3: Tests to Evaluate the Transmission Market

The following tests are intended to measure the functioning of the transmission market. The degree to which transmission was made available, the degree to which it was unavailable due to bottlenecks or due to monopoly, the price charged for transmission and its effect on production efficiency are our interests.

Presumably, any regulatory agency, federal or state, could ask the utilities to explain in detail when FA, SPS or EA would be adopted and what principles would be used in pricing the transmission. The answer to such an inquiry is likely to be a long one as the pricing principles would depend on the dynamic conditions of the market.

Our goal in this section is to use the data collected in an idealized experiment or during the operation of a Pool to assess the above aspects regarding transmission. It is assumed that the interconnected systems can be broken down into the idealized configuration of three connected systems of chapter 2. In a "real world" situation, it may not be possible to breakdown the system to such modules of configuration for several reasons. The applicability of these tests to the WSPP Experiment is the subject of a subsequent chapter. The following are the tests for the transmission market.

Test T1: Statistics of Transmission Service

This test, designed to ascertain the range of prices for transmission service, requires the portrayal of the data collected regarding transmission service as a frequency diagram. Figure 3-7 shows such a plot from which one can obtain the mean, standard deviation and other details regarding the price of transmission service offered during an experiment.

A question regarding the data to be collected for transmission service arises in obtaining such a plot. In practice, there will be many contracts and interconnection agreements between the interconnected companies with certain rules for pricing transmission. In addition, the interconnection between the illustrative B and C in Figure 2-1 may be jointly owned by all the parties and the connection between A & B may be jointly owned by A and B with certain agreements regarding the pricing of transmission service. The utilities, during the course of integrated operation, exchange many categories of service over the line in any given day or hour. Under these circumstances, it becomes almost impossible to define the actual number of transmission services made available. Therefore, we suggest that, in Figure 3-8, one plots only the number of services (and their prices) which are above and beyond any entitlements or rights to transmission capacity granted to the owners and nonowners through contracts and agreements.

The motivation for this may be obvious. The existing contracts between the entities will have been approved by the federal and state regulatory agencies. Interchanges according to the contracts is commonplace and are not due to any experiment per se. Therefore, any additional service granted can be attributed to a better knowledge of the market and the flexibility in pricing precipitated during an experiment. It is possible that such services are granted to nonowners even in the absence of an experiment. In such instances, it would be desirable to compare the frequencies obtained by this figure before and during the experiment to isolate the additional service provided during the experiment.

Test T2, Adequacy of Transmission

The intent of this test is to ascertain if adequate transmission exists in a particular region and/or if any monopoly power in the provision of transmission was exercised.

Figure 3-8 shows the number of transactions that were not possible due to the absence of transmission service as a ratio of the incremental costs of the parties intending to transact. Our assumption here is that parties

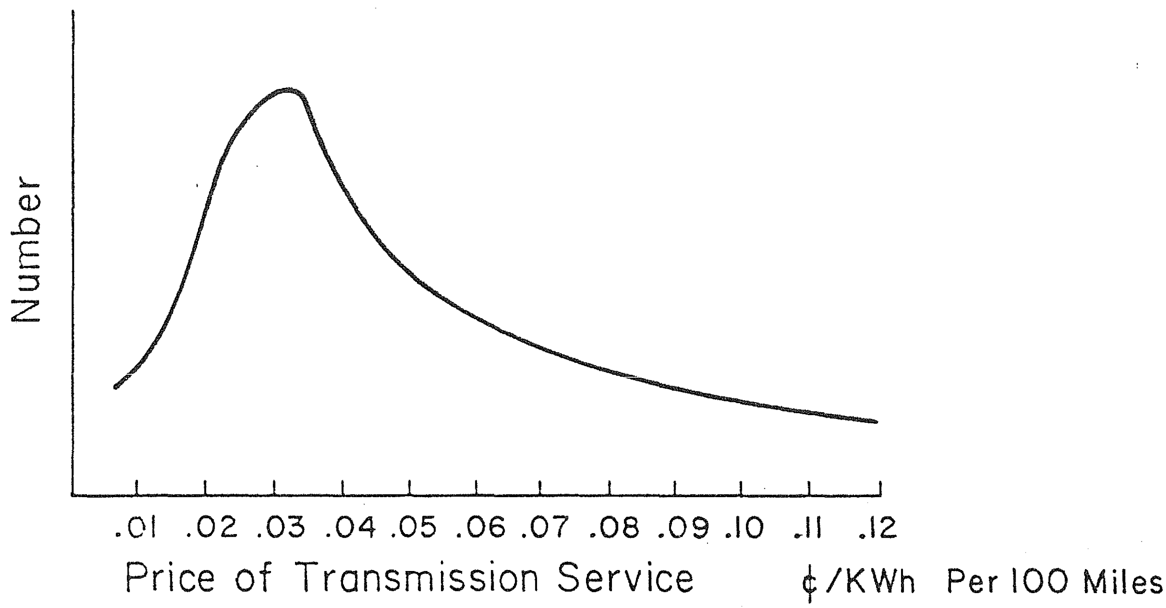


Fig. 3-7 Frequency of transmission service prices

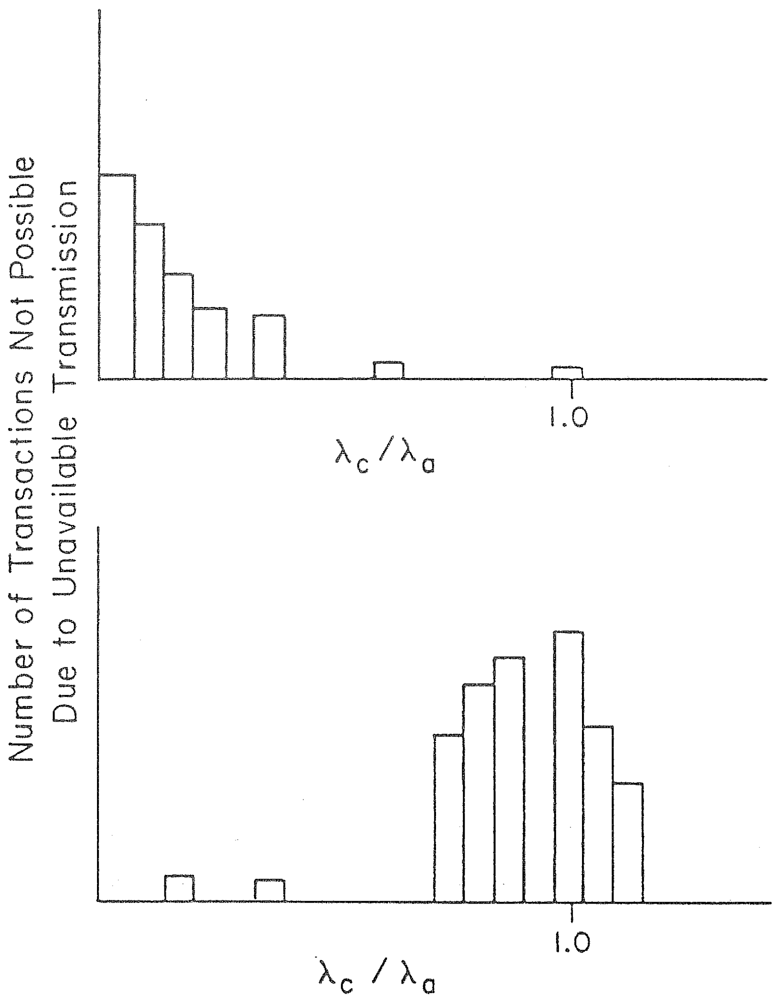


Fig. 3-8 Two illustrative frequencies of curtailed transactions

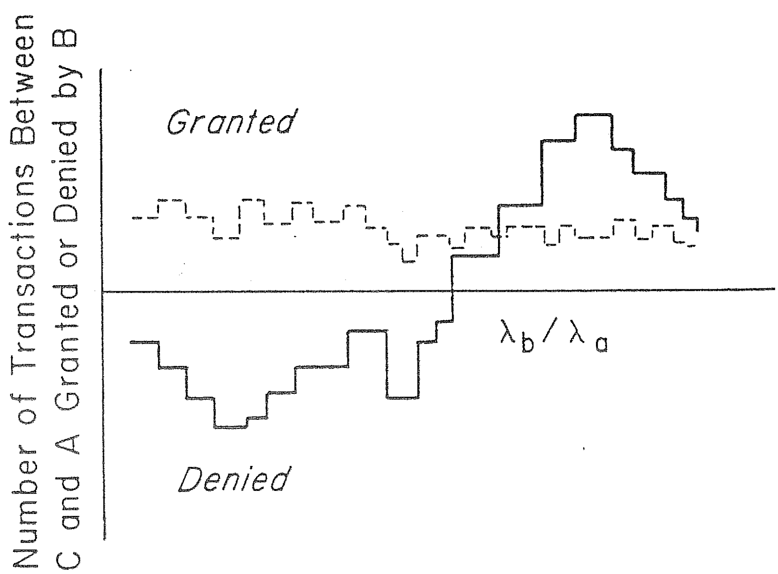


Fig. 3-9 Frequency of granting or denial of transmission access

do post quotes to buy or sell without any preconceived ideas about transmission availability, at least in the interest of gathering data and evaluating an experiment. (This aspect of participation or awareness can be measured under test BP1 discussed earlier). In the WSPP context, the number of quotes on the "hub" computer that were not consummated due to the absence of a transmission service quote between any two parties can be computed.

If most of the occurrences were at values of λ_c/λ_a much less than one, as in the top illustration, one would note a serious loss of production efficiency and would conclude that there was either a serious inadequacy in the transmission or that transmission access had been denied due to monopolistic behavior or other reasons.

If most of the occurrences were at or near the ratio of λ_c/λ_a equal to unity, one would neither note a serious loss of production efficiency nor an undue denial of transmission or congestion.

Test T3, Additional Test on Transmission Adequacy

This test is an extension of test T2 and would be warranted if serious loss of production efficiency under Test T2 were to be revealed.

The test illustrated in Figure 3-9 shows the granting as well as denial of access (as measured by the presence or absence of quotes for such service in the WSPP context) plotted against the ratio of lambda of the intermediary and the intending purchaser. Again, as under Test T1, we suggest counting only those services offered or denied outside of contractual agreements, rights and entitlements.

If one obtains a pattern illustrated by the solid line, it would appear that either (1) B had inadequate transmission to make a sale from his system to A and accommodate a sale from C to A or, (2) B did not grant access to its transmission either due to monopolistic reasons or due to inadequate capacity.

In actual practice, one may not obtain simple and explainable patterns. Other variants of the pattern, for instance the dotted line pattern shown in the figure, are possible. The dotted line pattern would indicate that B granted some form of access all the time. One would obtain a pattern entirely below the horizontal axis if no transmission service was made available.

Test T4 Sharing of Benefits

This test could be applied to some major participants individually and collectively. As in the previous cases, this test can be applied to the average energy price of firm transactions as well as the economy energy transactions.

If λ_c is the incremental cost of production of the seller and λ_a is the decremental cost of production of the buyer, for equal sharing of benefits, it is known that the per unit price of the transaction would be $(\lambda_c + \lambda_a)/2.0$ plus transmission charges, if any. Note, again, that the λs are costs and are not necessarily the posted prices in the bulletin board of the WSPP Experiment. In the WSPP Experiment, the BPA quotes are likely to be at a fixed price per KWh during the surplus season and would not necessarily be BPA's incremental cost of production. BPA's fixed price offerings of dump energy should therefore be excluded from this test.

Let the posted bids on the bulletin be represented by C_c (cost for for seller) and V_a (value for the buyer). In addition to the transaction price negotiated from the posted prices there would be a transmission charge, if an intermediate Utility would be involved in wheeling. Let this charge, paid either by the seller or buyer, be T_{ca}.

Figure 3-10 shows a plot of the number of deviation of the transaction price from $(\lambda_c + \lambda_a)/2$ in percent of $(\lambda_c + \lambda_a)/2$. From an application of this one can ascertain the pricing of transactions in relation to the costs of the buyer and the seller. If one obtains a plot as indicated in the figure, it would appear that most transactions are on a more or less equal sharing (split savings) basis. However, large numbers of positive deviation indicate that more benefits occur to the sellers than buyers. The opposite is true for large excursions in the negative direction.

In Figure 3-10, the effect of transmission charge has also been shown. The motivation for this is to examine the approximate cost of the transmission as a percent of the transaction price and if the transmission price was borne by the seller, the buyer, or by both equally. In this figure, the transmission cost would be added to the transaction price if paid by the purchaser of energy and would be subtracted from the price if paid by the seller. If large deviations of transaction price from $(\lambda_c + \lambda_a)/2$ are observed, subsequently, one may compare such deviations with

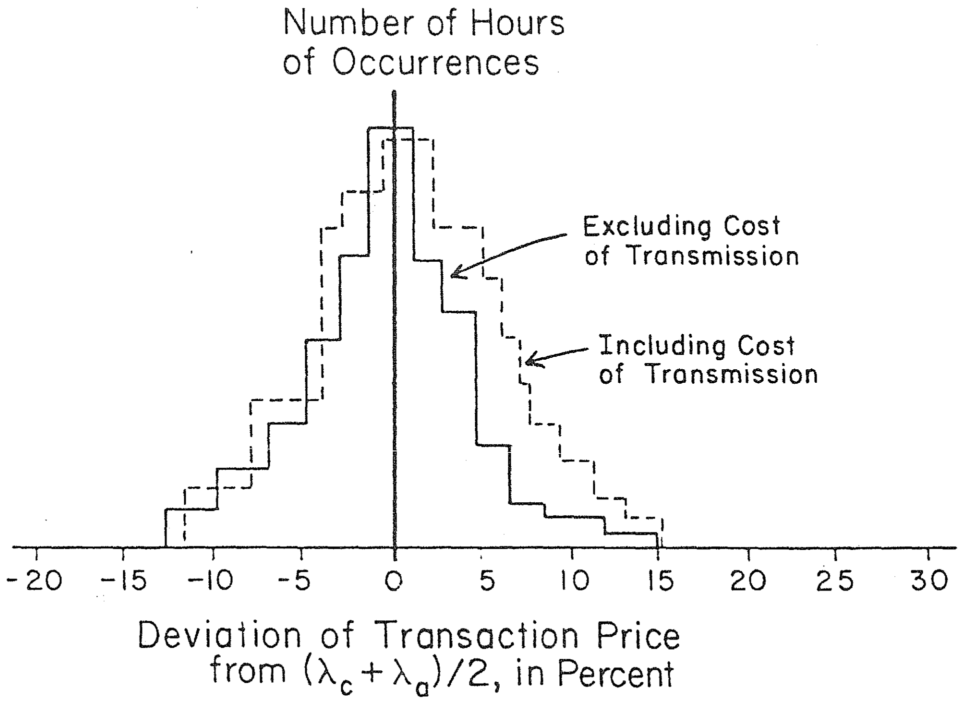


Fig. 3-10 Deviation in transaction price from mean cost

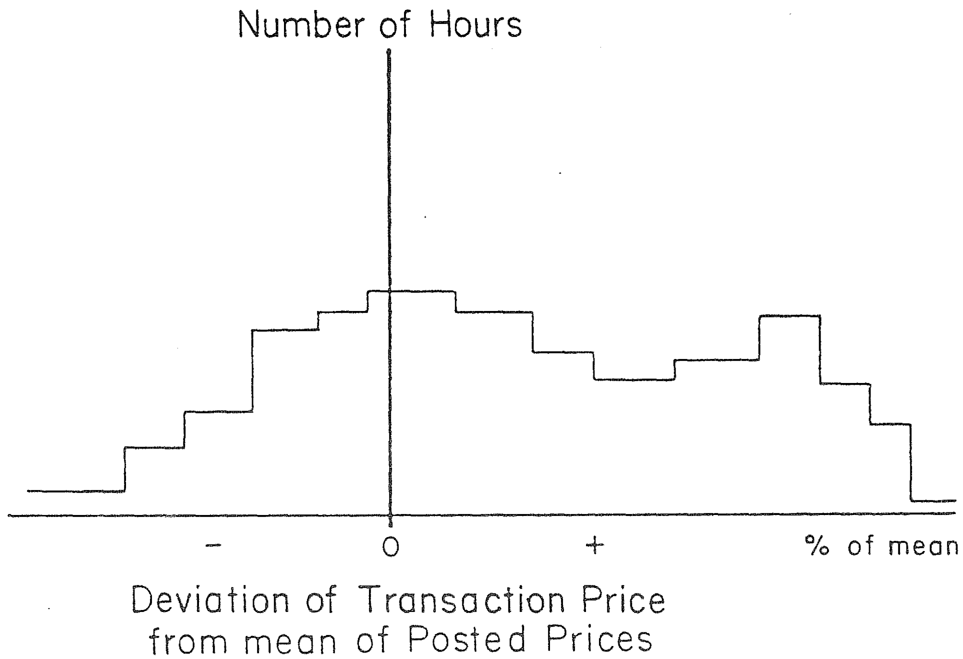


Fig. 3-11 Deviation in transaction price from mean of posted prices

the difference between λ_c and λ_a to examine if any particular pricing practice can be identified.

Figure 3-11 shows a plot identical to 3-10 but the deviations are from $(C_c + V_a)/2$, the posted prices on the bulletin board. Observe, however, that Figure 3-11 could be identical to Figure 3-10 if the percent inflation of sellers' quotation from their cost is the same as the deflation of value in buyers' bid. Also, if the posted prices are true to the actual costs, the two Figures 3-11 and 3-10 would be identical.

We understand that the deals during the WSPP Experiment will be negotiated from the posted prices. Therefore, large positive deviations mean either one or more of the following: 1. That it is a sellers' market, not too may sellers, 2. That buyer underposted the worth of purchase, 3. That sellers' posting of costs were lower than their actual costs (unlikely to happen).

Similarly, large deviations in the negative direction in Figure 3-12 would indicate one or more of the following: (1) That it is a buyers' market. There is a surplus of cheaper energy with not so many buyers, or (2) That producers overstate their costs in their bids.

Test T5, Effect of EA on Production Efficiency

This test is intended to measure the degree of loss of production efficiency due to the Entitlement Attitude.

The Entitlement Attitude was discussed in chapter 2. In it, it was pointed out that the EA could, at times, hinder production efficiency, by not allowing the energy with the lowest incremental cost of production to displace the energy with the highest incremental cost. Figure 2.6 discussed this aspect and the definition and interpretation of "incremental cost" by an intervening utility for subsequent sales. As an example, in the WSCC, PG&E could be considered an intervening utility (B in the simplified illustration) using its entitlements in the NW-SW interties. PG&E is also a member of the California Power Pool, a pool formed by the three California power companies to minimize production cost and to obtain other benefits due to pooled operation. PG&E makes subsequent sales of energy obtained from the NW to the other two companies in the California Power Pool. These aspects are discussed in detail in the next chapter.

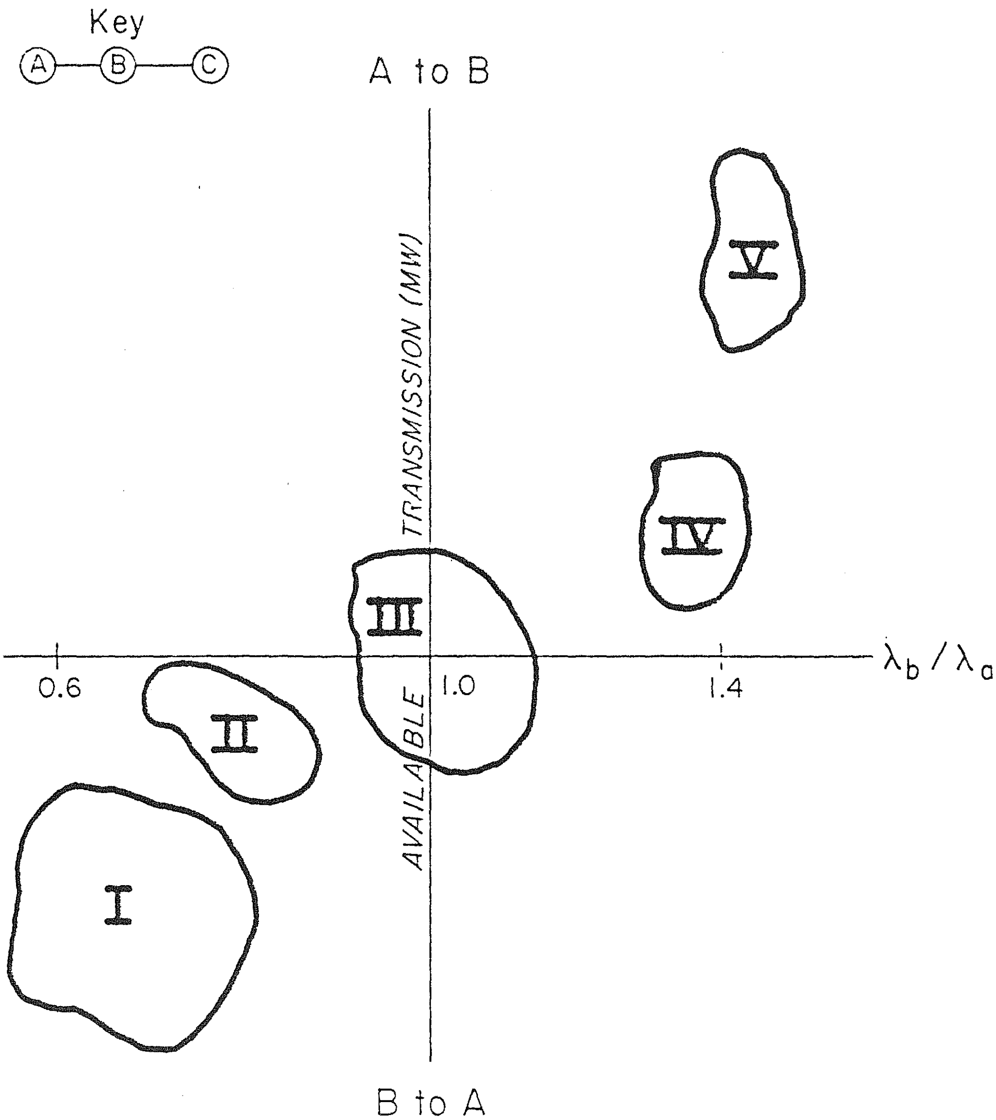


Fig. 3-12 Ratio of lambdas and available transmission to A

The concern about production efficiency may not be a serious one if the intending purchaser's incremental cost is almost the same as that of the intermediate utility. In the California Power Pool, this appears to be the case (hourly incremental costs are of utilities being similar) except when PG&E with substantial hydro resources would be experiencing a wet period.

This test is motivated by the above factors and is intended to assess, qualitatively, the loss in production efficiency, if any, due to the EA.

As is implied by the EA, we have assumed that both B and A (see Figure 2.1) and perhaps other utilities, have certain rights for transmission capacity between C and B. We have assumed C in our illustrations to be the cheapest producer. In the WSPP example, PG&E (B) and SCE and SDGE (A) own rights in the interties from the Pacific NW. The details of such entitlements to transmission capacity are discussed in the next chapter.

Figure 3-12 shows the test, a scatter diagram obtained by plotting the transfer capacity in the transmission between A and B against the ratio of lambdas of B and A. The figure has been plotted for hourly data involving one point in the scatter for each hour. Only the hours when the flow of energy is from C to B are taken into account. Note that for ratios of $\lambda_b/\lambda_a>1$, the plot is in the first quadrant and for $\lambda_b/\lambda_a<1$, the plot is in the third quadrant.

In terms of ratios of lambdas, it is important to recognize that lambda is the incremental cost of the most expensive machine operating in a system after the purchase or the sale. <u>It is not</u> the cost of the machine that would have operated before the purchase of energy by B.

Zone I implies that $\lambda_a > \lambda_b$ and that there existed additional transfer capacity between B and A. B could have given up some of its entitlement in the line from C to B to allow the displacement of higher priced generation in A by the generation of C.

Points incident in Zone II indicate insufficient capacity between B and A and, therefore, the systems could not be operated in a more economical manner. Of course, there is a zone of uncertainty between zones I and II.

Points in Zone III indicate no serious concern as the lambdas of A and B do not differ widely.

Zone IV indicates that generation from utility A should have displaced that of Utility B but the lack of transmission between them was the constraining factor.

Zone V indicates no transmission constraints and that the generation in A should have replaced that in Utility B.

One has to temper these conclusions by the fact that there might have been engineering constraints such as minimum loading of machines or reliability and stability considerations.

This test is also applicable to other entities in a region that have generation capabilities, but do not have an entitlement to the transfer capacities of interties. However, certain modifications to the test would be required. Such modifications are site dependent and, therefore, cannot be generalized. For instance, consider the circumstance when an entity is located in the territory of B. The use of the tie-lines between B and A would not be required to serve the entity. Also, Utility B, under those circumstances, cannot compare the entity's cost just with its own in reaching decisions regarding exchanges to maximize production efficiency. Utility B has to compare its cost with A and other companies, possibly, with whom it has contractual, pool or other partnership agreements.

Under those circumstances, instead of using λ_b/λ_a for the abssisa of Figure 3-12, one could use the minimum value of the ratio between the lambdas of B, A and other companies in the pool to the λ of the entity. In our example, one would use the minimum of λ_b/λ_e and λ_a/λ_e (where λ_e is the incremental cost of the entity) as the abssisa in Figure 3-13. Then, conclusions regarding the production efficiency drawn earlier will be equally applicable to such a case.

It must be noted that B may charge an additional transmission related fee to make this service available to the entity.

Modifications to the test if the entity were to be in the territory of A are left to the reader, in the interest of brevity.

Test T6, Consistency in Pricing Transmission

In chapter 3, the dynamic nature of the market resulting from changing incremental costs was discussed. Also shown was that the intermediate party may like to implicitly price transmission service according to any of the three attitudes or at the incremental cost of providing the service to maximize its gains. Furthermore, discussions relating to Figure 2-4 stressed the importance of correctly determining T_{min}, the incremental cost of providing transmission service, and the ensuing loss of production efficiency from a failure to do so.

This test is intended to check the consistency in pricing transmission in the dynamic market. Assuming first that the ratios of incremental costs of three adjoining parties are at some value in a particular hour, B, the intermediate utility, may adopt SPS. The use of SPS as the pricing principle for the ratios of λ at that hour would produce more benefits to B than pricing transmission at T_{min}. Yet in some other hour, for the same ratios of λ among the three parties, B may price transmission service at T_{min} or, for that matter, at any other arbitrary value.

Such inconsistencies in pricing transmission may arise from several considerations. It may be that the network flow patterns are different in the two instances under comparison. Therefore, the preponderance of losses for a particular flow pattern might motivate B to price transmission at T_{min}, the incremental cost of providing transmission.

Or, the inconsistency may be motivated by B's preference to the consummation of certain transactions. Such a preference could result from a joint ownership of units with the transacting parties or because B may be partial owner of one or more of the companies intending to transact.

Other reasons for the inconsistency in pricing may be due to (1) contractual obligations of B with some entities to provide the service at a certain price while it may not be willing to offer the same price to others, (2) incorrect determination or inflated declaration of T_{min}.

The goal of this test is to determine if inconsistencies exist and if it led to loss of production efficiency. The inconsistencies might be justifiable due to conditions existing in a region. Their examination will lead to further inquiry and analysis.

The test is that of tracking the ratios of λs of selected three adjoining parties and the price for transmission service. The benefits accruing to B from the three attitudes can be calculated for the particular ratios of incremental costs. The price of transmission in relation to the benefits obtainable from the three attitudes can be found and stored in the computer. For example, "transmission price was 90% of SPS, 120% of EA," at a particular hour. At the end of a period, (a month, say) a sorting of the stored data would permit the tabulation of transmission price for the same ratios of incremental costs (within a small band or class interval). Any apparent inconsistencies would be probed further to examine if they resulted in loss of production efficiency.

The above are the tests applicable to the idealized three interconnected systems. We have frequently drawn parallels between the WSPP and the idealized three interconnected systems. It is conceivable that one could devise more tests, perhaps site specific ones, to evaluate electricity exchanges. As mentioned earlier, the tests proposed here are conceptual in nature and are neither exhaustive nor conclusive. They are intended to point directions for further inquiry and to indicate if there is a loss of production efficiency.

Our interest in the subsequent chapters is to study the WSCC system and to examine the applicability of these tests to the WSPP Experiment.

CHAPTER 4

THE TRANSMISSION AND OPERATION OF SYSTEMS IN THE WSCC AREA

The purpose of the following sections is to obtain an understanding of the major transmission paths and their ownerships. First, the historical development of resources in the regions will be traced. The development of the resources has impinged on the main paths of transmission. Next, the existing major transmission in the Western Systems Coordinating Council area, as it pertains to the WSPP experiment, are detailed. In subsequent sections, our task is to examine the contractual obligations among the utilities that own the transmission facilities and the effect of such obligations on the operation of the utilities in the region. In the last two sections, the effect of the contractual obligations on the WSPP Experiment is discussed. Readers familiar with the WSCC system and its contractual obligations may skip the initial sections of this chapter and proceed to the section where the applicability of tests is discussed.

Generation in the WSCC Area

Background

The evolution of the transmission paths has been influenced by historical and geographical reasons and by the generation mixes in the various regions of the west.

The generation mix of some selected utilities in the PNW region (and other regions) can be found in Table 4-1. The states of Washington, Oregon and northwestern Montana in the PNW region have predominantly hydroelectric resources. The Federal Government through its agencies plays a major role in the generation of electricity in this region. In addition to BPA, there are several IOUs in PNW who jointly with BPA serve the needs of municipal and industrial customers. The amount of energy generated from federal hydro plants has a high degree of seasonal variability as it depends on the flow conditions and reservoir elevations. This is true of non federal hydro

Table 4-1

CAPACITY AND ENERGY GENERATION BY MAJOR PARTICIPANTS IN THE WSPP EXPERIMENT, 1986*

UTILITY NAME	CAPACITY				ENERGY GENERATION			
	Nuclear	Hydro	Fossil	Total	Nuclear	Hydro	Fossil	Total
Pacific Power and Light Co.	0.36%	11.4%	88.2%	7591 MW	0.9%	19.6%	79.5%	19888252 MWh
Portland General Electric Co.	46.2%	14.1%	39.7%	4115 MW	54.9%	28.3%	16.8%	8846184 MWh
Bonneville Power Administration	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Pacific Gas and Electric Co.**	13.1%	28.6%	58.2%	16865 MW	24.4%	27.2%	29.6%	50251593 MWh
Southern California Edison Co.	16.0%	19.8%	64.2%	14350 MW	25.6%	12.5%	61.9%	46497886 MWh
Salt River Project	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Sierra Pacific Power Co.	0%	1.1%	98.9%	1072 MW	0%	1.5%	98.5%	2089238 MWh
Nevada Power Co.	0%	0%	100%	1744 MW	0%	0%	100%	5370756 MWh
L.A. Department of Water and Power	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
San Diego Gas and Electric Co.	20.6%	0%	79.4%	2511 MW	39.1%	0%	60.9%	7155446 MWh
Arizona Public Service Co.	16.9%	0.15%	82.9%	4673 MW	19.5%	0.3%	80.2%	13113740 MWh
Arizona Electric Power Cooperative Inc.	0%	0%	100%	566 MW	0%	0%	100%	1156227 MWh
Public Service Company of New Mexico	16.5%	0%	64.5%	1571 MW	13.2%	0%	86.8%	6874067 MWh

*Data reported by Arizona Electric Power Cooperative is for the year 1987.
**About 8.1% of capacity and 18.8% of energy generation of Pacific Gas and Electric Co. comes from geothermal and solar plants.

plants in the region as well. Outside the PNW region, PG&E has a hydro energy generation of some 28% of its demand with a corresponding 12.5% by SCE.

The generation of power by BPA is governed by several acts of Congress which take into account flood control, fish migration, environmental concerns, etc. The "Preference Act" enacted by the Congress in 1964 and the other obligations of BPA to the federal government will be discussed later when contractual obligations will be examined.

The Pacific Southwest region, comprising the California and Las Vegas area, represent large load centers. The generation in these areas has a substantial component of more expensive oil based generation. Recognizing the advantages of serving the large load centers of PSW with surplus PNW energy, particularly during high run-off periods, AC and HVDC transmission interties connecting these areas were built in the mid and late sixties. In addition, lines to transmit cheaper power from dedicated plants in the Desert Southwest and the Rocky Mountain areas to the PSW region were built.

The overall share of resources and demand in the region can be seen from a comparison of the demand and resource (Figure 4-1) as well as in Table 4-1.

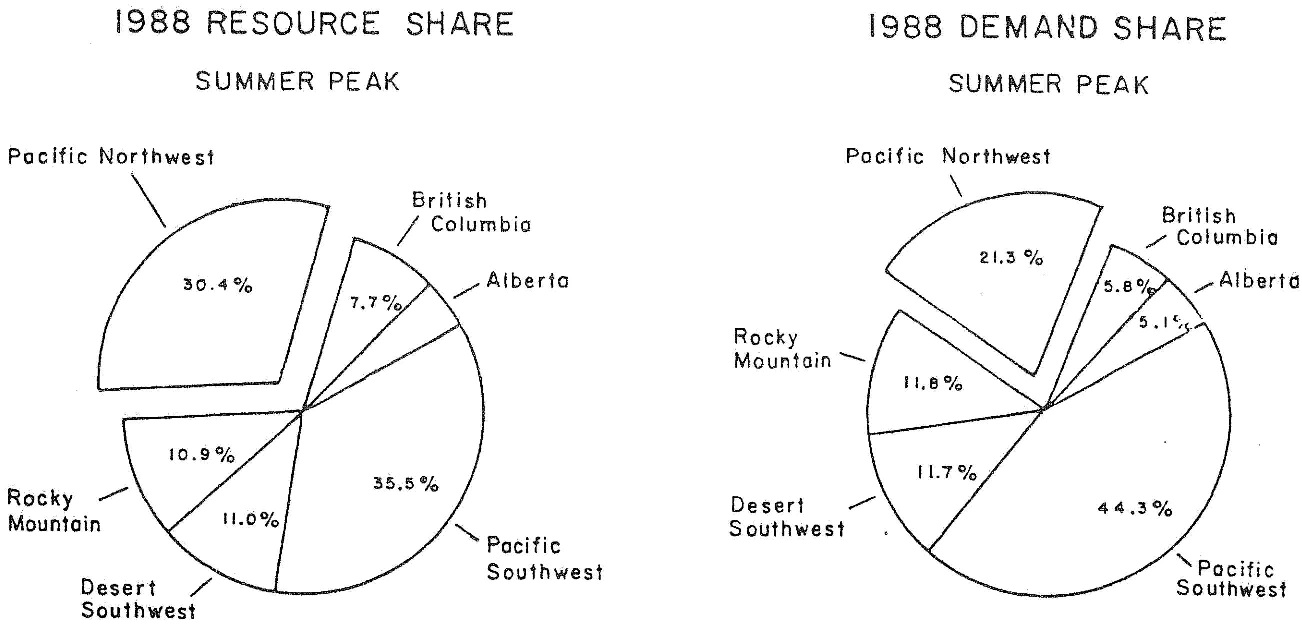
The following is a brief historical sketch tracing the development of the major resources in the WSCC regions.

The Role of BPA and Other Utilities in PNW

Historical

The Bonneville Project Act (Project Act) of 1937 established BPA as the marketing agent for power produced by the Bonneville Dam. BPA has been given additional responsibility to market power from 31 federal dams in the Columbia River Basin and some thermal resources through subsequent statutes. Congress has defined BPA's primary marketing area to be the PNW region, encompassing the states of Washington, Oregon, Idaho, and the state of Montana west of the Continental Divide.

BPA markets bulk wholesale power to four groups of customers: Preference Customers, Direct Service Industries (DSIs), Investor Owned Utilities (IOUs), and Federal agencies. Under the Project Act and the



Source: Draft Western Electric Briefing Paper, Northwest Power Planning Council, December 28, 1987

Fig. 4-1 Demand and resource shares

Pacific Northwest Electric Power Planning and Conservation Act (PNW Power Act), BPA must give priority to preference customer applications when competing applications from nonpreference customers are received and when there is surplus power available after BPA has met other power contract obligations established by law. Under the PNW Power Act, DSIs (industrial end users that purchase directly from BPA instead of through a utility) have an initial 20 year's right to power contracts and additional follow-on contracts as prescribed by law. BPA is authorized but not required to serve federal agency power needs.

BPA also sells power outside the PNW region to public agencies and IOUs, primarily in the state of California. Extra regional sales are made subject to certain restrictions which provide the PNW customers a preferential access to BPA power. The restrictions for extra regional sales are addressed in the Northwest Regional Preference Act of 1964 (16 U.S.C. 837) and the Pacific Northwest Power Act (16 U.S.C. 839). According to these acts, only that amount of power and energy which is surplus to PNW needs can be sold outside the region. Surplus energy is defined in the Preference Act to be

> "...electric energy for which there is no market in the Pacific Northwest at any rate established for the disposition of such energy, and 'surplus peaking capacity' shall mean electric peaking capacity for which there is no demand in the Pacific Northwest at the rate established for the disposition of such capacity."

<u>Generation Pattern</u>

The energy generated by BPA and other PNW utilities depends on river flows. Therefore, there has been a large seasonal and annual variation in the amount of energy produced. Other utilities in the PNW region have river basins similar to that of BPA and, therefore, the hydro generation from other utilities has a high degree of correlation with that of BPA. Therefore, during the spring freshet (usually during April and May), BPA and the PNW utilities are generally in a surplus situation. Bonneville declares a spill or a dump rate during this surplus season to avoid spilling of the water in its reservoirs. The rates now vary from 20 to 25 mills/kWh during the "spill" season. Depending on the reservoir conditions, BPA puts into effect other rates to get rid of its surpluses, or near surpluses, during the other months of the year. Generally, the market for this surplus hydroelectric energy, after meeting the needs of PNW, is in California.

The generation in Northern California (PG&E's territory) consists of a considerable number of hydroelectric resources. Very often, when the PNW is experiencing a wet season, PG&E will also be experiencing a wet season and, therefore, cannot absorb the surplus of the North. In Southern California, until recently, the generation was predominantly oil based and could absorb the surplus of PNW. However, due to the recent commissioning of nuclear plants in the southwest and the desert southwest and because of the building of other dedicated plants, the ability to absorb the PNW surplus would be somewhat lessened.

In general, however, it is clear that all the utilities in PNW would want to export to the PSW at the time of surplus production. Because of this and a somewhat limited transfer capability of the interties in relation to the surpluses, BPA proposed a near term intertie access policy[1] in February 1985. This policy is not without its critics. Our purpose here is limited to describing the policy and to the examination of the effects of the policy on energy interchanges in the region.

Generating Plants in Desert Southwest and Rocky Mountains

Plants dedicated to the needs of California have been built in the desert southwest. Because of the ownership of lines from these plants by California Companies (and in some cases the generation from these plants as well), there are no wheeling or other concerns associated with transmission in moving energy from these plants to the California market. The following is a brief description of the dedicated plants.

Four Corners Power Plant

This power plant is fueled by coal/gas. Unit 1, 2 and 3 of 634 MW each one 100% owned by APS. Units 4 and 5 of 818 MW each one owned 15% by APS,

---

[1] BPA has adopted a long-term intertie access policy since the writing of this report.

7% by El Paso, 13% by Public Service of NM, 10% by Salt River Project, 48% by SCE, 7% by Tucson Electric and 15% by APS.

Navajo Plant

The plant is fueled by coal/oil. The three units of 337 MW each are owned 100% by APS.

Palo Verde Nuclear Plant

Units 1 and 2 have a total generation capability of 2719 MW. 15.8% of the total generation is owned by SCE and 29% by APS. The balance is owned by other entities.

Inter-Mountain Project

This project is owned by LADWP.

There are other large generating plants in the desert southwest region. Since they do not affect the California market in a big way, a listing of such plants has been omitted.

The Transmission System in the WSCC Area

Figure 4-2 shows the major transmission lines that impact the interregional transfers. There are major transmission lines extending to Canada from PNW. (A discussion of these has been omitted as it does not pertain to the concerns of this report.) There are scores of other high and medium voltage lines omitted in this portrayal since they do not impinge on the transfers in a major way. It is important to recognize that the figure portrays the paths of power flow and not necessarily the geographical routes traversed by the lines. The ownership of the lines has also been shown in the figure and are taken from references [7] and [8].

The following is a description of the major transmission lines.

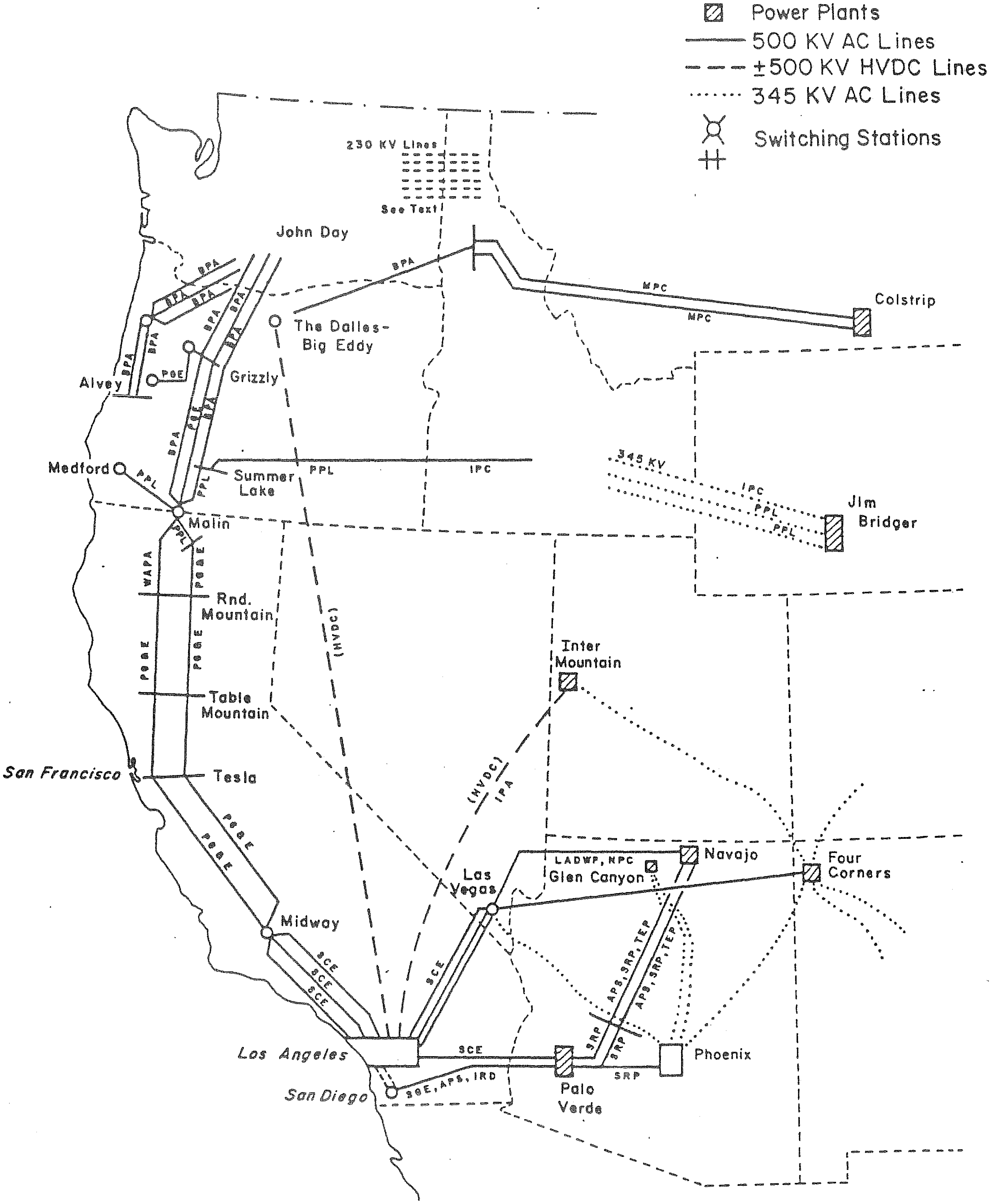


Fig. 4-2 Major transmission in the WSCC region

Pacific Northwest - Pacific Southwest

The interconnection consists of a ± 500 KV DC intertie, three 500 KV AC line to California/Oregon border (COB) and two lines thereafter to Midway, a substation midway between San Francisco and Los Angeles.

Within the Pacific Northwest where BPA's generation is located there are many 230 KV lines connecting load and generation points. Of particular significance are the two 500 KV lines, generally east west traversing, and five 230 KV lines connecting Idaho with Washington and Oregon. Three of these 230 KV lines are owned by Washington Power and Light Co., two by Idaho Power Co., and one by BPA.

Pacific Southwest - Desert Southwest

Interconnections between these two regions were built to transfer electricity from remote power plants (some dedicated plants) to Southern California and Las Vegas. Two 500 KV lines, one from SCE and the other from SDGE, connect Southern California with the Palo Verde Nuclear Plant in Arizona. The coal plant at Navajo and at Four Corners (NM) is connected to Las Vegas by a 500 KV line from each plant. Other major connections include the 345 KV line from Hoover Dam area near Las Vegas to Phoenix and two 345 lines from Glen Canyon to Phoenix.

Pacific Southwest - Rocky Mountain Region

The generation from the Intermountain Station is transmitted to the Southwest by a ± 500 KV HVDC line. Two 345 KV lines connect the Intermountain Generation Station to the Utah System.

Pacific Northwest - Rocky Mountain Region

There are two major interconnections: two 500 KV lines from Colstrip in Eastern Montana and three 345 KV lines from Jim Bridger Coal Plant in Wyoming. The five 230 KV lines from Idaho to Washington and Oregon have been discussed earlier.

Desert Southwest - Rocky Mountain Region

The interconnections include two 345 KV lines from Four Corners to the New Mexico System, one 345 KV line from Four Corners to Colorado and some lower voltage lines.

Ownerships and Entitlements

Motivation

In the previous section, the major lines and their ownerships have been described. For instance, the lines from Intermountain to Los Angeles or Palo Verde to Los Angeles are owned by IPC or SCE. The owners of the line would be one of the parties involved in any energy interchanges between these areas. Therefore, certain problems and pricing choices associated with providing transmission by a third party owner of the transmission line would not arise.

In regard to third party owners, the AC and DC interties between the PNW and PSW regions is the case in point. These interties traverse more than one state. Different sections of the line are owned and maintained by different entities. Furthermore, due to the fact that these lines have been financed by several investor-owned, federal and state agencies and due to certain federal laws, many parties have access to the transfer capacities in these interties. The contractual obligations concerning the entitlements of different parties have to be honored in the day-to-day operation of the systems.

Our purpose in this section is to understand the entitlements and other contractual obligations. In a subsequent section, we shall examine the effect of these entitlements and obligation on the operation of the systems and energy transfers. The effects of such obligations on the applicability or otherwise of the tests for idealized systems (developed in chapter 2) will also be examined.

Entitlements in PNW-PSW Interties

The AC and DC Northwest-South interties transmit large quantities of surplus hydro energy from NW to SW. Before a discussion of the contracts that exist between various entities in the WSCC area, the capacity entitlements in the PNW-PSW interties are described.

The AC PNW-PSW Interties

The transfer capability of this tie is 3200 MW from North to South and 2000 MW from South to North under normal system conditions.

In the PNW, the entitlements in percent of transfer capability are: BPA 65.6%, PGE 25%, and PPL 9.4%. The entitlements of the entities in California to the transfer capabilities in the PSW region are: PG&E 35.9%, SCE 30.9%, WAPA 12.5%, CDWR 9.4%, SMUD 6.3%, and SDGE 5%.

These entitlements are shown in a diagramatic fashion in Figure 4-3. In the figure, the corresponding geographical positions of the utilities holding these entitlements has been more or less preserved. It is important to recognize that the network and the power flow pattern is not as simple and radial as is depicted in Figure 4-3. But, in general, it would be correct to say that the power flowing to the more southerly entities (say PG&E or SDGE) has to flow through the northern sections of the intertie, to a first approximation. The relevance of this aspect to wheeling and access to transmission service will become clearer in latter sections.

The DC Intertie

This intertie traverses the states of Oregon, Nevada and California. It starts at a converter station called Ceilio near The Dalles in Oregon and terminates at Sylmar near Los Angeles. At present the intertie has a North to South transfer capability of 1956 MW at the Nevada-Oregon border (NOB) and 1910 MW South to North.

The intertie in the PNW region north of NOB is 100% owned by BPA. The Southwest rights to the existing transmission capability are as follows: LADWP 40%, PG&E 25%, SCE 21.5%, Glendale 3.8%, Burbank 3.8%, SDGE 3.5%, and Pasadena 2.3%. Note that the entitlements are divided in the ratio of 50:50

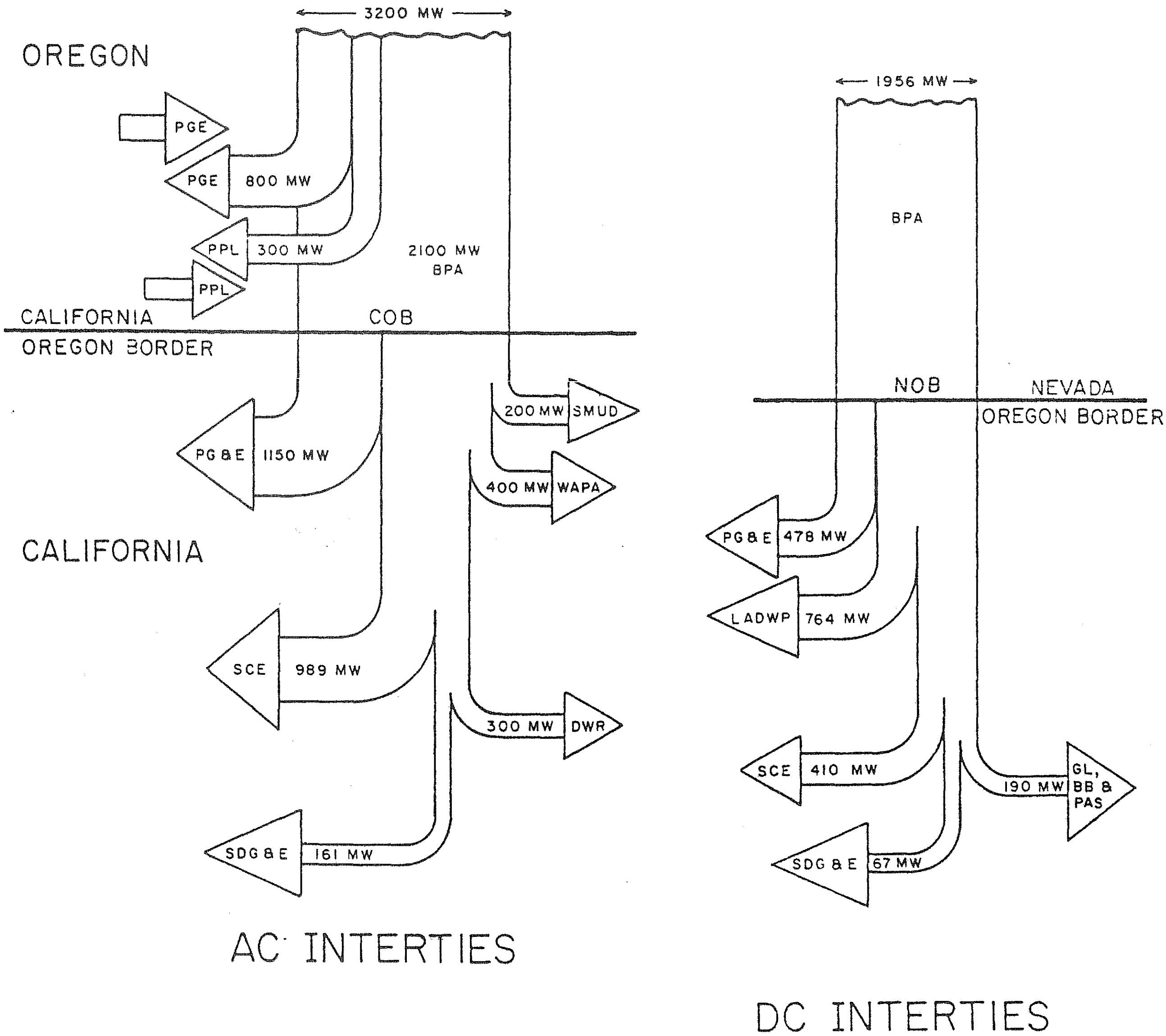


Fig. 4-3 Transfer capacity entitlements in the Pacific interties

in PSW between publicly and privately owned Utilities. Both the AC and DC intertie rights of utilities are illustrated in figure 4-3.

It is important to recognize that the flow of energy on both the AC and DC interties can be from the PSW to PNW. As mentioned earlier, the present total South-North transfer capability is 2000 MW and 1910 MW for the AC and DC interties respectively. Energy could flow from PSW to PNW in actual operating practice. This report, however, does not examine such northerly flows. First, the direction of energy flows at present, for the most part, is from PNW to PSW since there is a preponderance of hydro energy in the North and the fossil/oil based generation in the South. The energy flow to the North takes place under some contract provisions requiring the return of energy at certain times outside of peak load periods or under emergencies. Second, the intent of this report is to examine certain economic implications of energy transfers and, therefore, the energy flows to the North for relatively shorter times have been ignored without affecting the analysis in a serious way.

Contractual Obligations

The operation of the systems that are interconnected by these interties is governed by several agreements and contracts. Some agreements are listed under References at the end of this report.

It is needless to stress that there are scores of other contracts between the major Utilities and between the major Utilities and other entities. The choice of the following contracts to be summarized was guided by our desire to examine certain aspects of efficiency and transmission bottlenecks.

The operational aspects as they bear on the efficiency of production is summarized in this section. Subsequently, the operating practice is critiqued and examined to ascertain if they are amenable to the application of tests proposed in chapter 2 for idealized systems.

The reader may find the following summary of contractual obligations a rather dry reading. However, an understanding of the contracts is essential to grasp the meaning behind certain electricity transactions.

The Exportable Agreement and the Near Term Intertie Access Policy [6]

Interest in understanding this agreement stems from the need to know the policy BPA exercises in granting transmission access to other NW utilities to sell energy in the SW market.

The contract currently governing the use of BPA's portion of the NW-SW intertie is the Exportable Agreement, executed on January 1, 1969 and scheduled to terminate on January 1, 1989. The Agreement, signed by BPA and 14 PNW generating utilities, was created to share BPA's southwest market with those utilities when the northwest's hydroelectric/thermal system is capable of producing more nonfirm energy than can be marketed in the region. When this surplus (exportable) energy exceeds the available intertie capacity or California demand, the Agreement, generally, prorates the sales to California among the exportable parties on the basis of the ratio of each party's available nonfirm surplus to the total available northwest surplus during each hour. The share of each party thus determined is termed the apportionment.

Any party to the Exportable Agreement may have BPA sell its apportionment of exportable energy provided that such party is willing to sell at applicable BPA rates. When a party does this, the party's energy is combined with the BPA apportionment and all other exportable energy scheduled to BPA and sold by BPA as federal energy to California utilities under BPA's existing power sales contracts. The scheduling party is credited by BPA (i.e., paid) its "share" of exportable energy made available to BPA at the referenced rate. A party to this agreement may schedule under section 5(c) of the agreement all or part of its apportioned share of an exportable energy on a bilateral basis to a specific California entity at a price other than the "applicable rate." However, for such bilateral sales, the seller and the purchasers have to use their entitlements in transmission capacity.

During times when the Exportable Agreement allocation is not in effect, i.e., when applications for intertie use do not exceed the intertie capacity or the California market demand, BPA's past intertie practices permitted intertie capacity to be used to transmit power bought and sold between PNW and PSW parties pursuant to short term scheduling requests.

Reference [9] (near term access policy of BPA) gives the details of other contracts already in existence between BPA and other parties that are being honored. The intertie transfer capacity should be adjusted accordingly to account for such firm contracts. The access to the intertie capacity by the PSW utilities is governed by three conditions in the policy. They are:

(1) Condition 1: When Exportable Energy is being scheduled pursuant to the terms of the Exportable Agreement, capacity will be allocated pursuant to the Exportable Agreement. An example of an allocation is shown by a formula in [9].

(2) Condition 2: When the Exportable Agreement allocation formula is not in effect, but BPA and other scheduling utilities declare amounts of power available for access to the intertie that exceed the available intertie capacity determined as above, the capacity will be allocated pursuant to the following procedure:

Allocations for each hour among scheduling utilities will be determined and will approximate the ratio of each scheduling utility's declaration for that hour to the sum of all declarations for each hour multiplied by the available intertie capacity. An example of an allocation under Condition 2 is shown in [6].

(3) Condition 3: When the Exportable Agreement is not in effect, but when BPA and other scheduling utilities declare power available for access to the intertie in an amount that does not exceed the available intertie capacity, BPA's and every other scheduling utility's allocation will be equal to its declaration. An example of an allocation under Condition 3 has also been shown in [6].

Agreement between Bonneville Power Administrator and the Portland General Electric Co. [13]

PGE is a major utility in Oregon which partially owns major interties. Therefore, PGE, along with BPA, control the route to access the southern market. Our interest in this agreement arises from a desire to understand the sharing of the transmission capacity between BPA and PGE.

This agreement provides for certain exchange in transmission capacities in the AC lines between John Day and Malin, the "Oregon DC line" (HVDC line between The Dalles and Sylmar near LA) and in a proposed HVDC line between Big Eddy and the Hoover Dam near Las Vegas called the "Nevada DC line". The following are the details of such exchanges. (See Figure 4.2 for the approximate locations of substations named.)

1. BPA gives PGE the right to use half the transmission capacity in its two AC lines from John Day to Grizzley in exchange for the BPA's right to use half the capacity in PGE's Grizzly-Malin line.

2. Commencing on the date the "Nevada DC line" is completed, PGE will get the right to use up to 250 MW of transmission in the HVDC line to California ("Oregon DC line").

In exchange for the right of PGE to use the "Oregon DC line", the BPA, during the same periods, shall have the right to transmit, over the capacity entitlement of PGE in the John Day Malin circuit, an amount of power equal to that which PGE has opted to transfer in the "Oregon DC line" (250 MW limit). Furthermore, during the periods PGE would be transmitting over the "Oregon DC line", BPA agrees to transmit energy from Big Eddy to points of delivery in the 230 KV system of PGE at maximum rates of delivery equal to the amount of capacity rights exercised by PGE on the "Oregon DC line".

3. BPA has the right to use the capacity of PGE on the AC lines not used either to transmit power for itself (PGE) or to others, subject to certain adjustments depending upon the deliveries made by PGE to BPA for credit and the scheduled deliveries by PGE to California entities.

4. If the amount of surplus energy available from the PGE system exceeds the scheduled delivery between PGE and California entities, PGE can return such excess energy for credit into the BPA system. The amount of energy that can be returned to the BPA system has certain limits depending on the deliveries scheduled by BPA to the California entities.

The agreement, interalia, sets out the method of accounting for losses, metering requirements and the rates for energy returned for credit into the BPA system.[2],[3]

Intertie Agreement between BPA and PPL [12]

PPL Company owns facilities in southern Oregon and at Malin. Some conditions are stipulated by BPA in regard to PPL's future access to the California market. It is with this and other transmission aspects in mind that this contract is of interest.

BPA has an agreement with PPL called the Midpoint-Medford agreement. This agreement relates to the coordination of operations for transmission on PPL lines between Summer Lake-Malin-Medford and the BPA facilities at Malin.

In a subsequent agreement entered into in 1986, called the Intertie agreement, the parties have agreed to certain conditions in order that BPA may be in a position to increase the transfer capability in the AC Intertie to about 4800 MW (present transfer capacity is 3200 MW). In the northern portion of the AC Intertie in Oregon, one of the options that is being considered is the building/upgrading of a circuit from Alvey to Meridian (near Medford) to 500 KV. The following is a summary of some of the aspects of the agreement.

If PPL constructs the Alvey-Meridian line, BPA has an irrevocable option to acquire a 50 percent ownership and 50% of incremental transfer capacity in the line. The sharing of capital and operating costs of the Alvey-Meridian line between the two parties is outlined in the agreement.

If BPA exercises the above option and if PPL is unable to obtain permits and licenses to build the line, BPA, without acquiring an interest in the Alvey-Meridian line, may proceed with other alternatives to increase the transfer capacity and PPL has the option to participate in such alternate plans to provide PPL up to 1875 MW of load carrying capability by

---

[2] The plans to build the Nevada DC line have now (May 1988) been shelved.
[3] PGE has essentially sold some of its interest in the AC intertie (through an intermediate financial institution) to SGE.

an equitable sharing of costs. Present load carrying capability of PPL in its 500 KV lines is about 1150 MW.

In the event of BPA not exercising its option and PPL building the line, PPL agrees to limit the use of the line to support its load carrying capability, and BPA may elect to use the line by making appropriate payments to PPL. Three options of payment (including that of paying a certain wheeling rate) for such use by BPA and the details of their calculation are shown in the agreement.

Commencing on the date the rated transfer capacity of the AC Intertie is 3200 MW until such time the transfer capacity is determined to be 4000 MW or more (arising from changes to the network including the above option), PPL's scheduling right at Malin shall increase by 0.125 MW for each MW increase in the rated transfer capability. The present scheduling right of PPL is 300 MW. Any schedules in excess of the sum of 300 MW per hour and the above additional right shall be deemed to be transmitted from John Day and will be subject to the current Intertie access policy of BPA with applicable transmission rates payable to BPA. If PPL has any unused scheduling rights, such rights shall revert to BPA for Intertie transaction at no charge.

Commencing on the date the transfer capability of the AC Intertie is 4000 MW or more, PPL's scheduling rights will be 400 MW. Excess scheduling or unused portions of the scheduling will be treated as in the previous case (the case of the transfer capacity between 3200-4000 MW).

Construction and Operation of Parallel Facilities by PPL.

PPL's right to construct and right to operate existing and new interconnection with PG&E or other utilities adjoining the service territory of PPL is subject to the following conditions.

1. The interconnection shall operate at 230 KV or below and shall include a phase shifter.
2. On any given hour, the sum of PPL's load and the schedule on the parallel path shall not exceed its load carrying capability.
3. PPL's total Rated Transfer Capability on such interconnection shall not exceed 300 MW and if the AC Intertie transfer capability is

4000 MW or more, PPL's Rated Transfer Capability shall not exceed 400 MW.

In addition to the above conditions, PPL shall not construct, participate in or allow a new interconnection for any 345 KV or above from any point in its system in Oregon to the existing two Malin-Round Mountain-Table Mountain lines. PPL and BPA agree not to sell, assign, lease, sub lease, or otherwise transfer the interest in this agreement, in Malin Sub-station, summer lake-Malin line, Malin-Meridian line or Alvey-Meridian line to any third party without the written consent of the other party.

California Companies' Pacific Intertie Agreement between PG&E, SCE and SDGE [10]

It has been mentioned earlier that the transfer capacity of the NW-SW AC and DC interties is shared by several parties. In terms of transfer capacity in California, it is not only of interest to know the entitlements but it is also important to know if the entitlements unused by their owners can be transferred to other parties. Furthermore, when PNW is in a surplus situation, it is of interest to know if non-investor-owned utilities in California can have access to the energy entitlements of IOUs and if the IOUs can transfer their unused transmission entitlements and PNW energy to others. Therefore, the Pacific Intertie Agreement among the three California IOUs is examined below.

This agreement between the companies covers the operation and sharing of transmission capacity in the Pacific Northwest-Southwest AC and DC interties.

Relative size percentage of each company (or entitlements) remaining after the entitlement of SMUD, WAPA, and CDWR in the AC lines and after the entitlement of LADWP, Glendale and Burbank in the DC intertie are: PG&E 50%, SDGE 7%, SCE 43%. The monthly cost of capital and maintenance of the interties is shared between the companies in this proportion. The agreement allows each company to purchase from BPA or other PNW entities as much NW dump energy as it can use economically in its system subject to the above limit of transmission relative size percentage. It also allows each company to receive and exchange peaking capacity and to fulfill the obligation to deliver exchange energy to BPA. Under the agreement, SCE shall provide to MWD off peak transmission capacity capable of delivering up to 438 GWh of energy per year.

The southern terminal of DC intertie is in SCE territory. The agreement, therefore, stipulates that SCE shall keep other companies informed of all significant changes in transmission capacity on this intertie. If SCE contemplates the sale of any portion of its interest in the DC intertie, it shall give the right of first refusal to the other companies.

When unused (excess) transmission capacity is made available to the state (SMUD, WAPA, CDWR and other government or municipal entities) for the transmission of PNW dump energy, each company furnishes that fraction of such transmission capacity equal to the ratio of (1) the amount of unused capacity of its entitlements each company determines it has at the Southern Oregon border, to (2) the total amount of such capacity all companies determine they have available.

No company can transfer or make available any of its assured capacity entitlement to any other company or any other entity not a party to the contract without the consent of the company owning the facilities in which such capacity is available. Before any company may transfer or make available to a non-company entity any of its assured intertie capacity, it must first offer such capacity to the other companies in the ratio of their relative size percentages on terms and conditions no less favorable than those which would otherwise be offered to any other entity not a party to the contract.

If the transmission capacity contracted by BPA, DWR or SMUD is not being used by such entities, such unused capacity shall be made available to each of the companies between the southern Oregon border and its system as decided by the coordination committee. In the event the coordination committee cannot agree of such determination, each company shall have the right to use its relative size percentage of such unused transmission capacity.

Each company has the right to purchase its share, based on relative size percentages, of any NW power acquired by one or more of the companies, on the same terms and conditions as the acquiring company. The coordination committee shall decide on the reallocation of such NW power to provide maximum equitable benefit to all the companies. If any company rejects all or part of the NW power made available to it, the other companies shall have the right to share the rejected amount in the ratio of their relative size percentages.

Before any company may assign or transfer all or any portion of its NW power to a non-company entity, such company should first offer it to the other companies in the ratio of the relative size percentage on terms and conditions no less favorable than those on which it is then purchasing NW power. If one of the companies rejects all or part of such offer, the other shall have a right to accept all or a part of the rejected amount.

If replacement SW power is available, SDGE shall have the right to use its assured intertie capacity to transmit such power subject to its first obtaining a written permission from the company owning the Pacific intertie facilities. If such permission is refused, SDGE may request a reduction of its relative size percentage and, if necessary, demand arbitration.

If the owning company grants such permission, SDGE may use the unused assured intertie capacity for the transfer of such replacement SW power and may then negotiate and, if necessary, demand arbitration of a reduced share of the monthly costs.

If no replacement NW power is available or if such power is available for purchase by SDGE and can be generated within its own system at a cost less than available power at COB or NOB, SDGE may utilize such resources in its system and negotiate and, if necessary, demand arbitration for a reduction in its relative size percentage.

Under the curtailment of transmission capacity due to any operational problems, deliveries under interruptible power commitments shall be curtailed first, and each company's share in such a curtailment shall be in proportion to the amount of power it has scheduled. After all such interruptible deliveries have been curtailed, deliveries under firm power commitments shall be curtailed, if necessary, and each company's share in curtailment will be in proportion to the amount of power it had scheduled.

Contract between SCE, PG&E, SDGE and SMUD [14]

This contract and the next one comprise the agreement between the California IOUs and the public entities who have a share in the intertie transfer capability. The object of this examination is to understand the cost of transmission service and the scheduling rights of the public entities. The following is a summary of the contracts.

According to this contract, the California Companies (SCE, PG&E and SDGE) accept capacity and energy from any NW entity for delivery to SMUD or accept capacity and energy from SMUD for delivery to any NW entity. Such deliveries made on the intertie AC lines shall not exceed the energy as can be transmitted by the use of up to 400 MW of Intertie capacity. The charge for this service is set at $3.35 per KW per year.

In addition to the above, the companies accept NW dump energy which, during any 12 month period commencing February 1, does not exceed 225 GWh for delivery to SMUD. The tariff for this service is set at $0.0005 per KWh. SMUD can elect to receive service up to the above limits. Change to the elected amount of firm service requires, normally, 5 years notice to the companies (unless a shorter notice is agreed upon mutually by the companies and SMUD).

The contract provides for other services such as delivery into the 230 KV system of SMUD, operation under emergencies, exchange of Canadian entitlements, etc.

<u>Contract between California Companies (PG&E, SCE and SDGE) and U.S. Dept. of Interior, Bureau of Reclamation, Central Valley Project, California</u> [15]

This contract between the three IOUs of California and the United States stipulates the terms of service to WAPA. Under the terms of this contract, the California Companies (Contractors) accept amounts of electric energy as can be transmitted by the use of 400 MW of capacity of the EHV alternating current line (1) at the Round Mountain substation obtained by the United States (WAPA) from northwest entities for use or sale by the project or (2) accept energy delivered by the United States (WAPA) from sources available to it at Tracy substation (near San Francisco) for delivery at Round Mountain substation in order that the United States may fulfill its contractual obligations with Pacific Power and Light and other northwest entities.

The above deliveries of energies are adjusted for losses in the transmission system.

Rates

The charge payable to the Contractors for firm transmission service from COB to Tracy over the combined U.S. line section and PG&E lines is $3.35 per kw per year. For transmission service provided by the United States between Malin and Round Mountain, the contractors compensate the United States by:

1. A monthly payment equal to the amortization and interest of the U.S. investment in the Bureau line, its share of equipment in Round Mountain substation and Malin including compensation equipment. This monthly payment is the sum of the above costs multiplied by a factor of 0.00323879.

2. Paying the United States its cost of operation and maintenance of the Malin-Round Mountain line and any costs associated with additions and betterments as mutually agreed.

<u>California Power Pool Agreement</u> [11]

Motivation

The three IOUs in California (California companies) have a power pooling agreement among them. The object of the pool, among other aspects of coordination of services, is to minimize the cost of production by exchanges of energy. Our interest in this agreement stems mainly from the desire to ascertain how the PNW surpluses are absorbed within California to maximize production efficiency. The process of exchanging energy between the companies uses a pricing formula related to the incremental and decremental costs of the seller and the buyer. The definition of these costs and its bearing on the attainment of maximum production efficiency was discussed in chapter 3 in relation to Figures 2-5 and 2-6. The following summary of the agreement examines the aspects that influence the production efficiency. Particular attention should be paid to the definition of incremental and decremental costs in the contract. The effects of these definitions on the production efficiency is discussed in Chapter 5.

The Agreement

This agreement among PG&E, SCE and SDGE allows for the coordination of operations and the exchange of service transactions such as economy energy service, economy capacity service, short-term firm service energy interchange service, emergency service, and capacity resource standby service. The agreement also lists service obligations, the operating criteria for the Pacific intertie and the rate schedules for the service transactions.

In the interest of brevity, we focus only on aspects of economy energy interchanges as they pertain to the subject of this report.

Whenever there will be a net savings of at least four-tenths (0.4) mill per KWh resulting therefrom, any two parties may agree to purchase and sell economy energy. The goal would be to minimize the difference in the incremental costs of production in the three companies by the exchanges of economy energy.

The tariff for economy energy service is:

"Supplier's incremental energy cost as agreed upon in advance plus (a) if intermediate systems are not involved in the transaction, 50 percent if the net savings, or (b) if intermediate system is involved in the transaction, 50 percent of the net savings after deduction of the intermediate system's cost for delivery of energy. However, if the receiver's decremental energy value and the net savings cannot be readily determined, the rate shall be either (i) 110 percent of the supplier's incremental energy cost as agreed upon in advance, or (ii) if the supplier's incremental energy cost is the price paid to another party or to a third party for purchased energy, the rate shall be the incremental energy cost plus one (1) mill per kilowatthour."

The net savings has been defined to be the difference between the supplier's incremental energy cost and the receiver's decremental energy values at the point of delivery as agreed upon in advance.

The decremental energy value and the incremental cost have been defined as follows:

"The **decremental energy value** is determined by either

(a) the estimated expense which the receiver would incur if it were to purchase energy under then existing purchase agreements with a party or third party, if energy could then have been furnished under such agreements, or

(b) the estimated expense which receiver would incur if it were to generate energy on the most economical generating unit, or units if necessary, included in its available capacity resources but not being utilized to meet its energy requirements, which expense shall be the sum of the following items: If necessary for the purpose of supplying such energy, the cost of making ready, starting and shutting down such generating unit and the replacement cost of no-load fuel and fuel required to generate station uses.

The **incremental cost of energy is defined** as the supplier's expense per KWh, but not less than one mill per KWh, incurred by it in generating the energy from the most economical generating unit not being used to meet its energy requirements suitably adjusted for increase or decrease in transmission losses in the supplier's system and shall include the following expenses:

(a) if necessary for the purpose of supplying such energy, the cost of making ready, starting and shutting down such generating unit and the replacement cost of no-load fuel and fuel requirement to generate station uses;

(b) the replacement cost of fuel consumed in generating such energy;

(c) the incremental cost of maintaining such generating unit, which shall initially be 0.2 mill per kilowatt-hour but may be changed from time to time by the Board of Control as may be justified by operating experience under this Agreement; and

(d) the cost of additional direct labor and direct supervision required to generate such energy provided, however, that if supplier purchased all or part of such energy at a price lower than the foregoing expense, for the purpose of supplying such energy to receiver and not to meet supplier's own energy requirements, then supplier's incremental energy cost for the energy so purchased shall be equal to the purchase price of such energy, such price being adjusted for any increase or decrease in transmission losses on supplier's system and losses on account of energy interchange service on the intermediate system if used in the transaction."

<u>Contract between State of California and California Companies (PG&E, SCE and SDGE) for the Sale, Interchange and Extra High Voltage Transmission of Electric Capacity and Energy</u>. [16]

This contract illustrates the obligations of the IOUs in California to the State of California acting by and through the Department of Water Resources.

This contract provides for services as follows.

1. Firm Transmission Service to the State.

The companies shall accept NW power acquired by the State at COB and deliver it to the State at Table Mountain, Tesla, Los Banos, Midway, Grapevine or such other points (adjusted for appropriate losses) to be agreed upon by the parties.

The total capacity to be delivered under this category and under 2 below shall not exceed 300 MW.

Northwest firm power is defined as the NW capacity that is continuously available for periods of not less than twelve months and which is assured to the purchaser at least five years (or such lesser period as may be agreed upon by the parties) in advance of time of delivery.

The State shall compensate the companies for service between: (a) COB and Table Mountain, Tesla or Los Banos station by a monthly amount equal to the number or KW capacity contracted for multiplied by one-twelfth of $3.35 per KW (b) between COB and Midway or Grapevine, a monthly amount equal to the number of KW capacity contracted for multiplied by one-twelfth of $5.00 per KW.

The State shall give written notice of five years in advance of any proposed changes in the contracted amount of power subject to the above said limit.

2. Northwest Dump Energy

Whenever the firm transmission capacity contracted for by the State is fully utilized and if transmission capacity in excess of that required by the companies exists, the companies may accept at COB for delivery (adjusted for losses) to the State, northwest interruptible energy for periods of less than twelve months and shall be compensated at the following rates.

Deliveries at Table Mountain, Tesla or Los Banos substation, $0.0005 per kwh. Deliveries at Midway and Grapevine, $0.00075 per kwh.

In determining transmission capacity not required by the companies for the transmission of northwest dump energy or other purposes, the companies shall determine their requirement of northwest dump energy as though they were not selling power to the State. The companies are not obligated to provide or maintain transmission or substation facilities in excess of those required for firm transmission.

3. Purchase and Sale of Canadian Entitlement and Other Power.

The contract provides for (and outlines the rates and conditions of) the purchase of the State's Canadian entitlement and other power by the companies as well as the sale of power by the companies to the State.

4. Sale of Off-Peak Energy by Companies.

The contract stipulates the rates and conditions of off peak energy sales to the State. The sale of the amount of energy requested by the State can not exceed the amount of such energy that could be transmitted over the intertie EHV lines to the State under 1 above and which is not being used at such times by the State. (i.e. Maximum rate of delivery at any time cannot exceed the capacity contracted for, viz. of 300 MW).

With the above background information regarding the network and the contractual obligations, we are now in a position to examine the applicability of tests proposed in chapter 3.

CHAPTER 5

APPLICATION OF TESTS FOR THE EVALUATION OF INTERCHANGES

Intent

The applicability of the idealized tests developed in chapter 3 to "Real-World" situations is here examined with the WSPP experiment as the case in point. The removal of certain impediments prior to the conduct of an experiment to simulate idealized situations and a list of data to be collected during such experiments are also outlined.

WSPP Situation

Operational Aspects

The development of transmission and generation in the WSCC region has been sketched in chapter 4. The utilities in this region have a well developed operating practice and coordinate their operations to result in improved production efficiency. Frequent exchanges of transmission entitlements and the periodic swapping of AC and DC entitlements between the signatories of the Pacific Intertie Agreement have been common practices. Despite the high degree of coordination between the utilities, concerns regarding the availability of transmission to entities other than the major utilities have been expressed [17]. The WSPP Experiment is being conducted to examine if the efficiency and competition can be further improved by FERC's preauthorization of a band of prices for the commodities.

An examination of the major contracts among the utilities reveals that the parties entered into these agreements to improve their and their customers' lots. While their actions were well meant, focused mainly towards their interests, one might debate if the contracts were for the good of the whole of WSCC region. The following examples elaborate this further.

Contracts with BPA

BPA owns a major share of the NW and SW interchange capacity in the lines. This ownership gives BPA a virtual monopoly on transmission. One has to examine the "other side of the coin" and debate the obligations of BPA as well.

BPA has revenue obligations to the federal government. When the NW-SW interties were built in the early 60s, many held the view that it was very expensive and some even doubted its technical viability. Therefore, some entities which were invited to participate in the building and the sharing of transfer capacity refused to do so. The federal government, through its agencies and other utilities listed in chapter 4, have invested large sums of money in building these lines. Therefore, BPA and the other parties responsible for building the interties would like to maximize their efficiency and thus benefit their customers by the use of their entitlements to the transfer capacity in these lines. Some entities who refrained from participating in the building of the interties now see the advantages of the line and might like a share of the transmission capacity.

Some view the intertie access policy of BPA to be restrictive. Also, the fact that PPL can neither negotiate the building of stronger interties to California nor may increase its schedule above 300MW might be seen as examples of BPA trying to control the market.

As required by the PNW act, BPA has to ascertain if its surpluses are not required in the PNW region. Therefore, it has to declare the price of its surplus energy and after its refusal in PNW, it can be exported to California and other southern markets. Recall that the other utilities in the PNW also have substantial hydraulic generation and that their seasonal surplus generally coincides with the surplus of BPA. Hence, after the refusal of BPA surplus, other PNW entities may set a price below the declared price of BPA and demand transmission access to the South to sell their surpluses. BPA, having financed a major portion of the cost of building these lines, would like to mitigate the effects of such actions by other PNW entities on its revenues. It is with this in view that the intertie access policy has been put in place to "equitably" share the transfer capacity to the South with the other PNW entities.

In terms of the agreements with PPL, BPA and some other entities are planning to upgrade the transfer capacity in the DC and AC interties. Several engineering options are being considered and some have been committed to. Therefore, any parallel action by others to serve the same market might jeopardize the economic viability of such plans. Due to the large geographical area of the region, the money involved in these upgrade schemes is not small. Therefore, BPA would like to ensure a coordinated planning of the increase in transfer capacity and that the building of interconnections by others does not affect the economics of such upgrades.

Contract Between: (1) California Companies, (2) California Companies and Other California Entities

The Pacific Intertie Agreement between the California Companies stipulates that unused transmission entitlement of any company or unused entitlement of NW power be first offered to the other companies in the ratio of their relative size percentage shares. It also stipulates that no company can transfer or make available any of its entitlement to other signatories to the agreement or other entities without the consent of the company owning the facility. Any intended transfer must be first offered to the other California Companies in the proportion of their relative size percentages.

Some might argue that this agreement excludes the others from improving their production efficiencies. On the other hand, one may argue that it is reasonable to expect the companies which have invested in and own the transmission facilities to reap the benefits from it.

Production Efficiency

The seminal question to be addressed is that of production efficiency. The question is whether the operating practice and contractual obligation hinder the attainment of a greater production efficiency in the region. If the answer is in the affirmative, then, by making changes to the operating practice, there would be larger net gains to be shared by all. The parties owning the transmission might still claim the same benefits as under the existing system. If the answer is negative, there would be no gains in production efficiency by making changes to the operating practice and by forcing the provision of transmission access to others. The tests proposed in chapter 2 aid in answering this question. To clarify this point further, consider the following example.

A California entity, say entity X, has an hourly incremental cost of production of 7 cents/kWh when BPA is selling surplus energy at 2.2 cents/kWh. Let the highest incremental cost of production amidst the three California Companies at the same hour be 5.5 cents/kWh. If the NW-SW interties are fully loaded, the California Companies should divert some or all of BPA energy to displace X's energy instead of their own generation. Then there would be higher net gains and the California Companies may be allowed to demand a share not less than the benefits to them if BPA's energy displaced their generation (EA or FA of chapter 2). All the parties involved would benefit from such a scheme.

A somewhat confusing aspect in the California Power Pool in regard to the definition of incremental cost must be noted. Certain aspects of operation are unclear from the contracts. As an elucidation of this, consider that PG&E and other California Companies are purchasing energy from BPA up to their entitlements in the interties during the surplus season. Consider also that the λ of SCE was higher than that of PG&E before such a purchase. Therefore, to achieve the maximum production efficiency, BPA's energy should displace as much of SCE's energy as possible, at first. The same effect can be obtained by PG&E's purchase of BPA generation and by a subsequent selling of energy to SCE in the California Power Pool.

However, if PG&E in its subsequent sale to SCE defines the incremental cost to be the cost of the most expensive unit on line <u>before</u> the import of energy into its system from BPA (as in the left hand side of Figure 2-6), the same quantum of SCE generation as from a direct purchase from BPA will not be displaced by the PG&E resale. One might, then, observe a loss of production efficiency if there is a substantial difference between the λs of PG&E and SCE. Under these circumstances, the achievement of maximum production efficiency would, in theory, be hampered by the entitlement attitude of PG&E and the California Power Pool Agreement.

On the other hand, if PG&E defines the incremental cost for its resale to other California Companies to be the cost of the most expensive unit on line <u>after</u> the import of energy into its system from BPA, the total quantum of SCE generation displaced at the end of the process would be the same as when BPA's energy would be purchased directly by SCE. There would be no loss of production efficiency. However, the division of benefits between the intermediate utility and the other utilities may not be the same as under a scheme when BPA's generation displaces the most expensive generation in the region. All the same, the fact that there is no loss of production efficiency is the matter of paramount importance.

From this we conclude that it is important in the evaluation of the WSPP Experiment that the participants address the above aspects. A mere reading of the contract does not indicate which of the above methods will be used in the definition of the incremental cost.

Another factor affecting the production efficiency in the region is the near term intertie access policy of BPA [reference 6]. The degree of access to the intertie is proportional to the ratio of the declared surplus of a PNW entity to the total regional surplus. The access is not related to the cost of production. In addition to this access policy, PGE and PPL have certain scheduling rights. Maximum production efficiency would be attained by allowing the cheapest PNW generation (may be BPA's own) to displace the more expensive generation in the south in increasing steps (as in a brokerage system). At present, the costs of production of the PNW entities are somewhat similar. But there is no guarantee that they will continue to remain so. In the light of PNW act, BPA has to declare the price of its surplus energy which, subsequently, might be matched by the other PNW entities. The above policies (scheduling rights, PNW act, access policy) might not permit the export of the cheapest PNW energy to the south under all circumstances. Therefore, these policies could be viewed as a hindrance to the attainment of maximum production efficiency.

A third concern regarding production efficiency is the offering of transmission entitlement of one company to other California Companies. On many occasions, when PNW is experiencing a wet period, PG&E will also be in a wet and surplus situation. PG&E has to drain its own reservoirs and, therefore, cannot absorb PNW's surplus energy. Similar situations of being unable to absorb BPA's or other PNW entities' energy may arise due to technical reasons such as reliability, stability, and minimum loading constraints of machines. Under these circumstances, the unused entitlements in transmission must be offered to the other California Companies and non-investor-owned entities. It is important to ascertain if such offers are being made and the refusal of such offers by the other companies (IOUs) are subsequently offered to other California entities. It appears that there was no formal mechanism to make such subsequent offers to the other entities prior to the WSPP experiment. Presumably, such offers can now be posted on the "hub" computer.

From the above discussions, it is amply clear that the primary tests should be those of measuring production efficiency via the measurement of differences in λ. Appendix B outlines the WSPP Experiment and its authorization by FERC. Before discussing the applicability of tests proposed in chapter 3, we shall comment on the WSPP Experiment and its peculiarities. Also discussed are the disadvantages of the application of statistical methods alone to assess the outcome of electricity interchange experiments.

Comments Regarding the WSPP Experiment

The following are some observations regarding the conduct of the WSPP experiment and its evaluation. This commentary is not intended to second guess the outcome of the experiment. Rather, it is intended to focus on certain conceptual aspects that may hinder or aid experiments and their evaluation.

FERC's Authorization

In approving the conduct of the experiment FERC has not indicated the data that have to be collected by the parties to the experiment. It has been left up to the participants and the consultants to decide on the data to be collected and on the method of its evaluation.

It is understood that participants would be posting on the Bulletin Board of the "hub" computer the commodities and their prices. It is unknown whether the posted quotes have any relation to the incremental or avoided costs. In the Florida Broker System, the quotation for "buy" and "sell" quantities reflect the costs (fuel, start up, O&M etc.) calculated according to a method agreed to by the participants. It would be very difficult to measure improvements in efficiency unless the quotations are related to costs. Presumably, the consultants would have access to the cost data of the participants which, understandably, are not made known to outsiders. Therefore, it is to be expected that the consultants translate the posted quotes to actual costs in their analyses designed to measure the efficiency of production.

Another aspect is that of the consummation of deals. To measure the effectiveness of the experiment or any interchange operation, it is essential to know the price at which the services were finally transacted, presumably at a price between the buy and sell quotes. Only with this knowledge can one assess competition and opportunities in the marketplace. It is not known at this time if the price at which the transactions are consummated is being entered into the "hub" computer for further analysis.

The WSCC is known to be a well coordinated area where a number of transactions were already taking place even before the experiment. Indeed, one may wonder why there was a need for an experiment. Certainly, the fact that there is an information exchange through a central "hub" computer to aid the participants would not hamper the existing cooperation and coordination in the WSCC. However, questions regarding the completeness of the data that are being collected arise.

Regulatory Aspects

In regard to the revenues, FERC has accepted [3] that the participants have the option to either: (1) use traditional rate commission mechanisms, or (2) not include considerations of WSPP transactions in future test period filings but propose at the time of a relevant rate filing the method that would be used to pass on the incremental WSPP benefits to requirement customers. In accepting either of the above methods FERC has said that [3]:

> "...it is not entirely clear how jurisdiction utilities would, under the proposal, insure that requirements ratepayers receive a reasonable portion of WSPP sales to the extent that WSPP results in coordination sales above the level already reflected in requirements rate."
>
> "Therefore, we shall accept either method of treating revenues as long as the jurisdictional utility proposes a mechanism to insure that at least 75 percent of the benefits attributable to an increase in the level of coordination sales under the WSPP, not already reflected in

the current requirements rates, are flowed through to the utilities requirements ratepayer..."

"...we do not control the treatment of all the benefits that will result from the proposed experiment. Our jurisdiction extends only to the portion of the benefits to be allocated to the investor-owned utilities' wholesale requirements customers. The remainder of the benefits is under the control of state regulatory commissions through their regulation of utilities' retail sales..."

As evidenced by FERC's decision, the regulatory commissions would have to decide on a method of flowing through benefits to the retail customers. The commissions will have to determine a satisfactory method of evaluating the <u>increase</u> in benefits.

Another matter is that of treating hydro energy. In some states the utilities are allowed to pass on all the purchased power costs to the consumer. Similarly, under normal circumstances, the utilities would pass on any additional gains from the sale of energy to the consumers. However, during the experiment, 25% of any <u>additional</u> benefits gained will be retained by the stockholders.

The determination of the additional benefits is a complex task. However, because of this financial incentive during the experiment, a utility with some hydro resources might be tempted to sell hydro energy from its system to others through coordination sales and retain 25% of the benefits thereof. Later during the year, when the hydro energy would be normally used to serve its customers, the utility may purchase energy from the market at any price--even at a price equal to or higher than that at which the hydro energy was sold off and pass on the full cost of such purchases to the consumers. Stockholders would obviously stand to gain by such a practice.

The regulatory commissions in states where the above asymmetry in revenue treatment of sold and purchased power is permitted (retention of 25% of benefits due to sale and passing on 100% of the cost of purchases) will have to monitor the use of hydro and other storable energy carefully to ensure their efficient use. This matter would not be of smaller concern in states where the costs of purchasing energy additional to those accepted by the commissions are to be absorbed by the stockholders. Many variations to this scenario are possible depending on the state's regulatory practice, the generation mix of the utilities, the seasonal variation of riverflows, etc.

Evaluation of the Experiment

The methods that will be used by the participants to evaluate the experiments are not yet publicly known. However, statistical analysis used for the evaluation of the SW Experiment in reference [1] raises several questions. The Report [1] attempts to measure the complex issues of market efficiency and competition.

The direct applications of the concepts in [1] to evaluate the WSPP Experiment would not be possible for several reasons. In the SW Experiment FERC had required that the participating utilities have at least one contract path to each potential trading partner. Therefore, the analysis of competition was made in [1] by using the Lerner index. In the WSPP, however, the availability of transmission service is not mandatory and would be the key to the consummation of trades between intending utilities. Furthermore, transmission service is also a commodity that is being offered for trade. Hence, one would have to measure competition in the tradings of transmission as well. For the foregoing reasons, a direct application of the Lerner index might not reveal the degree of competition.

The efficiency analysis in [1] consists of two concepts. The first is that of obtaining the ratio of actual to potential gains with different constraints such as transmission and the spread between the buyer's and seller's costs. The examination of the ratio of actual to potential gains is proper. But, in the WSPP experiment, due to a large penetration of hydro energy from BPA and other participants, one has to account for the variations in riverflows. Although the examination of the spread between the seller's and buyer's cost is pertinent, reference [1] neither extends the analysis by attempting to explain why certain transactions with a large spread were not reconciled nor does it question if transactions with the spread of more than 10 mills were not consummated. Surely, unconsummated transactions with a large spread reduce the production efficiency.

The second concept used in [1] is that of a statistical analysis. A multiple regression and tests on the statistical significance of constants have been made. In the WSPP Experiment, such tests would not be directly applicable again because of the variability in the hydro energy production, transmission bottlenecks, and the contractual entitlements of entities to the transfer capacity in the lines.

Analyses to test the statistical significance of the number of trades per hour, volume of trade or actual dollars is not very meaningful because of the following. The counting of number of trades is unworkable and poses difficulties such as the following: (1) In a simultaneous buy and sell situation, is the number of trade one or two? (2) If the parties post four quotes of smaller quantities, say, instead of one quote of four times the quantity of smaller quotes (same total MWh), should the number of transactions be counted as four or as one? (3) How should transactions such as diversity sale and return of energy for capacity be counted?

The price and quantity of energy traded is greatly affected by the surplus hydro energy, particularly during the wet seasons. This and the change in the amount of hydro energy from the year previous to the experiment have to be factored into such analyses involving the volume of trade or the actual dollars. Without such adjustments, tests would be meaningless.

In chapter 3 certain tests have been outlined for idealized experiments. The applicability of the tests to the WSPP is discussed below.

Applicability of Tests Proposed in Chapter 3

The general tests under Category 1, GT1 to GT3 to measure the enhancement of trade, simulation of joint dispatch, and frequency of differences in λ, are directly applicable to any experiment, power pool or brokerage.

The category 2 tests to evaluate the functioning of the bulk power market are also applicable to any experiment. Note that tests BP1 and BP2, using the differences in λ, are the cornerstones and measure the improvement or possible improvement in production efficiency. Tests BP3, BP4, and BP5 provide certain insights and statistics. Test BP6 to measure the degree of participation is also applicable to the WSPP situation.

The category 3 tests, T1 to T4, to evaluate transmission market are also directly applicable to the experiment. Test T5 is of particular interest to WSPP where the EA appears to be prevalent. This test (or others of this nature) is of extreme importance in measuring the effect of transmission access or denial on production efficiency. Note that the tests make a qualitative assessment of production efficiency. If serious concerns come to light from such tests, transmission access may well be an issue.

The WSCC region is somewhat unique in the sense that the PNW and the desert southwest both compete to sell to the California market when the PNW utilities are not in a surplus situation. When the PNW is in a surplus situation, the desert southwest cannot compete with the PNW due to the lower incremental cost of hydro energy of the PNW.

The network of WSCC is complex. In spite of this, one could break it down to modules of three interconnected systems to suit the analysis of chapter 2. However, the analysis of chapter 2 applies to three idealized systems among which energy can be exchanged to improve production efficiency. In the idealized system, recall that the lines were either owned by the utilities in their territory or that the middle utility B had an entitlement in the transfer capacity between it and C (See Figure 2-1). The contractual obligations allocating transmission entitlements to several parties in the WSCC region are not amenable to the idealized analysis of chapter 2. Therefore, in spite of a segregation of the network into three radially interconnected systems, the analysis of chapter 2, particularly in regard to the pricing of transmission, would be inapplicable due to the contracted obligations. Contractual obligations between the major IOUs in California mean that the unused transmission service is not in the open market where all could have free access to it. Entitlements must be offered to the other companies in the proportion of their relative percentage shares. The analysis of Chapter 2 will not be directly applicable to the WSPP Experiment on this account as well. All the same, if the tests reveal a large amount of unrealized production efficiency, the transmission charges as they relate to the ratios of λs can be examined according to the principles proposed in Chapter 2.

As an example, with a knowledge of the λs of neighboring utilities in any hour, the posted transmission service rate can be compared with the required benefits under FA, EA, and SPS. A computation and collection of such data for major utilities owning transmission would portray the percentage of time the transmission price was equal to less than the implicit price that would have existed under EA, FA, or SPS. The examination will help determine when the pricing of transmission has lead to loss of production efficiency and when the loss emanated from bottlenecks, stability, reliability, or other reasons.

Required Data

One of the goals of this research was to identify the data to be collected in energy exchange experiments. It can be seen from the proposed tests that the required data are the usual system data such as the actual hourly costs of production, line loadings, number of transactions rendered possible or not possible, etc. However, the data have to be manipulated to obtain certain ratios between λs or to calculate their maximum, minimum, or average values.

While the list of data is obvious from the tests, the following, in addition to the joint dispatch simulation, is a list of principal items of the data and their manipulation.

Data List

- Hourly incremental costs.
- Quotes for buying and selling of commodities (Costs, block size and duration for capacities, energies, and transmission service).
- Consummation price of transactions.
- Number of transactions not possible due to
  a. lack of transmission service (absence of quotes)
  b. technical reasons
  c. pricing reasons
- Number of transactions possible.
- Amount of hydro energy production.
- Amount of energy spilled.
- Statistics regarding the energy generated, load, energy sold as firm or interruptible, losses, energy sold and purchased from extra-regional entities during the year of the experiment and the year before.
- Hourly transmission loadings or the available transmission capacity in major interconnections.

Data Manipulations

The application of the tests would require some manipulations. They are:

Calculation of all combinations of ratios of λ in each hour

Calculation of all combinations of differences between λs in each hour

Differences between the posted prices for capacity and energy

Calculation of the products of block size x number of hours for capacity posted for sale.

Calculation of frequency distribution for transmission service price

Deviation of consummation prices from posted prices

Deviations of energy transaction prices from $(\lambda_c + \lambda_a)/2$

Calculation of average, minimum and maximum values of price of transactions

Table 5-1 lists the data required for the application of tests proposed in chapter 3. The required data for the indicated tests are cross referenced in the table. The list of data in the left hand side of the table may vary somewhat to accommodate the peculiarities of a region.

Conduct of Idealized Experiments

The preceding has indicated that the experiments conducted so far have some shortcomings and are not amenable to easy analysis. The biggest problem appears to be that of calculating the incremental benefits due to an experiment.

We have also alluded to complex transmission configuration compared to the idealized three radial systems of Figure 2-1, rendered further complex by contractual obligations. The legal and contractual agreements may contribute to the non-achievement of maximum production efficiency. On top of this, we have stated that the primary question is that of achieving the maximum production efficiency. The secondary question is that of a "fair" and "appropriate" share of the gain to the several parties. The debate

TABLE 5-1

DATA REQUIREMENTS FOR THE APPLICATION OF TESTS

Data required / Test	GT1	GT2	GT3	BP1	BP2	BP3	BP4	BP5	BP6	T1	T2	T3	T4	T5	T6
1. Monthly energy demand															
a. current year	x														
b. previous year	x														
2. Monthly hydro generation															
a. current year	x							x							
b. previous year	x														
3. Monthly total non-hydro generation															
a. current year	x							x							
b. previous year	x														
4. Firm purchases & sales in the region															
a. projected for current year	x														
b. previous year	x														
5. Extra-region monthly purchases & sales	x														
6. Spilled energy	x														
7. Hourly cost of generation			x	x	x		x	x	x		x	x	x	x	x
8. Details of posted quotes															
Price of energy				x	x	x		x	x				x		
Block sizes				x	x	x			x				x		
Number				x	x	x			x				x		
Duration				x	x	x			x				x		
Party sold to and consummation price				x	x	x		x	x				x		
Price of transmission quotes										x			x		x
Location of and amount of transmission offered										x	x	x	x		
9. Hourly transmission line loadings or available transfer capacity in major transmission links														x	
10. Forced outage rates, incremental costs of production and other details for joint dispatch simulation		x													

about the division of gains can be as varied as one's perception of fairness.

During an experiment, the intent is to create unimpeded trading as close to the idealized circumstances as possible. Without unimpeded trading, the application of tests and other measurements may not reveal much information regarding improvements in production efficiency. The following sets out an alternative method of conducting experiments which avoids the above shortcomings.

The Idealized Experiment

Under this suggested approach, a voluntary agreement between the participants would suspend the legal and contractual obligations in regard to transmission access for the duration of the experiment. Then, in a region under experimentation, the interchange dispatching strategy would be that of displacing the highest priced generation by the lowest priced one, limited by the technical constraints and quantities of energy available.

Under this strategy the production efficiency may increase marginally or to a high degree depending on the state of coordination present before the experiment. Each participant owning or having entitlements to transmission will collect an appropriate amount based on EA, FA or the incremental costs of providing transmission. Because of the dynamic nature of the market, the principle used for transmission pricing could change from hour-to-hour. In a given hour, EA might provide the maximum benefits, while in another hour the FA or the incremental cost approach might produce higher revenues to the provider of transmission. The charges for providing transmission to result in a benefit not less than which would accrue without the experiment can be calculated by a central computer.

During the experiment, the benefits to all the parties will not be less than the benefits without the experiment. If there is a vast improvement in production efficiency, some entities may obtain more benefits than would be possible without an experiment. The degree of success of the experiment can be easily calculated. It is the difference between the total actual costs of production during the experiment and the total cost of production calculated by a central computer hour to hour according to the operating practice existing prior to the experiment.

Two potential problems should not be overlooked. The first is that of a division of incremental gains. The incremental gains may accrue to entities other than the providers of transmission service who would price the transmission service (price varies from hour-to-hour) to recoup the same benefits as under the old operating practice. In the years after the experiment, therefore, if such free access to transmission were to continue, the providers of transmission service would require a share of the incremental gains. Discussions regarding each party's appropriate share of such incremental gains is beyond the scope of this report.

The second is that of conducting and coordinating the experiment. Certainly, in view of the new operating procedures during an experiment, quick decisions have to be taken regarding reliability levels, loading levels of lines and machines, stability margins etc. Such decisions are hard to make where previous experience in certain network flow patterns that may arise during an experiment is lacking. This aspect coupled with that of a central computer to make calculations of gains under standard operating practice would require a considerable amount of effort and expense from the participants. The mathematical model to mimic standard operating conditions would be complex in certain situations.

The following is an example of the application of these concepts to the conduct of the WSPP Experiment. The example is, perhaps, simplistic and needs further refinements. In spite of this, we believe that the principles are defensible.

Example of an Idealized Experiment for the WSCC

In the WSPP context portions of the PNW Act and all the other aspects of intertie agreements dealing with entitlements would have to be rendered inoperative for the duration of the experiment by a voluntary agreement among the participants. One would allow the PNW entities to have a first call on the BPA quotes in order to give them a priority on BPA surpluses in accordance with the PNW Act.

All the parties to the experiment would post buy and sell quotes. The quotes must reflect their incremental costs (as, for example, in the Florida Brokerage). In the case of BPA, although it is preferable to see quotation of incremental cost of production, a fixed price under surplus or near surplus situations would not defeat the purpose of the experiment. But, the important feature is that the quotes must be resolved on a high-low basis by necessarily providing transmission service subject to the condition that transfer capacity is available without jeopardizing reliability, stability and other technical considerations.

In the event that the quotes of BPA would be matched by other PNW entities for export to the South, the access would be guided by ownerships, entitlements or the then current intertie access policy. While invalidating certain provisions of the contracts in regard to transmission entitlements, certain aspects can be maintained without jeopardizing the experiment. There could be a problem regarding truth in the disclosures of costs that would be reflected in the quotes.

A central computer would simulate a dispatch under the standard operating practice and would calculate the benefits to the transmission owners or owners of entitlements. Such owners would collect an amount equal to the benefits under the standard practice from those to whom transmission was made available. The total increase in gains (decrease in production costs due to the experiment) can also be calculated by the central computer and would be directly attributable to the experiment.

While the above represents the rudiments of an idealized experiment, a considerable amount of thought on additional factors regarding its implementation would be required.

CHAPTER 6

CONCLUSIONS

There is a great deal of interest in energy exchanges and transmission access at the present time. Many concerns and proposals to improve the efficiency and competition in the bulk power market are being heard from the utility industry, consumers, and the regulatory bodies. Pricing of transmission service, open access to transmission, deregulation of the industry, and effects of "bypass" (created by wheeling) on the consumers are but some of the hotly debated topics. In the light of calls for reform, change, and the maintenance of status quo, FERC has authorized two experiments: the Southwest Experiment during 1984-1985, and the WSPP Experiment that is now being conducted. In the conduct of such experiments the question as to how the incremental benefits arising from the experiment can be quantified occupies the center stage. The allied question is, of course, what data are to be collected for such an evaluation.

The main object of the report was to identify a list of data to be collected during an experiment to (a) quantify total and incremental benefits, (b) measure the degree of competition among participants, and (c) measure transmission restriction. With the national interest in the WSPP Experiment, another concern of the report is that of examining the experiment and the identification of "suitable" methods to measure the resulting benefits.

The report examines wheeling and pricing principles for the provision of transmission service. The term "attitudes" has been used rather than "pricing principles" to reflect the instantaneous reactions of the operating staff in a dynamic market where prices fluctuate from hour-to-hour and a buyer of energy in any particular hour may find itself a seller in the next.

Tests have been proposed to measure production efficiency and competition in idealized experiments. The network in the WSCC region and the ownerships of and the entitlements to the transmission capacity have been described. The application of some tests, particularly in regard to transmission, would not be possible to the WSPP Experiment because it deviates far from the idealized situation envisioned. The WSPP Experiment does not fit the idealized concept due to contractual obligations arising from joint ownership of lines and entitlements to transmission capacity.

However, a majority of tests proposed to measure the production efficiency are applicable to the WSPP. It has been pointed out that the definition of incremental cost in the California Power Pool Agreement is not very clear and may not be conducive to the attainment of maximum production efficiency. This can be confirmed by the application of tests to measure production efficiency.

A list of data to be collected during idealized experiments for the application of the tests has been proposed. Essentially, the data consist of the hourly generation costs, quotations for buying and selling power, consummated prices for transaction and the amount of energy generated by different fuel types. The application of the tests would, however, require the manipulation of data to obtain certain frequency distributions, differences in buy and sell quotes, etc. Such manipulations in the present day of electronic computing are trivial.

As a sequel to the analysis presented in the report, a method of conducting idealized experiments has been suggested. It is important to remove the impediments to free flow of energy, such as ownership entitlements, in order to assess the maximum production efficiency attainable in idealized experiments.

Epilogue

The following are some comments in the light of the analyses presented heretofore.

Debates on power transfer embrace several aspects. The concern is about the sharing of gains in situations when (1) a private generator sells to a private user using a particular utility's network (both the generator and the user are assumed to be located in the utility's service territory) and (2) a requirement customer or a private user purchases energy from a regulated utility that does not service the customer's geographic location using the transmission service of a utility serving the geographic location of the purchaser. In the experiments (WSPP and SW), however, it is primarily a question of improving the production efficiency in a region.

Therefore, the primary concern under the latter circumstance of the experiments should be that of finding out the improvement in production efficiency possible. To first address the issue of transmission access or forced wheeling would reverse the logic of examination. Certainly, after establishing that there are unrealized efficiency gains, one must examine if the non-availability of transmission was the reason for the unattained efficiency. It is believed that the maintenance of this logical order is vital in the evaluation of experiments.

This report has attempted to do so, that is, that of maintaining the attainment of production efficiency as the main concern. The report has examined certain transmission pricing aspects, keeping in mind that they are questions secondary to those pertaining to production efficiency.

APPENDIX A

BROKERAGE SYSTEMS

This appendix is intended to describe the Brokerage system in terms of the sale of economy energy. Longer term transactions that may be entered into in a Brokerage System is not of relevance to the thrust of this report. A background knowledge regarding economic dispatch is required for the understanding of the following. For the uninitiated, Appendix B of the September 1987 NRRI report entitled Non-Technical Impediments to Power Transfers is suggested as background reading.

Consider three interconnected systems. Ignore for the moment the interchange capacities and other transmission restrictions. We are concerned here only with the formation of the buy bids and the sell quotes.

In any one of the three systems, for illustrative purposes, let the load in any particular hour be, 5000 MW. This demand is met by a mix of resources with increasing average value of incremental cost of production. The incremental cost, λ, of producing electricity in thermal generating units is depending on the load of the machines. The value of λ represented in the following is an average value considering all load levels. The units of λ is \$/MWh. In the following sections, the units of λ have been omitted for convenience in writing.

Let the demand of 5000 MW be supplied by the following generation.

		Cap.MW	λ \$/MWh
1.	Nuclear	1200	0.6
2.	Hydro	1500	0.5
3.	Firm purchase	1000	1.2
4.	Coal burning unit	300	2.1
5.	Coal burning unit	600	4.2
6.	Oil burning unit	50	8.0
7.	Oil burning CTU	200	9.0
8.	Oil burning CTU	150	10.0
		5000	

The system incremental cost (System λ) is 10 \$/MWh.

In the above example, we have assumed that the generating units with lower λs are fully loaded first before using those of higher λs to meet the load. This is not the case in reality. In practice, the generating units are put in an "Economic Dispatch" mode. In such a case as well, it is well known that the system λ is a nondecreasing function of load, as shown in Figure A-1. One could consider discretizing the load axis and of obtaining a stepwise approximation to the curve as in the figure. The discrete values of load and λ obtained thus could be used in the above mentioned table with increasing values of λ.

The Utility, in order to displace or avoid its high cost of generation, would be willing to buy power and off load its units. Such a purchase of power would reduce internal generation which can be seen in Figure A-1 as a decrease in load. In order to make such a purchase worthwhile, the price of purchased power should be less than or equal to the price at which the Utility can generate power itself. In this figure, the bids to buy power in blocks would then be at: C_1 at a price some what less than λ_1, C_2 at λ_2, etc.

Returning to our illustrative utility, the application of these concepts show that the buy bids for purchases of power would be,

Cap.	λ
150 MW	10.0
200 MW	9.0
50 MW	8.0

When these are posted on the bulletin board or entered into the computer, they form part of the buy bids to be reconciled in a manner discussed later.

In regard to sell quotes, this utility would have to use generating equipment that is in reserve at that particular hour to make sales to outside parties. For example, if the next more expensive units in reserve are a 100 MW CTU at an average λ of 10.5 and 150 MW CTU and an average λ of 11.0, the sell quotes would be as follows:

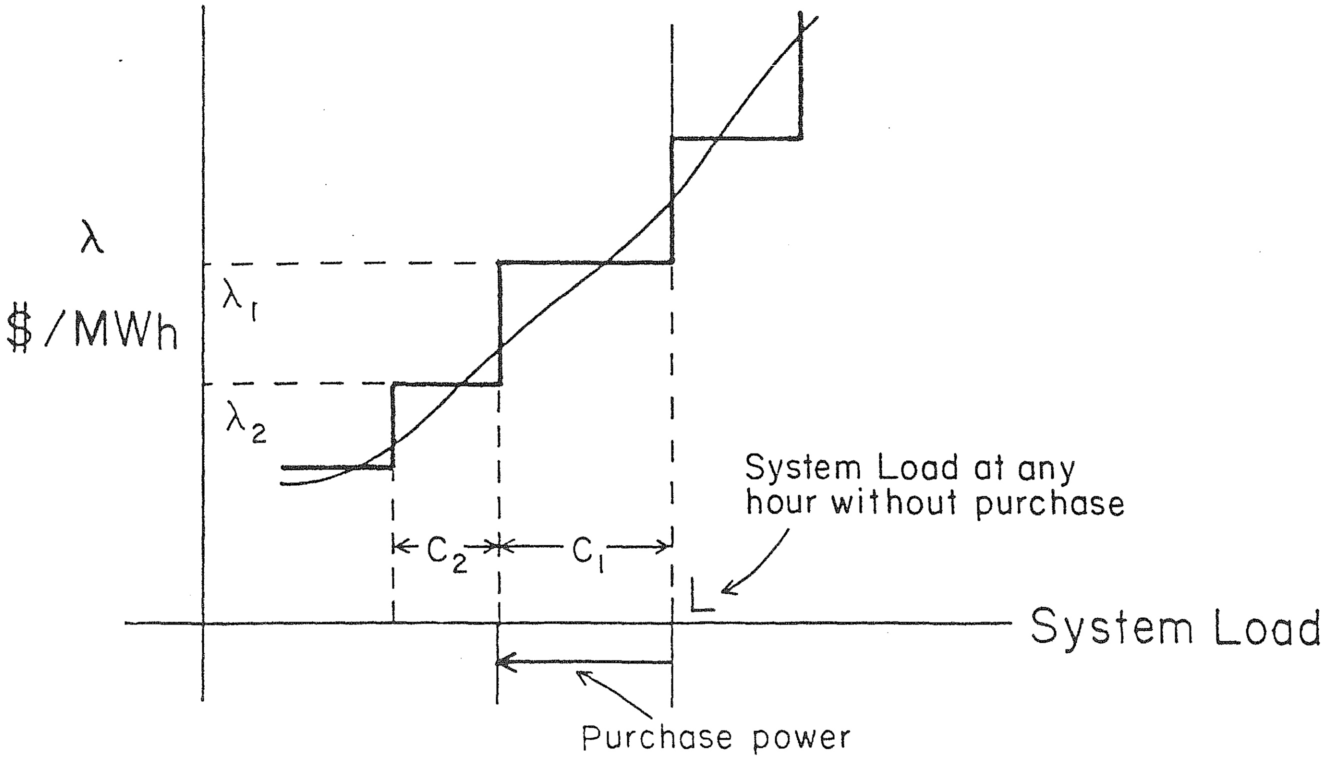


Figure A-1 Block representations of incremental costs of production

Sell Quotes

Cap.	λ
100 MW	10.5
150 MW	11.0

Resolution of Bids and Quotes

Consider three interconnected utilities A, B and C which have posted the bids and quotes in any particular hour as shown in Table A-1. Note in the above that our previous illustration refers to Utility C. It is neither necessary for the Utilities to post both buy bids and sell quotes nor is it necessary for the Utilities to be willing to displace all their generation due to engineering constraints such as minimum generation level of units, thermal cycling problems etc. For example, Utility C may not post its sell quotes because of its knowledge of the market where its sell quotes are very expensive and have no chance of finding a buyer amidst A & B (see Table A-1). In a similar vein, Utility A may consider its buy bids to be superfluous since all the sell quotes are at a price well above that of its buy bids.

TABLE A-1 Buy Bids and Sell Quotes

Utility	A		B		C	
	MW	λ	MW	λ	MW	λ
Sell quotes	100 150 50	5.0 7.5 9.0	200 200	7.0 8.0		
Buy bids	300 800	3.0 2.0	800	6.0	150 200 50	10.0 9.0 8.0

To achieve higher Production Efficiency, more expensive generation must be displaced by the lower cost generation. In order to achieve the maximum gain attainable, the quotes are matched in a "high-low" order as explained below.

First, the sell quotes are sorted in an increasing order of λ and the buy bids are sorted in a decreasing order of λ as in Table A-2. Then the consummation of a deal between A and C in the first line of the table λ_A = 5, λ_C = 10) improves Production Efficiency. This process is continued down the table till the λ of sell quotes are equal to and not higher than the λ of buy bids.

TABLE A-2 Sorted Sell Quotes & Buy Bids

Sorted Sell Quotes			Sorted Buy Bids		
Utility	Cap.	λ	Utility	Cap.	λ
A	100	5.0	C	150	10
B	200	7.0	C	200	9.0
A	150	7.5	C	50	8.0
B	200	8.0	B	800	6.0
A	50	9.0	A	300	3.0
		A	800	2.0	

Table A-3 indicates the resulting transactions that would enhance Production Efficiency.

Benefits and their Division

We shall review certain principles regarding the evaluation of the economic benefits.

The upper part of Figure A-2 portrays the incremental cost of production in two systems A and B as a function of their loads in a continuous fashion. This ubiquitous "λ curve" shows the incremental cost of production as a nondecreasing function of load. In reality, there are some finite jumps and discontinuities in the "λ curve" of Utilities but, it is

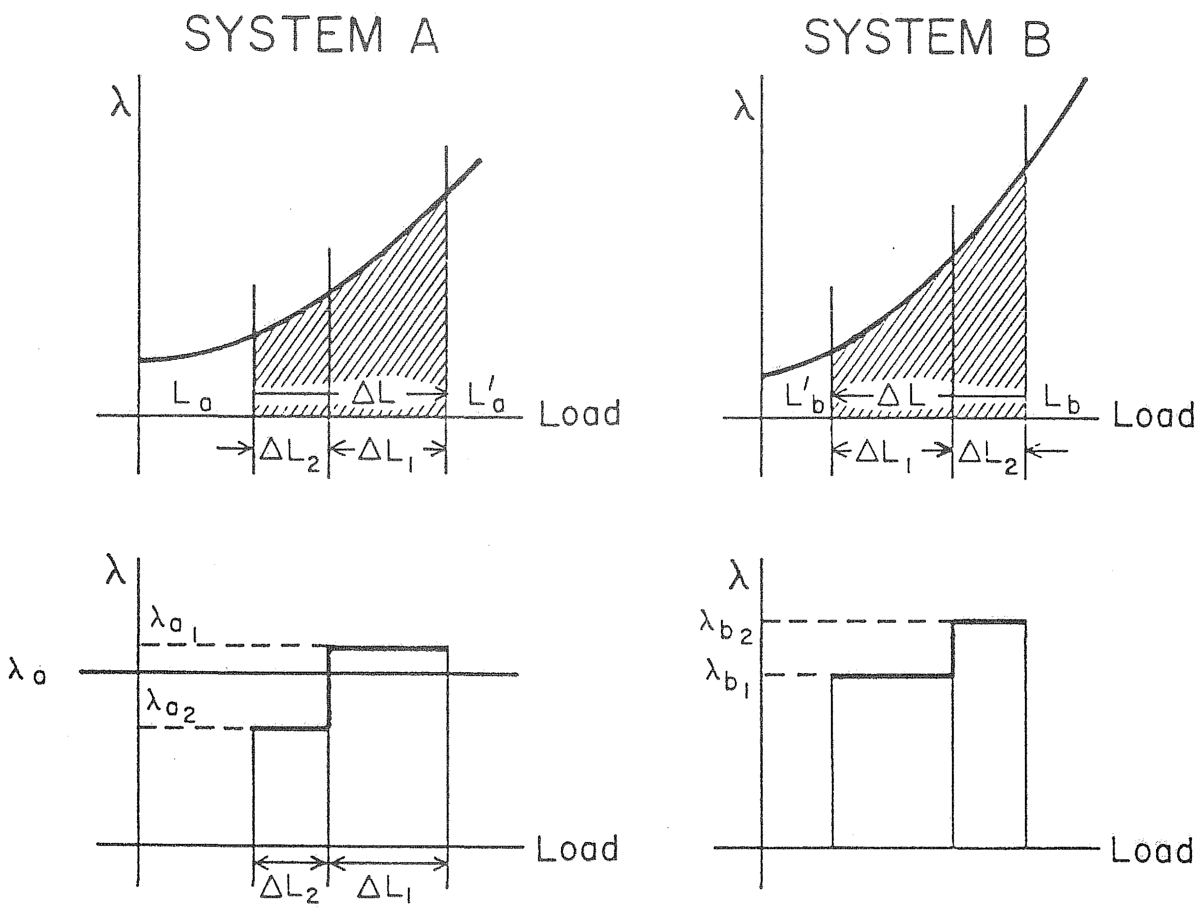


Fig. A-2 Effects of sales and purchases

TABLE A-3 Transactions

No.	Transaction Between	Cap.	λ_s of Transacting Parties	
1	A-C	100	5	10
2	B-C	50	7	10
3	B-C	150	7	9
4	A-C	50	7,5	9
5	A-C	50	7,5	8

important to observe that the curve is a monotonic function of L, i.e., nondecreasing with load.

Let L_a and L_b be the loads in the two systems before the interchange. A sale of ΔL from A to B reduces the generation in B to L_b' and increases the generation in A to L_a'. Then, the avoided fuel cost in system B is the hatched area between the "λ curve" and the Load axis and the incurred fuel costs in system A is a similar area shown hatched in the figure. The incurred cost in this illustration does not consider start up costs, the cost of incremental losses, etc.

The net economic benefit from the transaction is therefore the incurred cost minus the avoided cost and is available for division between the two transacting parties. If there are more than two transacting parties, the total benefits available for division among them is the sum of all avoided costs minus the sum of all the incurred costs.

Before considering the distribution of these benefits, let us examine the effects of a stepped approximation to the λ curves.

Transacting parties in a brokerage system post the bids and quotes in quantum blocks. The lower half of Figure A-2 depicts a step wise approximation to the λ curve. Here, λ_{b1} represents the <u>average</u> avoided cost by importing ΔL_1 to utility B and λ_{b2} is the average avoided cost by importing ΔL_2, after importing ΔL_1. Similar values for the exporting utility A are obvious from the figure. Then the following relations are valid.

1. The total avoided cost shown hatched in the figure = $\lambda_{b1} \cdot \Delta L_1 + \lambda_{b2} \cdot \Delta L_2$
2. Total incurred cost shown hatched in the figure = $\lambda_{a1} \cdot \Delta L_1 + \lambda_{a2} \cdot \Delta L_2$
3. Area under the "λ curve" of system B between ordinates at L_b and at a distance ΔL_1 to the left of $L_c = \Delta L_1 \cdot \lambda_{b1}$

Division of Benefits

Traditionally, the benefits due to Economy Energy interchanges have been shared equally between the buyer and the seller. There has been some debate about this trading practice, some arguing that it exercises price discrimination and the others that it represents the value of service and that it has stood the test of time in the market place. Such a debate is neither the intent nor is it within the scope of this report.

In any event, it is obvious that an equal division of benefits means splitting the difference between avoided cost and incurred cost equally. The application of these ideas is shown by enlarging Table A-3 in Table A-4

TABLE A-4 Division of Benefits

No.	Transaction Between	Cap. MW	λ_s of Transacting Parties		Total Benefits $	Benefit to A	B	C
1	A-C	100	5	10	500	250		250
2	B-C	50	7	10	150		75	75
3	B-C	150	7	9	300		150	150
4	A-C	50	7.5	9	75	37.5		37.5
5	A-C	50	7.5	8	25	12.5		12.5
					1050	300	225	525

One observation, perhaps an obvious one, is pertinent. Note that in order to achieve equal division of benefits, the transaction price will be half the sum of the two lambdas. For example, in transaction number 2, the price paid per unit of energy by C (buyer) to B (seller) would be (7 + 10)/2 = 8.5 \$/MW•h.

Summary

The above has outlined the operating principles of a Brokerage System. It must be noted that in practice several other features such as the transmission loadings, systems security, etc., may or may not permit certain transactions. All the same, the principles portrayed serve as background material to understand the Experiments discussed in the main body of this report.

APPENDIX B

THE WESTERN SYSTEMS POWER POOL EXPERIMENTS

Background

During the 1950's and 1960's the FPC performed studies that demonstrated the economic feasibility of an extra high voltage EHV intertie between the pacific Northwest and California. The FPC considered interconnection and coordination issues in its 1960 and 1970 National Power Surveys. The issues of coordination and energy interchanges become more important after the oil Embargo of 1974. Five regional reports on power pooling were prepared by the FERC during the early 1980's. Specific recommendations for improved power pooling were sent to congress. These documents helped provide the groundwork for the next information gathering phase by the FERC outlined in "Bulk Power Experiments" (Public Utility Fortnightly April 30, 1987).

The Southern Experiment on December 1983, FERC authorized a two-year experiment (Southwest experiment) under which six utilities were to trade power with relative freedom and to price it under a "zone of flexibility": no more than twice the average fully allocated cost for the participants and no less than half the average regional incremental running cost. Each company had to make its transmission facilities available to the other five to allow sales among the entire group. The companies were being allowed to retain for themselves 25% of the profits from such sales. The participating companies were: Arizona Public Service, El Paso Electric, Public Service of New Mexico, Southwestern Public Service, the City of Farmington Electric Utility, and the Salt River Projects. In its opinion 203, which accepted the experiment for filing, the FERC cited planned experiments as the best method of gathering information and moving in a controlled manner towards regulatory change.

Following the Southwest experiment, over 50 utilities in the Western Systems Coordination Council (WSCC) negotiated the possibility of conducting the WSPP experiment in 1986. A group of 10 utilities and power agencies agreed to file at FERC a proposal to conduct a two-year experimental program (The WSPP Experiment) on bulk-power marketing that is similar to the

"Southwest Experiment". The WSPP experiment would include several innovative approaches to pool arrangements. Pacific Gas and Electric (PG&E) Company, on behalf of the WSPP participants, filed a request for approval by the FERC on November 7, 1986. The motivation for the experiment was to realize the economic gains possible in the bulk power market without the participants having to file for FERC approval of prices before the transactions could be consummated. Therefore, the participants sought a preapproved flexible and a broad band of prices for the commodities they intended to trade. The WSPP Agreement* allow for the following aspects during the experiment.

(1) Flexible pricing would apply to the marketing of three energy commodities: economy energy, unit commitment and firm system capacity and/or energy sale or exchange transactions; and to the marketing of transmission services;

(2) The flexible prices would be subject to certain ceilings: (a) the ceilings for the energy commodities' transactions would be based on costs associated with the highest fully allocated cost resource among Participants during The prior year; and (b) the ceiling for transmission service would be 33 percent of the difference between the highest and lowest decremental cost of generation among Participants during the prior year. There would also be a floor of 1 mill per kilowathour for transmission service reservation;

(3) Membership would be open to any utility interconnected with a Participant which owns or has entitlement to generation facilities and which operates its own control area or has appropriate arrangements with its control area operator;

(4) The WSPP would utilize an "electronic bulletin board" i.e., a central "Hub" computer to facilitate the daily exchange of buy and sell quotes among Participants;

---

* Western Systems Power Pool Agreement (Execution Copy).

(5) A committee drawn from a diverse mix of Participants (public and investor-owned utilities, and State and Federal agencies) would prepare for the Commission an interim and a final report on the results of the WSPP Experiment. The interim and final reports would include quantitative and qualitative analyses. In order to measure the effects on efficiency and competition.

Information on a number of variables would be collected and analyzed across time, including the volume of Participants' quotes and bids as well as actual transaction prices and volumes. (However, it is not known what data will be made available to the "hub" computer by the participants.) Participants would also provide qualitative assessments of the market context and changes in efficiency and competition, including the incremental volume of transactions made possible solely by the WSPP. The analyses performed with this information would be directed toward answering key policy question relating to efficiency, competition, and distribution of benefits; and

(6) No existing agreements would be replaced or superceded as a result of the WSPP, instead, the WSPP Agreement would provide another contractual option whereby the Participants could benefit from other trade opportunities to capture additional economies.

The Participants also requested waivers of certain of the Commission's regulations to allow the following: (a) that the WSPP Agreement be accepted as an initial filing under the FPA, (b) that application of FERC Order No. 84* be suspended for transactions made pursuant to this experiment, (c) that all other regulations relating to supplemental filing requirements with respect to transactions under the WSPP Agreement be suspended, (d) that the notice of termination be preaccepted, subject to the terms of the WSPP Agreement, and that the 120-day notice requirement be waived, (e) that the submission of a filing fee not be required for this filing, nor for any future filing necessary to add new participants; (f) that any and all other

---

* Order No. 84 requires that utilities limit percentage adders applied to third-party purchase power costs.

necessary waivers for the filing to be accepted be granted, and (g) that the jurisdictional utilities be allowed the option of not including any consideration of WSPP transactions in future test year period filings for ratemaking purposes covering the period of February 1, 1987 through January 31, 1989. The other option is that costs and revenues for WSPP transactions would be treated under existing retail and wholesale rate mechanisms. If Participants choose the first option, they must describe any method they propose to use to pass on to their customers any incremental benefits from WSPP transactions. (Docket No. ER87-97-00, p.7).

FERC found the WSPP's application to be deficient, particularly on transmission access and pricing question. Notices of intervention were submitted from several Agencies, Commissions and Counsels reflecting two different streams of opinions. The Public Service Commission of Nevada, the California Public Utilities Commission (CPUC), NCPA, BPA and Nevada Attorney General Office submitted notices of intervention (December 1986) supporting the WSPP filing. The main Opponents were the American Public Power Association (APPA) and ELCON. APPA filed a motion to intervene on December 11, 1986 requesting that the Commission (the FERC) not allow the Experiment to take place without modification and a hearing. APPA argued that the WSPP Agreement had not explained how its proposed market-based flexible rates for power and transmission service would result in a more efficient and competitive market. APPA asked for changes in the agreement to prevent abuse of monopoly power, particularly in the area of transmission service. APPA also questioned the application's treatment of the rate schedules as initial rates, which means they cannot be suspended by FERC. In addition, APPA complained that the WSPP does not provide a flow-through of all pool transaction benefits from the utilities to the rate payers. Also, APPA challenged the membership criteria because it excluded entities without ownership or control of a generating unit but which may otherwise have contractual rights to power and energy. APPA also contended that the "control area" criterion is vague. APPA requested clarification regarding how transmission losses would be determined and charged and requested that the participants identify non-participants or the amount of coordination transactions currently between participants and non-participants.

PG&E respond to FERC (January 6, 1987) regarding all the above concerns. PG&E claimed that the hetrogenity of WSPP membership provides an inherent safeguard of the competitive public interests in the West. PG&E also argued that the latitude in pricing services appears not to present a clear or present danger of monopolistic pricing. NCPA also responded stating that all pool transactions are voluntary and that any distribution of benefits from transactions should be deferred to subsequent rate cases. In addition, BPA stressed that the WSPP is a data gathering exercise for which there are no a priori answers. Therefore, participants request the commission to accept the agreement for filing without ordering a hearing during the two year experiment period.

FERC asked PG&E (January 15, 1987) to submit an amendment containing more information on how provisions for transmission service will increase competition and prevent abuse of monopoly power, and on development and dissemination of information on results of the experiment.

WSPP responded to FERC's request for more information about the scheme (ER87-97-001) saying that they do not claim that their proposed experiment "guarantees" a competitive market "as a result" nor do they "believe that the issue of potential 'monopoly power' can or should be determined in the proceedings." They also said that they did not see a need for an independent consultant to prepare a report or critique the program.

In supplemental motion to intervene APPA continued rejecting WSPP proposal claiming, that the response from PG&E did not contain necessary changes to the agreement underlying the proposal. APPA reaffirmed the positions in its earlier intervention and said that "to permit the proposed experiment to proceed without transmission access and rate protection requirements would fly in the face of the commission's obligation to establish fair prices and promote the policies of the antitrust law." [EUW, March 2, 1987]

The following is a summary of the Commission views and its response to APPA and ELCON arguments as expressed in Docket ...

Commission Views

1. Transmission Pricing:
   a. WSPP experiment will provide FERC with valuable information
   b. Competition is likely to occur in WSPP market because:

(i) Electronic bulletin board will provide participants a better and instantaneous information on prices and services

(ii) Number of participants will increase

(iii) Access to generation and transmission services will increase due to flexible pricing

c. Due to the facts that participants may become both a buyer and a seller, the variety of generation capacity in the region, the extent of the transmission systems in the West, and the number of alternatives available to each participant for the various transactions, any participants in WSPP will be able to affect the delivered price of electricity.

d. Since WSPP is a voluntary pool and offers an alternative to current arrangements, there is little potential for harm from monopoly.

e. APPA and ELCON have not provided bases to support their allegations for harm resulting from voluntary transmission access.

2. Pricing Flexibility

FERC finds that the flexibility proposed by WSPP for the sale of generation service will help in determining whether increased pricing flexibility for bulk power sales can improve efficiency by allocating scarce generating capacity to those entities that value it most. FERC found also that the definitive boundaries within which the prices can fluctuate will promote certainty.

3. Membership Criteria:

Under the WSPP proposal, an entity can join the pool if it is an electric utility which is interconnected directly or contractually with at least one other WSPP member, and which either owns, leases, or controls all or part of at least one generation unit, and operates its control with contract area operator. FERC believed that the membership criteria are fair and reasonable.

4. Revenue Treatment

The participants, under WSPP proposal, would treat benefits in either of two ways: (1) use traditional commission rate mechanisms, or (2) not include consideration of WSPP transactions in future test period filings but propose at the time of the relevant rate filing the method they will use to pass on the incremental WSPP benefits to requirement customers. FERC accepted either method as long as the jurisdictional utility proposes a mechanism to insure that at least 75 percent of the benefits attributable to an increase in the level of coordination sales under the WSPP, not already reflected in the utility's current requirements rates, are flowed through to the utility's requirements rate payers.* This revenue treatment would apply to coordination sales in both the energy commodities and transmission service.**

5. Transmission Losses and Nonparticipants Identification:
FERC conditioned the approval of the order on the requirement, which originally raised by APPA, that participants submit within 90 days from the date of the order a specification of how the losses shall be determined. FERC did not believe that the identification of nonparticipants or the amount of transaction between participants and nonparticipants, as required by APPA, was necessary.

6. Evaluation of the Experiment
The participants will provide FERC with interim and final reports. The reports, at a minimum, should help the commission distinguish competitive from non-competitive markets. The commission objective is to make sure that the reports are asking the right questions; proposing an analytical method that will be able to answer these questions; and providing reliable and consistent data. Thus, FERC is asking the participants to address the following type of questions:

---

* The split of benefit sharing to at least 75 percent to ratepayers and 25 percent to stockholders is a mechanism that was already adopted and tested in the Southwest experiment.

** FERC does not control the treatment of all the benefits that will result from the proposed experiment. The jurisdiction of the commission extends only to the portion of the benefits to be allocated to the investor-owned utilities' wholesale requirements service customers. The remainder of the benefit is under the control of state regulatory commissions through their regulation of the utilities' retail sales.

a - Was there any evidence that the allowed pricing flexibility enabled some participants to set monopoly prices for transmission and the other experiment services? If so, identify these situations.

b - Suggest "rules of thumb" that would enable the Commission to identify on a "before the fact" basis, situation in which a seller is likely to have the power to sell at monopoly prices.

c - Were there situations in which economic efficiency increased even though a seller was able to exercise monopoly power in setting transmission prices? If so, what distinguishes these situations from those in which the exercise of monopoly power led to loss of economic efficiency?

d - Is simultaneous purchase and resale not an adequate substitute for wheeling to ensure an optimal pattern of bulk power trades? If not, why not?

The Commission noticed that there would be two problems about the report and the evaluation process. First, the participants will not be willing to provide some very important data (e.g. the incremental costs, the transmission prices). Second, that there is no proposed well-defined analytical methodology to evaluate the experiment.

FERC offered the participants a choice between two options in order to produce a valuable evaluation to the experiment:

<u>Option A</u>:

The participants would be required to hire an outside consultant that will:

(1) develop a method of analysis.
(2) collect the necessary data (and maintain confidentiality).
(3) analyze the data to answer all the questions that has been raised.
(4) prepare the interim and final report.

<u>Option B</u>

The participants would be required to do two things:

(1) hire a consultant to advise them on the development of methodology

(2) hire at least 3 consultants to serve on a panel that will produce joint or separate written critiques of the interim and final reports.

FERC unanimously authorized the WSPP experiment plan [March 12, 1987), declaring the following:

- APPA's motions to reject the WSPP Agreement and initiate a hearing are denied.
- PG&E's request for waiver of the filing fees and all future filing fees is denied.
- PG&E's request for waiver to allow the agreement to be accepted as an initial rate is denied.
- PG&E's request for waiver of application of Order No. 84 is granted.
- PG&E's request for waiver of the Section 35.13 filing requirement is granted.
- PG&E's request for waiver so that the jurisdictional utilities be allowed the option of not including any consideration of WSPP transaction in future test year period filings for ratemaking purposes is granted, covering the two year period commencing the date that the WSPP begins operation, subject to the requirement that they flow a minimum of 75% of their profit to their requirements customer on current basis, as provided in the body of the order.
- The experimental rates proposed are accepted for filing as change in rates, to become effective for a two-year period concerning the date that the WSPP begins operation suspension or hearing.
- Summary judgment is ordered with respect to providing.

a - a satisfactory specification of how losses are to be determined.

b - the answers to additional questions to be addressed in the interim and final reports of the experiment.

c - the methodology, data collection, analysis and critique of the experiment.

d - supplemental filing regarding the review and report on estimates of percent of sales attributable to the WSPP in schedules A, B, C and D.

<u>List of Participants</u>

1) Arizona Electric Power Cooperative
Benson, AZ
2) Arizona Public Service Company
Phoenix, AZ
3) Bonneville Power Administration
Portland, OR
4) Department of Water Resources
Sacramento, CA
5) El Paso Electric Company
El Paso, TX
6) Nevada Power Company
Las Vegas, NV
7) Northern California Power Agency
Roseville, CA
8) Pacific Gas and Electric Company
San Francisco, CA
9) Pacific Power & Light Company
Portland, OR
10) Portland General Electric Company
Portland, OR
11) Public Service company of New Mexico
Albuquerque, NM
12) Sacramento Municipal Utility District
Sacramento, CA
13) San Diego Gas & Electric
San Diego, CA
14) Salt River Project Agricultural Improvement
and Power District Phoneix, AZ
15) Southern California Edison Company
Rosemead, CA

16) Puget Sound Power and Light Company
Bellevue, WA

17) Sierra Pacific Power Company
Reno, Nevada

18) Rocky Mountain Corporation

19) Montana Power

20) Riverside City

21) Anahiem City

22) Los Angeles Corporation

REFERENCES

[1] Jan Paul Acton, Stanley M. Besen, Regulation Efficiency, and Competition in the Exchange of Electricity, Prepared for the US Dept. of Energy by Rand, October 1985, ISBN 0-8330-76 86-3.

[2] Larry M. Kellerman, Joseph A. Vaccaro, Jr., Anatomy of a Power Sale, Public Utilities Fortnightly, vol. 120, No. 10, November 12, 1987.

[3] FERC Docket ER-87-97-001 Authorizing WSPP Experiment, March 12, 1987.

[4] Kevin Kelly et. al., Some Economic Principles for Pricing Wheeled Power, NRRI Report NRRI-87-7, August 1987.

[5] Kevin Kelly, Editor, Non Technical Impediments to Power Transfers, NRRI Report NRRI-87-8, September 1987

[6] Environmental Assessment, Proposed Near Term Intertie Access Policy, Office of Power and Resources Management, BPA, February 1985.

[7] Western Systems Coordinating Council, Coordinated Bulk Power Supply Program, 1986-1996, April 1, 1987.

[8] Draft Western Electricity Study Briefing Paper, Load/Resources Balances, Northwest Power Planning Council, February 3, 1988.

[9] Western Electricity Study Briefing Paper, Interregional Transactions, Northwest Power Planning Council, December 28, 1987.

[10] California Companies Pacific Intertie Agreement, August 25, 1966.

[11] California Power Pool Agreement, July 20, 1964.

[12] Intertie Agreement Between BPA and Pacific Power & Light Co., Contract No. DE-MS79-86BP92299, July 8, 1986.

[13] Agreement between BPA and Portland General Electric Co., August 6, 1965, Contract No. 14-03-55063.

[14] Contract between California Companies and Sacramento Municipal Utility District for Extra High Voltage Transmission and Exchange Service.

[15] United States Department of the Interior Bureau of Reclamation, Central Valley Project, California: Contract with California Companies for Extra High Voltage Transmission and Exchange Services, Contract No. 14-06-200-2947A, December 1967.

[16] Contract between the State of California and California Companies for the Sale, Interchange and Extra High Voltage Transmission of Electric Capacity and Energy. Contract No. 855524.

[17] Comments of Mr. Michael McDonald, General Manager, NCPA, before the hearing of California Legislature Assembly Committee on utilities and commerce, chaired by Glen Moore, October 1987.