Operations, Maintenance, and Replacement 10-Year Plan 1990–1999

1989 Utility OM&R Comparison

Bonneville
POWER ADMINISTRATION

September 1990

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DOE/BP--1481

DE91 006260

1989 UTILITY OM&R COMPARISON

**A COMPARISON OF
BPA AND SELECTED UTILITY
TRANSMISSION, OPERATIONS
AND MAINTENANCE COSTS**

**September 1990
Bonneville Power Administration**

MASTER

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REPORT ON REVIEW OF INTERUTILITY COMPARISON OF TRANSMISSION, OPERATIONS AND MAINTENANCE COSTS PREPARED BY TOUCHE ROSS INTERNATIONAL	

EXECUTIVE SUMMARY

For the past several years, competing resource demands within BPA have forced the Agency to stretch Operations, Maintenance and Replacement (OM&R) resources. There is a large accumulation of tasks that were not accomplished when scheduled. Maintenance and replacements and outages, due to material and equipment failure, appear to be increasing.

BPA has made a strategic choice to increase its emphasis on OM&R programs by implementing a multi-year, leveled OM&R plan which is keyed to high system reliability. This strategy will require a long-term commitment of a moderate increase in staff and dollars allocated to these programs.

In an attempt to assess the direction BPA has taken in its OM&R programs, a utility comparison team was assembled in early January 1989. The team included representatives from BPA's Management Analysis, Internal Audit and Financial Management organizations, and operation and maintenance program areas.

BPA selected four utilities from a field of more than 250 electric utilities in the U.S. and Canada. The selection criteria generally pertained to size, with key factors including transformation capacity, load, gross revenue, and interstate transmission and/or marketing agreements, and their OM&R programs.

Information was gathered during meetings with managers and technical experts representing the four utilities. Subsequent exchanges of information also took place to verify findings.

The comparison focused on:

- Transmission operations and maintenance program direction and emphasis;
- Organization, management and implementation techniques;
- Reliability; and
- Program costs.

Key Findings

BPA's Operations and Maintenance Programs are comparable to those of the comparison utilities. Cost comparison data indicate that BPA's average operations and maintenance costs are at reasonable levels, with respect to what is expected for a utility of BPA's size and mission.

Although few, if any, definitive conclusions can be drawn from utility cost comparisons due to differences in the utilities' size, configuration, and mission, the comparison does help verify that which might be recognized intuitively: utilities with the largest capabilities tend to accomplish more and spend more.

Expected benefits from economies of scale are also apparent. The utilities with the greatest transformation capacity (mVA) had the lowest costs per megawatt-hour (MWH) transmitted.

From a technical standpoint, BPA's practices are generally consistent with those of the four comparison utilities. Variations in program intensity and direction primarily affect maintenance and replacement activities.

For example, two of the utilities use preventive maintenance service intervals similar to BPA's. The other two utilities are sufficiently satisfied with the overall condition of their transmission systems and have chosen to lengthen service intervals in an effort to contain costs.

Another example of program variation is in the area of staffing. Staffing levels are determined differently by all four utilities. BPA uses various types of subjective analyses, based on work-hour standards, which are coordinated by Area offices and Operations, Maintenance and Construction (OM&C). The other utilities base staffing on workload requirements, emergency restoration response times, and/or historical trends. One utility, at the time of this comparison, actually had no dedicated transmission system maintenance personnel due to extensive use of regional customer service crews.

While these variations may serve as a valuable reference for BPA, comparisons with other utilities should be made with caution. Utilities, whose primary mission is to serve the end use customer, operate in a very different environment than a wholesaler such as BPA. Consequently, what might work well for one or another utility may not apply to BPA.

However, general trends should not be ignored by BPA. The utilities profiled in this study are setting or following trends toward increased dependency on contractors, longer maintenance intervals, and expanded use of non-operator craft personnel for switching. BPA will examine these trends and specifically explore the following recommendations:

- BPA could benefit from a comprehensive review of its preventive maintenance service intervals, known as Program Level Guides (PLG's). The review should focus on identifying opportunities to lengthen service intervals whenever system reliability and safety would not be jeopardized.
- Some efficiency improvements might be possible by expanding BPA's use of non-operations personnel to accomplish routine operations activities. A corresponding change — operations personnel performing some routine maintenance tasks — may also provide some efficiency improvements.
- BPA could increase the efficiency of its field maintenance units by expanding its use of diagnostic techniques and in-service equipment monitoring.

In conclusion, it is important to emphasize that this comparison should not be viewed as a competition among the participants. These are not "good," "better," or "best" conclusions being offered and no such conclusions should be drawn. The utilities which participated are four of the largest and most successful electric power utilities in the world. Each of them were responsive to the electric power industry's needs in the 1980's and continue to be so in the 1990's. As might be expected, each of these utilities is positioned differently in starting the new decade.

BACKGROUND

For the past several years, competing resource demands within BPA have forced the Agency to stretch Operations, Maintenance and Replacement (OM&R) resources. There are fewer OM&R personnel on staff today than there were in 1975 (Figure 1 "Operations, Maintenance & Construction: Staffing vs. BPA Plant in Service"). Recent BPA studies have shown that the reduction of OM&R programs may have gone too far. There is a large accumulation of tasks that were not accomplished when scheduled. Maintenance and replacements and outages, due to material and equipment failure, appear to be increasing.

BPA has made a strategic choice to increase its emphasis on OM&R programs by implementing a multi-year, leveled OM&R plan which is keyed to high system reliability. This strategy will require a long-term commitment of a moderate increase in staff and dollars allocated to these programs.

Figure 1
**Operations, Maintenance & Construction
Staffing versus BPA Plant In Service**

OPERATIONS, MAINTENANCE & CONSTRUCTION STAFFING VERSUS BPA PLANT IN SERVICE

In an attempt to assess the direction BPA has taken in its OM&R programs, BPA compared itself with other utilities of similar size, transformation capacity, load, gross revenue, etc. and their OM&R programs.

A utility comparison team was assembled in early January 1989. The team included representatives from BPA's Management Analysis, Internal Audit and Financial Management organizations, and operation and maintenance program areas. To assure the appropriateness and accuracy of all cost comparisons, the team secured the services of the accounting firm of Touche Ross International. The final report from Touche-Ross & Company is included as the Attachment titled *Report on Review of Interutility Comparison of Transmission Operations and Maintenance Costs*.

METHODOLOGY

The first task was to determine factors of comparability and to identify candidates for comparison. BPA, as one of a small group of Federal Power Marketing Agencies assigned to the U.S. Department of Energy, is unique in the electric power industry. As the primary electric power transmission and marketing organization in the Pacific Northwest, BPA operates and maintains a large inter-connected, multi-state bulk power transmission system. Its customers are utilities, with the exception of relatively few direct service industries (DSI's). BPA has no distribution system, and accordingly, no direct end-use customer responsibilities, except for DSI's. Yet, in terms of gross revenues, megawatt-hours (MWH) sold, and transmission plant in service, BPA is one of the largest utilities in the world.

The transmission system design and configuration requirements, and the operational realities dictated by such a large system make "apple to apple" comparisons with other utilities unlikely, at best. Nonetheless, the comparison team identified several comparable key factors which generally pertain to size. These factors were:

- (1) Miles of transmission lines;
- (2) Installed transmission transformation capacity;
- (3) Peak load;
- (4) Gross revenue from sales of electric power; and
- (5) Interstate transmission and/or marketing agreements.

Out of more than 250 electric utilities considered in the U.S. and Canada, fewer than 10 percent met the screening criteria. That 10 percent was reduced to a list of 10 candidates for comparison. This report contains results from the four utilities surveyed.

The comparison focussed on:

- Transmission operations and maintenance program direction and emphasis;
- Organization, management and implementation techniques;
- Reliability; and
- Program costs.

The comparison consisted of two parts, a technical component and a cost comparison component.

The technical component compared different approaches to technical utility management topics such as:

- Organization structure, craft utilization, staffing criteria, and minimum crew size;
- Reliability criteria, system reliability, and outage monitoring;
- Productivity plans and initiatives;
- Maintenance service levels, standards, and backlog; and
- Dispatching responsibilities and techniques, as well as clearance and switching procedures.

The cost comparison identified information about similar transmission operations and maintenance costs for each participating utility for calendar years 1985 through 1987. Data indicating transmission system size and scope were used with cost data to establish program cost comparison indices.

Meetings were arranged with managers and technical experts for each of the four utilities. Several days were spent with each utility, exchanging information and touring facilities. Subsequent exchanges of information also took place to verify findings.

CHARACTERIZING THE COMPARISON UTILITIES

It is important to emphasize that this comparison should not be viewed as a competition among the participants. There are no "good," "better," or "best" conclusions offered and none should be drawn. The utilities which participated are four of the largest and most successful electric power utilities in the world. Each of them were responsive to the electric power industry's needs in the 1980's and continue to be so in the 1990's. As might be expected, each of these utilities is positioned differently in starting the new decade.

Utility A

Utility A has recently completed a comprehensive productivity review of its operations and maintenance requirements and, as a consequence, is making changes and adjustments. Maintenance activities and work schedules are processed through a computerized system to better monitor and document work accomplishments and associated expenditures. While the majority of its maintenance work is scheduled on a time basis, some emphasis is being directed toward installing appropriate in-service monitoring devices and performing more frequent diagnostic tests on in-service equipment to enhance equipment reliability and maintenance efficiency.

Utility B

Utility B recently completed a reorganization in which cost containment and minimization were major factors. They are satisfied with the relative condition of their transmission plant in service and have chosen to extend preventive maintenance frequencies to reduce workload and associated costs. They will monitor equipment and system performance and accelerate preventive maintenance as necessary.

Utility C

Utility C also recently completed a major reorganization in which cost containment and minimization were key issues. Their plan is to reduce staff by approximately 10 percent over the next 3 years. Like BPA, they have been in a cost containment mode for the past few years and have accumulated a considerable maintenance and replacement backlog. Utility C has begun the 1990's with an emphasis on reducing the accumulated backlog while increasing the preventive maintenance of their system.

Utility D

Like Utilities B and C, Utility D recently completed a major reorganization focussing on cost containment and minimization. They were generally satisfied with the condition of their transmission system, and maintenance backlog did not appear to be a concern. Utility D successfully reduced its transmission operations and maintenance costs in each of the last 3 years and would like to continue that trend into the 1990's.

**SUMMARY OF
COMPARISON RESULTS**

ORGANIZATION STRUCTURE

	BPA	UTILITY A
Centralized or Decentralized	<ul style="list-style-type: none"> • 7 corporate offices; 4 Area offices. • Dispatching is centralized into 2 control centers. • Other O&M functions decentralized with authority and responsibility in Areas. • Areas divided into Districts for O&M. • Dispatching centers control about 143 substations. 	<ul style="list-style-type: none"> • 1 headquarters office; 5 Area offices. Area offices autonomous. • O&M functions authority decentralized to Areas.
Craft Utilization	<ul style="list-style-type: none"> • Substation electricians, transmission linemen, power system control, and system protection maintenance staff. • Operators, dispatchers, and SCADA controllers. • Open shop and IBEW. • Substation maintenance crew: 3 to 4 journey electricians, 1 working foreman, and 1 non-working foreman. • Line maintenance crew: 3 to 4 journey linemen, 1 equipment operator, 1 working foreman, and 1 non-working foreman. • Substation control: 3 staffed substations, 140 SCADA controlled substations. 	<ul style="list-style-type: none"> • Meter relay and power system control staff, transmission linemen, and substation electricians. • Substation electricians do operational work. • Switching dispatchers, load dispatchers, and technical writers. • Maintenance workers IBEW; dispatchers non-union. • Critical substations have 1 electrician. • Substation maintenance has no standard crew size. • Line crew: 6 crew members. • 6 control centers: 2 dispatchers (24 hours) and 1 technical writer. • Similar to BPA but no operators.
Staffing Criteria	<ul style="list-style-type: none"> • No corporate criteria. Various types of subjective analyses based on work hour standards, coordinated by Areas and O, M&C. 	<ul style="list-style-type: none"> • No corporate criteria. • Crew size based on 2 hour response time.

UTILITY B	UTILITY C	UTILITY D
<ul style="list-style-type: none"> • Headquarters office; 5 regional divisions. • Centralized O&M authority and responsibility. • 5 divisions are each divided into maintenance, transmission and subtransmission switching districts. 	<ul style="list-style-type: none"> • Headquarters; 6 regional centers. Currently reducing organization with focus on design and construction. Transmission and distribution responsibilities. • Outage centralized; switching and dispatching decentralized to regional centers. • Each region has 2 to 6 district offices. • 52 attended stations; 41 local control centers. 	<ul style="list-style-type: none"> • Headquarters; 6 regional divisions. • 115-kV system controlled by regions; 230-kV and above defined as transmission and controlled by headquarters. • Highly centralized O&M authority and responsibility for 230-kV and above. • 2% per year growth. • 1 dispatching center for 230-500-kV with no SCADA control. 38 staffed substations for transmission and distribution. 14 switching stations transmission only.
<ul style="list-style-type: none"> • Meter relay, transmission linemen, substation electricians, power system control staff, substation operators, checkers, safety watchers, utility workers, and dispatchers. • Advancement through apprentice program. All apprentices picked from internal rosters. • IBEW; dispatchers non-union. • Substation operator and transmission switching operator staff substations 24 hours per day. • Meter relay uses 2 person crews. Electricians on 5 to 6 person crews. • Emergency control center staffed 24 hours per day; minimum 5 person crew. • Similar to BPA. 	<ul style="list-style-type: none"> • Substation operators and electricians. • Non-operational duties not assigned to operators. • Craft people do own switching. • Similar to BPA. • 3 year apprentice program. 	<ul style="list-style-type: none"> • No dedicated TLM, must depend on district crews. (See note below.) Otherwise, similar to BPA. <p>Note: Since BPA's visit with Utility D, they have decided to establish 8 dedicated transmission maintenance crews.</p>
<ul style="list-style-type: none"> • No corporate criteria. • Crew size based on emergency response times and workload. 	<ul style="list-style-type: none"> • Staffing criteria is established at headquarters and regions are required to follow it. • Based on work hour standards. • Operator staffing based on subjective analysis of equipment and experience. 	<ul style="list-style-type: none"> • No corporate criteria. • Staffing based on workload.

RELIABILITY

	BPA	UTILITY A
Existence of Reliability Criteria	<ul style="list-style-type: none"> • In-house criteria in addition to NERC and WSCC criteria. 	<ul style="list-style-type: none"> • No in-house criteria. Use NERC and WSCC criteria.
Outage Monitoring	<ul style="list-style-type: none"> • Historical outage records retained. Some analysis performed, but not for most outages. Investigating more detailed analysis on all automatic outages. 	<ul style="list-style-type: none"> • Historical outage records retained on line and equipment. No analysis is performed.

PRODUCTIVITY

	BPA	UTILITY A
Existence of Corporate-wide Programs or Initiatives	<ul style="list-style-type: none"> • No corporate productivity measures. Strategic planning process leading to strategic choices and annual operating plans. • O&M Efficiency Study, 1985. • Safety, Suggestion, and Awards Programs. 	<ul style="list-style-type: none"> • Comprehensive productivity review of O&M activities recently completed. • Productivity reviews evaluated O&M activities based on network reliability. • Unable to define specific corporate-wide productivity measures.

MAINTENANCE SERVICE LEVELS

	BPA	UTILITY A
Existence of Service Level Guides Documents directing the type and frequency of preventive maintenance inspections and services. Also used in planning and scheduling work.	<ul style="list-style-type: none"> • Yes, equipment type specific categories and activities. 	<ul style="list-style-type: none"> • Yes, equipment type specific categories and activities.
Relative Comparison to BPA How did the utility's preventive maintenance service levels compare with BPA's? Were they more or less frequent?		<ul style="list-style-type: none"> • Comparable.
Standards Does the utility use equipment group or type specific maintenance time standards in program implementation?	<ul style="list-style-type: none"> • Yes, historical hours per unit (task). 	<ul style="list-style-type: none"> • Yes, historical hours per unit (task).
Backlog Did the utility have a quantifiable maintenance backlog? What steps were taken to reduce or manage the backlog?	<ul style="list-style-type: none"> • Yes, increasing dedicated resources. Implemented long range planning (10-year) and reviewing planning criteria. 	<ul style="list-style-type: none"> • No.

UTILITY B	UTILITY C	UTILITY D
<ul style="list-style-type: none"> • In-house reliability criteria. Use NERC and WSCC criteria. 	<ul style="list-style-type: none"> • No information. 	<ul style="list-style-type: none"> • Use determination criteria. Higher reliability criteria for metropolitan areas.
<ul style="list-style-type: none"> • Outage analysis performed on all interruptions. Annual report is completed. 	<ul style="list-style-type: none"> • Analysis performed on all outages on POD. Have corporate targets. 	<ul style="list-style-type: none"> • Historical records maintained in computer data base. Some analysis performed.

UTILITY B	UTILITY C	UTILITY D
<ul style="list-style-type: none"> • No formal productivity program. Monitoring equipment and system performance. • Developing performance indicators or quality service objectives with on-time switching as the base. Improve service to customers and better use employees by switching out on-time. 	<ul style="list-style-type: none"> • No corporate-wide productivity measures. Managers and supervisors encouraged to develop their own. • Corporate management has Organizational Performance Contracts with managers; management performance pay plan. • Awards program for union and non-union employees. 	<ul style="list-style-type: none"> • Each region compares current performance with past performance. No region to region comparison. • Corporate goal to reduce maintenance costs by 15% in next 5 years (3% per year). • Attempting to achieve higher productivity by developing standardized maintenance practices and equipment service guides.

UTILITY B	UTILITY C	UTILITY D
<ul style="list-style-type: none"> • Yes, equipment type specific categories and activities. 	<ul style="list-style-type: none"> • Yes, equipment type specific categories and activities. 	<ul style="list-style-type: none"> • Yes, equipment type specific categories and activities.
<ul style="list-style-type: none"> • Generally less frequent. 	<ul style="list-style-type: none"> • Comparable. 	<ul style="list-style-type: none"> • Comparable.
<ul style="list-style-type: none"> • No. 	<ul style="list-style-type: none"> • Yes, historical hours per unit (task). 	<ul style="list-style-type: none"> • Varies within regional division.
<ul style="list-style-type: none"> • Developing. • Heavy construction workload diverting maintenance resources. 	<ul style="list-style-type: none"> • Yes. • Attempting to increase resource commitments. • Reviewing planning criteria. 	<ul style="list-style-type: none"> • Yes. • Not yet concerned.

DISPATCHING AND OPERATIONS

	BPA	UTILITY A
Organizational Relationship to Transmission and O&M	<ul style="list-style-type: none"> Dispatching is centralized in 2 control centers. Operations is decentralizing in 4 Area offices and 19 districts. 	<ul style="list-style-type: none"> Dispatching is decentralized in 6 control centers. No substation operations personnel.
Responsibilities	<ul style="list-style-type: none"> Dispatching centers are responsible for continuity of service, arranging outages, directing switching and tagging, and issuing clearances. 	<ul style="list-style-type: none"> Dispatching centers are responsible for continuity of service in their area, generation control, arranging outages, writing switch orders, directing switching and tagging, and issuing clearances. Supervisory control of some substations.
Techniques: SCADA Supervisory Non-operator	<ul style="list-style-type: none"> Centralized supervisory control. Employs substation operators. Operators work independently under switching jurisdiction of dispatching centers. 	<ul style="list-style-type: none"> Centralized supervisory control in 6 control centers. No operator personnel.
Clearance and Switching Procedures	<ul style="list-style-type: none"> Switch orders are written by switchmen and approved by dispatchers. In most cases, operators complete the switching. Only BPA certified employees can take clearances. Contractors do no work on energized facilities. 	<ul style="list-style-type: none"> Switch orders are written by dispatchers or technical writers. Maintenance forces complete switching. Only utility employees can take clearances. Contractors do no work on energized facilities.

UTILITY B	UTILITY C	UTILITY D
<ul style="list-style-type: none"> • Dispatching is centralized in 1 control center. Substation operations is decentralized in 5 divisions. 	<ul style="list-style-type: none"> • Dispatching is centralized in 1 control center. Substation operations is decentralized in 6 regional centers. 	<ul style="list-style-type: none"> • Dispatching is centralized in 1 control center. Substation operations is decentralized in regional divisions.
<ul style="list-style-type: none"> • Dispatching centers are responsible for continuity of bulk power service, arranging outages, and generation control. Transmission switching centers in divisions write switch orders, direct switching and tagging, and issue clearances. Remotely operate substations via supervisory control from dispatching centers. 	<ul style="list-style-type: none"> • Dispatching centers are responsible for continuity of bulk power service, arranging outages, generation control, buying and selling power, collecting and verifying interchange transactions, and approving outages. Transmission switching centers in regions write switch orders, direct switching and tagging, and issue clearances. Minimal reliance on supervisory control from transmission switching stations. 	<ul style="list-style-type: none"> • Dispatching centers are responsible for continuity of bulk power service, arranging outages, and generation control. Transmission switching centers in regions write switch orders, direct switching and tagging, and issue clearances.
<ul style="list-style-type: none"> • No centralized supervisory control. Employs substation operators reporting to transmission switching centers. Substation operators can take little independent action. 	<ul style="list-style-type: none"> • No centralized supervisory control. Employs substation operators reporting to transmission switching centers. • Some local SCADA control. 	<ul style="list-style-type: none"> • No centralized supervisory control. Employs substation operators reporting to transmission switching centers.
<ul style="list-style-type: none"> • Switch orders are written and switching is directed by transmission switching operators. Switch orders are verified by other shift operators and Station Chief. Transmission operators receive clearances from dispatcher, then direct switching. Only utility employees can take clearances and switch. Contractors do no work on energized facilities. Some switching is accomplished by maintenance forces. 	<ul style="list-style-type: none"> • Switch orders are written and switching is directed by transmission switching operators. Only utility employees can take clearances and switch. Contractors do no work on energized facilities. Some switching is accomplished by maintenance forces. 	<ul style="list-style-type: none"> • Switch orders are written and switching is directed by transmission switching operators. Only utility employees can take clearances and switch. Contractors do no work on energized facilities. Some switching is accomplished by maintenance forces.

COMPARISON DATA

TOTAL CIRCUIT MILES

TRANSFORMER CAPACITY (MVA)

PLANT IN SERVICE

ENERGY TRANSMITTED (GWH)

TRANSMISSION O&M COSTS (1985-87 Average)

UTILIZATION AND DENSITY CIRCUIT MILES

UTILIZATION AND DENSITY MVA CAPACITY PER CIRCUIT MILE

**COMPARATIVE RATIOS FOR PLANT & OVERHEAD
PLANT IN SERVICE INVESTMENT
PER MWH TRANS.**

**COMPARATIVE RATIOS FOR PLANT & OVERHEAD
PLANT IN SERVICE INVESTMENT
PER MVA CAPACITY**

**COMPARATIVE RATIOS FOR
PLANT AND OVERHEAD**

**COMPARATIVE RATIOS FOR
TOTAL O&M EXPENSE**

COMPARATIVE RATIOS FOR TOTAL O&M EXPENSE

COMPARATIVE RATIOS FOR TOTAL O&M EXPENSE

O&M COSTS AS A PERCENT OF PLANT IN SERVICE

COMPARATIVE RATIOS FOR O&M COST VERSUS PLANT IN SERVICE

KEY FINDINGS

BPA's Operations and Maintenance Programs are comparable to those of the comparison utilities. Cost comparison data indicate that BPA's average operations and maintenance costs are at reasonable levels, with respect to what is expected for a utility of BPA's size and mission.

Few, if any, definitive conclusions can be drawn from utility cost comparisons. Variations in system size, configuration, and density render "cost per unit" type comparisons confusing at best. Recognizable and/or known differences in mission further compromise comparisons. Utilities, like any business, will tend to concentrate their resources and efforts in those program areas that generate the greatest return on investment. For most utilities that would be electric power generation and distribution; for BPA, it is transmission.

The comparison does help verify that which might be recognized intuitively: utilities with the largest capabilities tend to accomplish more and spend more. For example, if comparisons of physical size are discounted and we only look at a utility's transformation capacity, the result is a picture of the "capability" of the utility to transmit large quantities of electric power. This comparison shows that Utility C had the greatest transformation capacity at 68,579 mVA over the 3 year period of 1985 through 1987. They were followed closely by BPA, then Utility D, Utility B, and Utility A. Not surprisingly, Utility C also transmitted the largest amount of energy over the same period, followed by BPA and the other utilities in similar order (Utilities B and D were within 5 percent of each other). Total transmission operations and maintenance costs followed the same pattern. The utility with the largest capacity and the largest amount of energy transmitted also had the largest operations and maintenance cost, with the corresponding order of Utility C, BPA, Utility B, Utility D, and Utility A. (See Figure 2.)

Figure 2

Utility					
mVA Capacity	C	BPA	D	B	A
MWH Transmitted	C	BPA	B	D	A
Total O&M Costs	C	BPA	B	D	A
mVA/C. Mile	BPA	C	B	D	A
Plant in Service	BPA	C	B	D	A
<div style="display: flex; justify-content: space-between; align-items: center;"> Larger → → → Smaller </div> <p style="text-align: center;">Relative Size</p>					

Expected benefits from economies of scale are also apparent. The utilities with the greatest mVA capabilities had the lowest costs per MWH transmitted.

From a technical standpoint, BPA's practices are generally consistent with those of the four comparison utilities. Variations in program intensity and direction primarily affected maintenance and replacement activities. Transmission system operations were a relatively stable function. A utility does not defer operating for cost containment initiatives. Accordingly, the upward and downward movement in program levels tended to affect maintenance and replacement programs much more than operations.

The following points review some of these variations:

(1) Utilities A and C use preventive maintenance service intervals similar to BPA's. Utility C is trying to address an accumulation of maintenance backlog and is trying to increase its preventive maintenance program. Utilities B and D are sufficiently satisfied with the overall condition of their transmission systems and have chosen to lengthen service intervals in an effort to contain costs. Utility D has been reducing operations and maintenance costs for the last 3 years.

(2) Staffing levels are determined differently. BPA has no Agency-wide staffing criteria. Various types of subjective analyses, based on work-hour standards, are coordinated by Area offices and OM&C. Utility A uses a composite of workload requirements and the ability of crews to respond to system problems within 2 hours. Utility B bases staffing on emergency restoration response times and on workload (present staffing is below actual workload). Utility C bases staffing requirements on workload and historical trends. Utility D, at the time of this comparison, actually had no dedicated transmission system maintenance personnel. Maintenance and repair of transmission facilities was accomplished by "contracting" with regional customer service crews.

(3) Utilities A, B, and C are moving away from the traditional time-based preventive maintenance intervals to predictive or reliability-centered maintenance techniques.

(4) All four utilities appear to use more non-operations craft personnel to perform some routine switching functions than BPA.

While these variations may serve as a valuable reference for BPA, comparisons with other utilities should be made with caution. Utilities, whose primary mission is to serve the end use customer, operate in a very different environment than a wholesaler such as BPA. Consequently, what might work well for one or another utility may not apply to BPA.

However, general trends should not be ignored by BPA. Future rate initiatives will bring the Agency into direct comparison with others. The utilities profiled in this study are setting or following trends toward increased dependency on contractors, longer maintenance intervals, and expanded use of non-operator craft personnel for switching. BPA will examine these trends and specifically explore the following recommendations:

- BPA could benefit from a comprehensive review of its preventive maintenance service intervals, known as Program Level Guides (PLG's). The review should focus on identifying opportunities to lengthen service intervals whenever system reliability and safety would not be jeopardized.
- Some efficiency improvements might be possible by expanding BPA's use of non-operations personnel to accomplish routine operations activities. A corresponding change — operations personnel performing some routine maintenance tasks — may also provide some efficiency improvements. These possibilities will be studied further.
- BPA could increase the efficiency of its field maintenance units by expanding its use of diagnostic techniques and in-service equipment monitoring.

SPECIFIC OBSERVATIONS

Organization and Staffing

BPA

BPA is organized into seven corporate offices and four Area offices located within the BPA service territory. Each Area office is divided into district offices for operations and maintenance. Dispatching is centralized into two control centers: western Washington (Vancouver) and eastern Washington (Moses Lake). The dispatching centers centrally control approximately 143 substations. Other operations and maintenance functions are decentralized, with authority and responsibility vested in the Area offices.

BPA completed a major reorganization in 1988. This reorganization focused on eliminating duplication of effort and decentralizing decision making. Operations and maintenance staffing levels were not affected by this reorganization.

BPA's transmission system covers more than 300,000 square miles throughout a multi-state area, with 142 bulk delivery points. BPA has no distribution system. The Agency employs approximately 3,300 people, of which about 1,000 are dedicated to operations and maintenance activities.

BPA's system design characteristics (using a 1985-87 3-year average) include the following:

Total circuit miles of line.....	14,383
High-voltage circuit miles of line	9,351
Extra-high-voltage circuit miles of line	5,032
Number of substations for transmission.....	384
Breakers.....	1,775
Transformer capacity (mVA)	64,391
MWH handled	110,726,629
Plant in service.....	\$2,818,638,210

Operations and maintenance forces consist of substation electricians, transmission linemen, and power system control and system protection engineers and craft persons. BPA also employs substation operators, dispatchers, and Supervisory Control and Data Acquisition (SCADA) controllers. BPA is an "open shop," however any of these staff members may be represented by the International Brotherhood of Electrical Workers (IBEW).

Maintenance staffing levels at BPA are determined by workload. Operator staffing is based on a combination of response time and workload. A typical substation maintenance crew is comprised of three or four journeyman electricians, a working foreman, and a non-working, or supervising, foreman. A typical line maintenance crew is three or four journeyman linemen, an equipment operator, a working foreman, and a non-working foreman. BPA uses centralized SCADA systems to control 143 substations, with only three substations currently staffed on a 24-hour basis. All other operators work out of geographically dispersed district stations, and usually work day shift.

Utility A

Utility A is comprised of a headquarters office and five widely dispersed area offices, with their electrical facilities located remotely. Authority and responsibility for operations and maintenance functions is largely decentralized with oversight of policy and performance provided by the headquarters office. The utility has approximately 1,400 employees, of which 650 (46 percent) are dedicated to operations and maintenance activities. Utility A has just completed an efficiency study (productivity review) and is making changes and adjustments accordingly.

Much like BPA, Utility A has bulk power transmission but no generation or distribution responsibilities.

Utility A's transmission system covers an area of 1.3 million square miles which extends into 15 midwestern and western states. Its system design characteristics (using a 1985-87 3-year average) include the following:

Total circuit miles of line.....	16,232
High-voltage circuit miles of line.....	14,789
Extra-high-voltage circuit miles of line.....	1,442
Number of substations for transmission.....	242
Breakers.....	1,269
Transformer capacity (mVA).....	15,265
MWH handled.....	46,535,667
Plant in service.....	\$881,963,497

Utility A's staff has increased only 7.5 percent since 1978. Yet, the workload assigned to the operations and maintenance function has increased, largely due to: (1) a 25 percent increase in the number of customers, (2) a 10 percent increase in the number of

substations, and (3) a 13 percent increase in the installed capacity of the system.

The operations and maintenance forces are comprised of craft persons, which include meter relay and power system control personnel, transmission linemen, and substation electricians. Utility A does not employ substation operators. Instead, it uses its other craft persons to perform most of the traditional operational work. The regional control centers are staffed by switching dispatchers, load dispatchers, and technical writers. Maintenance forces are union employees covered by the IBEW; dispatchers and technical writers are non-union.

Staffing levels are determined by a combination of workload and the ability of maintenance crews to respond to system problems within two hours anywhere within their 1.3 million square miles of service area. A typical line crew is comprised of six crew members. Substation maintenance staffing levels are determined by workload. Critical substations require a dedicated substation electrician on site. The six control centers are staffed around the clock with a minimum of two dispatchers. A technical writer is added to the day shift on weekdays.

Utility B

Utility B's operations and maintenance organizations are the transmission/substation arm of the Power Supply Division of its corporation. The transmission/substation organization consists of a headquarters office and five regional Divisions. Each Division is comprised of operations and maintenance districts which provide both transmission and distribution support. The system dispatching function is centralized in one Energy Control Center which handles the 230-kV and above transmission system and inter-connections.

System design characteristics (using a 1985-87 3-year average) include the following:

Total circuit miles of line.....	12,201
High-voltage circuit miles of line	10,364
Extra-high-voltage circuit miles of line	1,836
Number of substations for transmission.....	150
Breakers.....	2,965
Transformer capacity (mVA)	47,359
MWH handled	73,700,962
Plant in service.....	\$1,747,928,173

Utility B employs meter relay technicians, transmission linemen, substation electricians, and power system control technicians. It also employs substation operators, checkers, utility workers, and four levels of dispatchers. All but the dispatchers are union employees covered by an IBEW contract.

Line crews maintain both overhead and underground transmission lines. There are two scheduled line patrols each year, one by air and the other by ground. Observers are line people assigned to Divisions; pilots are utility transportation services employees.

Operations and maintenance staffing is based on emergency response times and workload. Present staffing is below actual workload requirements. Transmission switching centers are staffed 24 hours per day. Each shift consists of a substation operator and a transmission switching operator. Additional operators are used at larger stations on weekdays. An Energy Control Center is staffed 24 hours per day, with a minimum of five staff members on a non-rotating shift.

Two-person meter relay crews are standard. Electricians are divided into crews, with five to six members per crew. The ultimate goal is three journeymen and two apprentices. Utility B has line crews, however a lineman may perform line patrols alone.

Utility C

Utility C is decentralized into six regional centers, with a headquarters organization that provides functional direction and standards. A Regional Director would be comparable to one of BPA's Area Managers. Each region has from two to six district offices, for a total of 21 district offices. There are 52 attended stations, and 41 local control centers.

Utility C is currently implementing a reorganization, with an emphasis on reducing staff. Utility C has generation, transmission, and distribution responsibilities, as it wholesales to 316 municipal utilities.

The Utility interchanges with six other utilities at 19 locations. Outage coordination and approval is centralized on the main-grid 500/230-kV system. Switching and day-to-day dispatching is decentralized to regional centers and attended substations.

System design characteristics (using a 1985-87 3-year average) include the following:

Total circuit miles of line.....	16,883
High-voltage circuit miles of line.....	15,494
Extra-high-voltage circuit miles of line.....	1,389
Number of substations for transmission.....	233
Breakers.....	2,395
Transformer capacity (mVA)	68,579
MWH handled	128,067,910
Plant in service.....	\$2,135,962,000

Utility C employs substation operators who complete the majority of the switching. However, craft people can do their own switching on de-energized equipment.

Operator staffing is determined by criteria developed by headquarters. These criteria focus on installed equipment and experience. The regions are required to follow the criteria in staffing decisions.

Utility D

Utility D is organized into a headquarters and six regional divisions. In 1988, this utility was reorganized. At that time, the regions were given control of the system at 115-kV and below. Control of the system identified as "transmission" (230-kV and above) was retained by headquarters. The general office has responsibility for operations and maintenance, and "contracts" most of the work to its regional offices. The transmission system has been growing at approximately 2 percent per year.

System design characteristics (using a 1985-87 3-year average) include the following:

Total circuit miles of line.....	18,654
High-voltage circuit miles of line.....	17,329
Extra-high-voltage circuit miles of line.....	1,325
Number of substations for transmission.....	623
Breakers.....	2,110
Transformer capacity (mVA)	48,759
MWH handled	70,326,274
Plant in service.....	\$1,465,201,620

The following observations compare BPA to all four utilities as a group. The topics include:

- Reliability criteria/outage monitoring;
- Productivity measures;
- Maintenance service levels and standards; and
- Dispatching responsibilities and switching procedures.

Reliability Criteria/Outage Monitoring

BPA

BPA has established reliability criteria in addition to those of the North American Electric Reliability Council (NERC) and of the Western Systems Coordinating Council (WSCC). The reliability criteria outline requirements for system design, transformers, and operator response.

Historical records are stored on a computer data base for both planned and automatic interruptions. Analysis is completed on some, but not all, interruptions. Collection and analysis of this information is receiving greater emphasis at BPA, and the program is being revised to reflect this emphasis.

Comparison utilities

All comparison utilities have reliability criteria, usually NERC, sometimes supplemented by individual criteria. Utility D uses deterministic criteria, with higher standards for metropolitan areas. Primary utility goals are to provide reliable service and economical energy in a safe, cost-effective manner. For instance, one utility evaluates performance by the ability to withstand severe emergency conditions without uncontrolled cascading tripouts of system components.

All comparison utilities collect data on interruptions of line and station equipment using an automated system. For some, little analysis is recorded; for others, data are analyzed and a line patrol performed to determine the cause of any interruption. An annual report is completed and reviewed at the corporate level in Utilities B and C.

Productivity Measures

BPA

BPA does not have overall agency productivity measures. A strategic planning process is used for goal setting to establish

strategic choices. The individual Offices and Areas set goals and timetables annually through Operating Plans.

Comparison utilities

Three of the four utilities have no formal productivity approach. Rather, they seek alternative or partial methods, such as performance indicators, incentive programs, or supervisor-developed approaches to productivity measures. The fourth utility compares each region against its past performance, with goals of consistent maintenance performance and reduction of maintenance costs by 15 percent over the next 5 years.

Maintenance Service Levels and Standards

BPA

BPA has an established preventive maintenance program. Preventive maintenance service intervals are primarily time-frequency-based. Intervals have been established based on manufacturers recommendations and actual experience, as well as through comparison with other utilities. BPA does not use equipment-specific preventive maintenance standards. Instead, the Agency has developed a series of Standards, Procedures, Instructions and Information (SPIF's) and guides to assist field crews. BPA does not use performance time standards, instead monitoring performance by comparing current actual performance with historical records and trends.

For the past 15 years, competing resource demands within BPA have forced the Agency to stretch its maintenance and replacement resources. There are fewer maintenance personnel today than there were in 1975. Recent studies at BPA have shown that the reduction of maintenance and replacement programs may have gone too far. There is a sizeable accumulation of backlogged maintenance, and replacements and outages due to material and equipment failure appear to be increasing.

BPA is concerned about this maintenance backlog and is actively pursuing strategies which will reduce the backlog to acceptable levels by 1999.

Comparison utilities

Utilities C and D have identified accumulating maintenance backlogs. Utility C regards its backlog as unacceptable and is actively working to reduce it. Management anticipates assigning

additional resources to this effort. They are moving toward predictive (reliability-centered) maintenance techniques and away from traditional time-frequency-based preventive maintenance intervals. At Utility D, on the other hand, the maintenance backlog does not seem to be a corporate concern, and they are in fact hoping to reduce maintenance costs by as much as 15 percent over the next 5 years.

Other innovations or variations are found in maintenance crew deployment. At Utility D, transmission line maintenance is carried out by distribution or construction crews, using no dedicated transmission line maintenance crews. They use troublemen/linemen for patrols in one-person units (including climbing assignments).

Refurbishment rather than replacement (75/35 percent) is actively pursued by Utility C. Utility D believes there are hidden costs which make refurbishment uneconomical.

Similar to BPA, Utility B regards equipment overhauls primarily as inspections, where only those parts needed are replaced. Maintenance foremen are held accountable for maintenance project schedules and budgets. Utility B and Utility C use their O&M organizations to procure and manage their own materials.

Customer maintenance is either not performed or performed on an exception basis only. Core maintenance activities are generally not contracted, but other tasks such as non-electric plant, wood pole inspection and treatment, and right-of-way maintenance are contracted. In some cases, cross-crafting is used to address maintenance tasks. For example, substation crews paint electrical equipment and maintain relays.

Dispatching Responsibilities and Switching Procedures

BPA

Dispatching is achieved from two control centers. The Dittmer Control Center (DCC) dispatches all the 500-kV transmission system and 230-kV major interconnections and the subtransmission west of the Cascade Mountains. DCC also handles the automatic generation control and supervisory control of 102 substations. The Eastern Control Center dispatches subtransmission east of the Cascades (230-kV and below) and provides supervisory control of 41 substations.

Dispatchers in both control centers are responsible for continuity of service, arranging outages, directing the switching and tagging, and issuing clearances. Switch orders are written by the switchman and approved by the dispatcher. In most instances, operators complete the switching. Only certified BPA employees are allowed to take clearances on BPA facilities. Contractors do not work on energized equipment and must always be accompanied by a certified safety watcher.

Comparison utilities

The comparison utilities vary widely in control, dispatch, and switching practices. Utility A has six control centers that serve customers in 13 states, and relies heavily on SCADA for control. Utilities C and D have no central SCADA system, but work through regional centers which use SCADA systems for single remote or, in some cases, multiple remotes to control substations.

At all comparison utilities, outages are approved through the outage office in the utilities' control centers where planned outages are coordinated.

All four utilities tend to use more non-operations craft personnel to perform routine switching functions than BPA does. Utility A does not employ substation operators, so all switching is completed by maintenance forces. Field personnel request outages from the outage coordinator or technical writers, who then prepare the switching program. At the appropriate time, the shift dispatcher performs and/or directs the switching to accomplish the desired action.

At Utility B, switching and clearance procedures are developed jointly by Safety and System Operations. Switching is accomplished through transmission centers located throughout the Division's area. Switch orders are written, approved by the energy control center, and directed step-by-step by the transmission switching centers. Substation operators and maintenance crews completing the switching are allowed little independent action.

Switching is directed from Utility D's transmission switching centers. Operators and, in some cases, electricians conduct switching. Decisions as to whether an operator or an electrician does the switching are based on the level of service and system risk. Only utility employees are allowed to take clearances and perform switching.

**REPORT ON REVIEW
OF INTERUTILITY COMPARISON
OF TRANSMISSION, OPERATIONS
AND MAINTENANCE COSTS**

**PREPARED FOR THE BONNEVILLE POWER
ADMINISTRATION BY TOUCHE ROSS INTERNATIONAL**

NOVEMBER 30, 1989

November 30, 1989

Mr. Robert Kiser
Coordinator, Interutility Transmission O&M Study
Bonneville Power Administration
Division of System Maintenance - MMB
P.O. Box 3621
Portland, OR 97208

Dear Mr. Kiser:

This letter summarizes the work performed by Touche Ross & Co. as part of the Interutility Transmission O&M Study, and presents our conclusions.

Touche Ross was engaged by Bonneville Power Administration (BPA) to assist generally in the study, and in particular to review the reasonableness of BPA's comparison of its transmission operation and maintenance (O&M) costs to those of similar utilities.

We also contributed substantively to the meetings during the study between BPA O&M managers and their counterparts at the subject utilities.

I. OVERVIEW OF METHODOLOGY

As part of BPA's long-term planning process for transmission O&M, BPA and Touche Ross undertook a study of transmission O&M practices and costs in a group of similar large utilities. The stated objective of the study was to learn from the experience of other utilities and provide a context for evaluating BPA's current practices and costs.

The subject utilities were selected on the basis of similarity to BPA in transmission system size, load, revenue, and transmission responsibilities. After screening a large number of candidates, four utilities were selected for study (in addition to BPA).

The study was conducted by gathering and analyzing data from publicly available documents, documents supplied by the subject utilities, and personal interviews. The written documents on transmission O&M practices included items such as procedures manuals, specifications lists, and organization charts. The documents on transmission O&M costs included items such as FERC Form 1 filings, internal cost accounting procedures manuals, and internal cost accounting reports. The interview data was gathered through intensive group meetings involving BPA transmission O&M managers, their counterparts at the subject utility, and Touche Ross personnel.

BPA's report on the study includes analyses of both transmission O&M practices and costs. Other than through its participation in interviews, Touche Ross was not involved in the portion of the study concerning transmission O&M practices. We reviewed and assisted in the development of the cost comparison portion of the study.

II. COST COMPARISON PROCEDURES

This section describes the procedures followed by BPA and Touche Ross in conducting the portion of the study that focused on transmission O&M costs. These procedures are also discussed in pages 2-3 of the overall utility comparison report.

Study Element

Procedures

Scope

The scope of the cost study was defined to cover costs associated with operations and maintenance of the utility's owned transmission system. Only those transmission O&M costs booked to FERC accounts 560 to 573, or their internal equivalents, are included. Expense for transmission by others (wheeling) is excluded, because it does not reflect O&M of the utility's own transmission system. The comparison of loaded transmission O&M costs also includes an allocated portion of the Administrative and General (A&G) costs booked to FERC accounts 920 to 936, or their internal equivalents.

Period

The period covered by the cost study was calendar years 1985, 1986, and 1987. Each utility's transmission O&M costs by account and physical data were averaged over these three years, to arrive at numbers for comparison.

Study Element

Procedures

Data Sources

The primary source of cost data for the investor-owned utilities in the study was their FERC Form 1 filings. For all but one of the government-owned utilities in the study, historical data by FERC account was also available in the form of reports that converted their internal cost accounting data to the relevant FERC accounts. For one government-owned utility, internal cost accounting data was converted to FERC accounts through a system jointly developed by the utility, BPA, and Touche Ross.

Audited financial statements or required reports to regulatory agencies were the source for the control totals.

Annual statistical reports on system operations were also used to develop physical data for two utilities.

A&G Allocation

Direct cost data for all utilities included supervisory and management costs up to the level of the vice-president (or equivalent) responsible for transmission O&M.

A&G expenses were allocated to the transmission function by the ratio of transmission direct labor expense to total direct labor expense for the production, transmission, distribution, and customer accounting functions. Two utilities did not have data available on direct labor expense by function. For those two utilities, A&G expense was allocated by the ratio of transmission direct expense (labor and other) to total direct expense.

Preliminary Spreadsheet

A spreadsheet containing the preliminary cost and physical data was developed. The same spreadsheet format and logic was applied to all utilities. Control totals were used to ensure reconciliation of detail entries to audited or regulated statements.

Study Element

Procedures

Data Request

Prior to meeting with the utility, a standardized data request was sent. The data request included specific questions on areas of potentially inconsistent cost accounting practices. See Attachment A. The utility responded with the requested information at the time of the meeting.

Interviews

BPA and Touche Ross personnel conducted 2-day meetings with the management of the transmission O&M activity at each subject utility. Most of the agenda revolved around transmission O&M practices.

The Touche Ross consultant and a BPA transmission financial analyst met separately with transmission accounting personnel at each subject utility. The utility's personnel explained how they had assembled their response to the data request. Numerous clarifying questions were asked. Follow-up questions on costs were pursued later by telephone or letter, where necessary.

Revised
Spreadsheets

Based on the further information received from the utilities, the cost spreadsheets were revised as appropriate to ensure consistency of the data.

Each utility was given the opportunity to comment on the spreadsheet representing its costs. No substantive comments were received

Summary
Spreadsheet

Aggregate cost and physical data for all utilities were summarized for comparison purposes on a single spreadsheet.

III. TOUCHE ROSS ROLE

In addition to participating generally in the study, Touche Ross conducted a detailed review of the design and implementation of the cost portion of the study.

Design Review

Touche Ross first reviewed the design of the cost study. Our review encompassed the following elements:

- o Consideration of the reasonableness of BPA's general approach, including scope, data sources, allocation methods, and measures of comparison.
- o Comparison to methods used in other interutility studies.
- o Research into the results of BPA's prior interutility O&M study in 1983.
- o Review of the general layout and flow of the spreadsheet model that processed the input data.
- o Check of the logic of all arithmetic operations performed on the individual utility spreadsheet and the summary comparison spreadsheet, through examination of formulas within the spreadsheet. A large sample of calculations were checked manually. No errors were found.

Implementation Review

The data-gathering and computational tasks in the cost study were performed by BPA staff. Touche Ross reviewed the computations and adjustments made by BPA staff. Our review encompassed the following elements:

- o Identification of source documents for cost and physical data entered for each subject utility, including BPA. Source documents were utility-provided financial statements or regulatory reports.
- o Verification of the accuracy of the transfer of data from the utility source documents to the spreadsheets for each utility, and then to the summary comparison spreadsheet. Where errors were noted, BPA corrected them for the final cost comparison.
- o Review of the reasonableness of any accounting conversions, where required. The conversions involved translating internal accounts, kilometers, and Canadian dollars to FERC accounts, miles, and U.S. dollars, respectively. No errors or unreasonable assumptions were found.

- o Review of all adjustments made to cost or physical data provided by the subject utilities. The adjustments involved either the treatment of routine line patrols or the calculation of O&M-related A&G for allocation by function. We verified the logic of the adjustment, checked the calculations, and followed the adjustment through the affected spreadsheet.
- o Review of all numbers appearing on the final "Utility Comparison" spreadsheet prepared by BPA. This spreadsheet contains the summary level quantitative information that is used in the report on the interutility comparison.

A summary of the results of the transmission O&M cost study follows.

IV. CONCLUSIONS

We conclude that:

- o The cost comparison methodology contains no inherent bias, and uses well-documented data from standardized accounts. It is a reasonable approach.
- o Appropriate data were used.
- o Adequate documentation was prepared.
- o Data were processed in a manner consistent with the comparison methodology.
- o The logic and implementation of each adjustment is reasonable.
- o The "Utility Comparison" spreadsheet reasonably presents the aggregates and ratios chosen for comparison.

Cost comparisons among different utilities should not be taken as straight-forward indicators of the efficiency of system management. Transmission O&M costs reflect the combination of system management and system characteristics. External factors such as geography, weather, density, local labor costs, and load characteristics are important influences on O&M costs, but they are largely beyond the control of utility management. After diagnosing the causes of relatively high costs in activities identified by the study, management should focus on those costs it can control.

We believe that the results of BPA's Interutility Transmission O&M Study reflect implementation of a consistent, reasonable, and unbiased comparison methodology.

Yours very truly,

Touché Ross & Co.

COST COMPARISON RESULTS

SUMMARY OF RESULTS

TRANSMISSION SYSTEM PHYSICAL SIZE			
(1985-87 AVERAGE)			
UTILITY	TOTAL CIRCUIT MILES	HV CIRCUIT MILES	EHV (1) CIRCUIT MILES
BPA	14,383	9,351	5,032
A	16,232	14,789	1,442
B	12,201	10,364	1,837
C	16,883	15,494	1,389
D	17,746	17,329	416

UTILITY	NO. OF SUB- STATIONS (2)	TRANS- FORMER CAPACITY (MVA)	ENERGY TRANS- MITTED (GWH)	PLANT IN SERVICE (MILLION)
BPA	384	64,391	110,727	\$2,819
A	242	15,265	46,536	\$882
B	150	47,359	73,701	\$1,748
C	233	68,579	128,068	\$2,136
D	623	48,759	70,326	\$1,465

(1) 350 KV AND ABOVE
(2) TRANSMISSION ONLY

TRANSMISSION O&M COSTS					
(1985-87 AVERAGE)					
UTILITY	DIRECT OPERATIONS EXPENSE	DIRECT MAINTENANCE EXPENSE	TOTAL DIRECT O&M	TOTAL LOADED O&M (3)	A&G LOADING PERCENT
BPA	\$32,258,752	\$42,369,973	\$74,628,724	\$102,346,938	37.14%
A	\$19,924,725	\$29,704,315	\$49,629,039	\$72,163,794	45.41%
B	\$32,153,216	\$30,553,747	\$62,706,963	\$99,651,589	58.92%
C	\$32,182,561	\$43,961,252	\$76,143,813	\$123,279,343	61.90%
D	\$21,116,200	\$23,090,323	\$44,206,524	\$74,921,761	69.48%

(3) TOTAL DIRECT O&M + ALLOCATED A&G

COST COMPARISON RESULTS

COMPARATIVE RATIOS FOR UTILIZATION AND DENSITY

UTILITY	CIRCUIT MILES PERCENT HV	CIRCUIT MILES PERCENT EHV	CIRCUIT MILES PER SUBSTATION
BPA	65.01%	34.99%	37.5
A	91.11%	8.89%	67.0
B	84.95%	15.05%	81.3
C	91.77%	8.23%	72.4
D	97.65%	2.35%	28.5

UTILITY	MVA CAPACITY PER SUBSTATION	SUBSTATION CAPACITY FACTOR (4)
BPA	167.7	19.63%
A	63.0	34.80%
B	315.7	17.76%
C	293.9	21.32%
D	78.3	16.46%

(4) MWH / (MVA CAPACITY * 8,760 HOURS)

COMPARATIVE RATIOS FOR PLANT AND OVERHEAD

UTILITY	PLANT IN SERVICE / MVA CAPACITY	PLANT IN SERVICE / MWH TRANS.	OPERATIONS OVERHEAD PERCENT (5)	MAINTENANCE OVERHEAD PERCENT (5)
BPA	\$43,774	\$25.46	13.98%	5.93%
A	\$57,775	\$18.95	16.85%	8.46%
B	\$36,908	\$23.72	22.10%	13.53%
C	\$31,146	\$16.68	9.59%	1.03%
D	\$30,050	\$20.83	11.95%	10.94%

(5) DIRECT SUPERVISION & ENGINEERING EXPENSE / TOTAL DIRECT EXPENSE

COST COMPARISON RESULTS

COMPARATIVE RATIOS FOR TOTAL O&M EXPENSE

UTILITY	DIRECT O&M PER CIRCUIT MILE	DIRECT O&M PER MVA CAPACITY	DIRECT O&M PER MWH TRANSMITTED
BPA	\$5,189	\$1,159	\$0.67
A	\$3,058	\$3,251	\$1.07
B	\$5,139	\$1,324	\$0.85
C	\$4,510	\$1,110	\$0.59
D	\$2,491	\$907	\$0.63

UTILITY	LOADED O&M PER CIRCUIT MILE	LOADED O&M PER MVA CAPACITY	LOADED O&M PER MWH TRANSMITTED
BPA	\$7,116	\$1,589	\$0.92
A	\$4,446	\$4,727	\$1.55
B	\$8,167	\$2,104	\$1.35
C	\$7,302	\$1,798	\$0.96
D	\$4,222	\$1,537	\$1.07

COMPARATIVE RATIOS FOR O&M COST VS. PLANT IN SERVICE

UTILITY	OPERATIONS EXPENSE / PLANT IN SERV.	MAINTENANCE EXPENSE / PLANT IN SERV.	DIRECT O&M EXPENSE / PLANT IN SERV.	LOADED O&M EXPENSE / PLANT IN SERV.
BPA	1.14%	1.50%	2.65%	3.63%
A	2.26%	3.37%	5.63%	8.18%
B	1.84%	1.75%	3.59%	5.70%
C	1.51%	2.06%	3.56%	5.77%
D	1.44%	1.58%	3.02%	5.11%

COMPARATIVE RATIOS FOR DIRECT O&M COST ELEMENTS VS. PHYSICAL SIZE

UTILITY	LINE MAINT. EXPENSE / CIRCUIT MILES	SUB. MAINT. EXPENSE / NO. OF SUBS	OPERATIONS EXPENSE / MVA CAPACITY	MAINTENANCE EXPENSE / MVA CAPACITY	DISPATCH EXPENSE / MWH TRANS.
BPA	\$844	\$61,055	\$501	\$658	\$0.0263
A	\$528	\$65,806	\$1,305	\$1,946	\$0.1292
B	\$903	\$61,983	\$679	\$645	\$0.0445
C	\$701	\$131,807	\$469	\$641	\$0.0960
D	\$619	\$15,133	\$433	\$474	\$0.0388

END

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