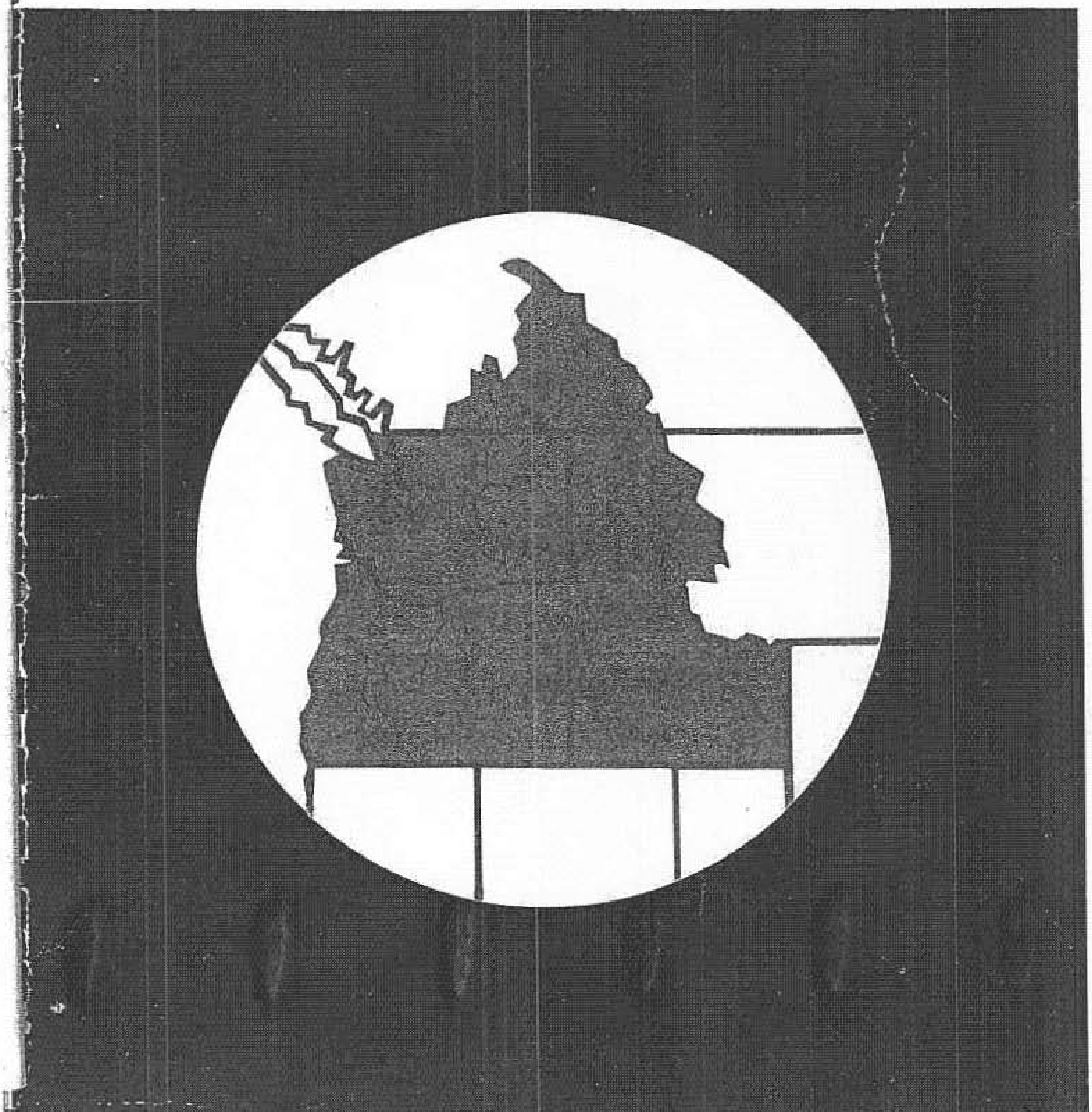
# DISCUSSION OF COORDINATED OPERATION OF ELECTRIC UTILITY SYSTEMS IN THE PACIFIC NORTHWEST IN CONJUNCTION WITH CANADIAN STORAGE

PRESENTATION BEFORE THE U.S. TREATY NEGOTIATING TEAM, WASHINGTON, D.C., JANUARY 13, 1961



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Presentation Before the U. S. Treaty Negotiating Team

Washington, D. C.

January 13, 1961

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## EXHIBITS

# FOREWORD

On January 17 of this year, the President of the United States and the Prime Minister of Canada signed a Treaty relating to cooperative development of the water resources of the Columbia River basin. It provides in essence that Canada will build three large storage dams in British Columbia and the United States may build one such dam near Libby, Montana. The Libby reservoir will extend into Canada.

The Treaty will require that the United States pay a certain sum of money over a period of years for the flood control benefits from the Canadian dams. It will also require that the United States Government return to Canada one-half the downstream power benefits which can be realized at United States projects due to the use of Canadian storage. The amount of the portion which must be returned to Canada must be computed and fixed in advance and must be computed under the assumption that all of the facilities in the United States portion of the Pacific Northwest, as well as the storage to be built in Canada, are operated in concert as a coordinated unit. If, in fact, they are not so operated, the amount of power and energy which must be delivered to Canada by the United States Government is unaffected, but the actual amount of power and energy realized from Canadian storage and available to the United States Government will be far less than was assumed in the computation. Under such circumstances, the government would be required to return to Canada much more than one-half the downstream power benefits actually realized from Canadian storage. And yet, such circumstances exist today. There is a measure of coordination among various projects and ownerships in the Pacific Northwest, but it falls far short of the coordination assumed for the purposes of the Treaty.

Coordination of hydroelectric systems is beneficial to all consumers and utilities in the Pacific Northwest with or without the use of Canadian storage. For that reason, various studies and attempts have been made during the past ten years to accomplish an overall coordination of the facilities in the Pacific Northwest; but the attempts, for various reasons, produced no dependable overall plan. They did, however, produce an understanding of the elements necessary for such a plan.

When the basic concepts to be included in the proposed Treaty were released to the public on October 19, 1960, the United States treaty negotiating team invited the interested non-Federal generating utilities to work toward a coordination plan that would fulfill the purposes of the Treaty and assure fair treatment of all affected persons. Technical experts from the Corps of Engineers and the Department of the Interior were made available in a working and advisory capacity, but no government official was authorized to indicate government agreement or disagreement on any point.

An informal working group of managers, engineers and lawyers immediately set to work on the problem. The organizations which have participated in the work are as follows:

Bonneville Power Administration,
Department of the Interior

U. S. Army Corps of Engineers

| | |
|---|---|
| Public Utility District No. 1 of Pend Oreille County, Washington | Newport, Washington |
| Public Utility District No. 1 of Chelan County, Washington | Wenatchee, Washington |
| Public Utility District No. 2 of Grant County, Washington | Ephrata, Washington |
| Northwest Power Pool, Coordinating Group | Portland, Oregon |
| City of Eugene Water and Electric Board | Eugene, Oregon |
| Seattle City Light | Seattle, Washington |
| Tacoma City Light | Tacoma, Washington |
| Puget Sound Power & Light Company | Bellevue, Washington |
| Pacific Power & Light Company | Portland, Oregon |
| Portland General Electric Company | Portland, Oregon |
| The Washington Water Power Company | Spokane, Washington |
| The Montana Power Company | Butte, Montana |
| Idaho Power Company | Boise, Idaho |
| Aluminum Company of America | Pittsburgh, Pennsylvania |
| Corporate Services, Inc. | Seattle, Washington |

The following is the presentation which was made to the United States treaty negotiators. It describes the technical and policy problems involved in coordination and suggests an approach to the solution.

## OPENING REMARKS

Gordon C. Culp, Lawyer
Representing Corporate Services, Inc.
Seattle, Washington

At the time of completion and release of the Analysis and Progress Report establishing the basic international agreement for development of the Upper Columbia, the United States treaty negotiating team called a meeting of the interested Pacific Northwest utilities to discuss the agreement and its effects on the area. All of the interested utilities deeply appreciated the whole-hearted willingness of the negotiators to work with people in the affected area in order to provide the best and fairest possible procedure to implement the proposed treaty. The interested utilities have worked hard on the matter and will continue to do so; and they all hope that their efforts will be some assistance to the government and will serve the mutual best interests of all citizens.

On November 10 of last year, a meeting of the same group was held in Washington, D. C., at which time it was decided that the groups should try to work out the basis for coordinating all affected American facilities in order that the proposed treaty might operate properly, and to assure a fair distribution of the costs and benefits flowing from the Treaty. The group further undertook to prepare suitable power studies and do the other work necessary to devise agreeable and effective coordination principles, terms and rules.

Since the meeting of November 10, the group, including several most helpful and talented representatives of the Corps of Engineers and the

Bonneville Power Administration, has held several full meetings and sponsored additional meetings of sub-groups to proceed with the work.

The following presentation describes the progress that has been made and calls attention to the areas of work which are still unfinished.

## GENERAL DISCUSSION OF THE AREA AND SYSTEMS

E. F. Timme, Coordinating Engineer
Northwest Power Pool
Portland, Oregon

The Pacific Northwest area is generally considered to include the States of Oregon, Washington, Idaho, the western part of Montana and the southern and western part of British Columbia. The United States portion of this region covers an area of a little over 300,000 square miles. The present Northwest Power Pool operation covers a somewhat larger area, including all except the eastern part of Montana and most of the State of Utah. The area being considered in the proposed coordination agreement includes the United States portion of the Columbia River Basin and the coastal areas of Oregon and Washington.

In any consideration of the Pacific Northwest area, and in particular to power resources in this area, an important element is the topography of the region. One of the topographic features is the long, relatively narrow coastal belt separated from the large inland area by the Cascade Mountain range running from north to south. Lying to the east of the Cascade Range is a large semi-arid belt. On farther to the east, numerous mountain ranges occur, culminating in the Rocky Mountains and the Continental Divide which forms the eastern boundary for the Columbia Basin.

The coastal belt is characterized by milder temperatures and heavier precipitation, due to the influence of the Pacific Ocean and the sweep of storms from the ocean across the area. As an example, the January mean normal temperature in Seattle is 41 degrees, compared to 25 degrees in Spokane. Normal annual precipitation at these two locations is 32 inches and 15 inches, respectively. Of course, deviations in these amounts occur throughout the area. Normal annual precipitation at various coastal locations may range higher than 100 inches, and in the more arid inland areas precipitation may be less than 10 inches annually.

Many relatively short rivers rise in the coastal belt and drain directly into the ocean, Puget Sound or the lower Columbia River. Since the period of heaviest storm activity occurs during the winter period and with the milder climate, flows in these rivers are generally higher during the winter period and low during the summer. In the area east of the Cascades, the colder climate results in a substantial percentage of the precipitation remaining in the form of snow during the winter, with the runoff occurring with moderating temperatures in the spring. Consequently, river flows in the inland area are generally low in the winter months and high in the spring and early summer. Substantial benefits in hydro plant operation can be derived from this peculiar climatological pattern as will be explained in later discussion.

The major population centers are located in the coastal belt. The metropolitan areas of Seattle and Portland, with nearly 2,000,000 people, constitute about 37 percent of the U. S. Pacific Northwest population. Altogether, about 60 percent of the population resides in the area to the west of the Cascades. While electric load centers and population are not necessarily in direct relation, they do generally go hand in hand. For instance, in January, 1960, approximately 57 percent of the load served was in the coastal area.

In addition to the Seattle-Tacoma and Portland centers, these include: Spokane, Wenatchee, Yakima and Hanford in central and eastern Washington; Boise and Pocatello in southern Idaho; the Salt Lake City area in Utah; Butte-Anaconda, Great Falls and Kalispell in Montana; the Willamette Valley area in Oregon; and Vancouver and Trail in British Columbia. The area load shape is also affected by the weather in the area. The load normally begins to rise in the late summer and continues to rise as temperature levels decline, hitting a peak in January. As temperatures warm after January, the load drops off until it hits a low in the summer months. To date, irrigation pumping and air conditioning load has failed to fill in the summer valley in the area load.

In the negotiations being carried on between the United States and Canada, a base system of hydro plants was used in making analyses to determine benefits from Canadian storage. This base system included most, but not all, of the hydro generating plants on the main stem of the Columbia River and its tributaries. Additional resources in the U. S. portion of the region, not included in the base system, have been termed "Other Resources." These resources are shown on Exhibit 1.

It might be of interest to briefly review the base system resources. The U. S. base system includes: the Federal plants at Hungry Horse, Albeni Falls, Grand Coulee, Chief Joseph, Ice Harbor, McNary, John Day, The Dalles and Bonneville; The Montana Power Company plants at Kerr and Thompson Falls; The Washington Water Power Company plants at Noxon, Cabinet, and Coeur d'Alene storage only; the Pend Oreille PUD plant at Box Canyon; Chelan PUD

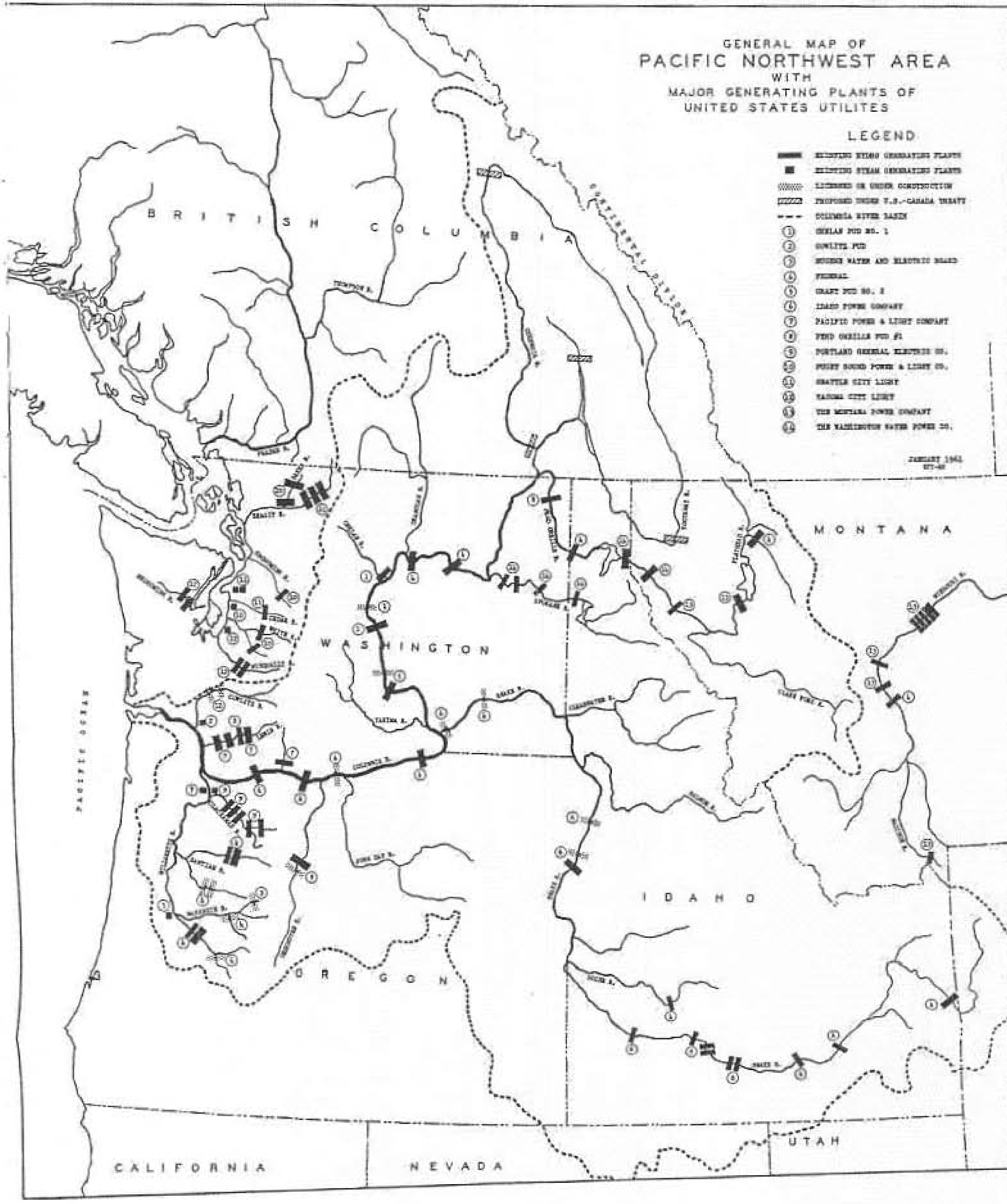

GENERAL MAP OF
PACIFIC NORTHWEST AREA
WITH
MAJOR GENERATING PLANTS OF
UNITED STATES UTILITES
LEGEND
EXISTING HYDRO GENERATING PLANTS
EXISTING STEAM GENERATING PLANTS
LICENSED OR UNDER CONSTRUCTION
PROPOSED UNDER U.S.-CANADA TREATY
COLUMBIA RIVER BASIN
CHELAN PUD NO. 1
COWLITZ PUD
EUGENE WATER AND ELECTRIC BOARD
FEDERAL
GRANT PUD NO. 2
IDAHO POWER COMPANY
PACIFIC POWER & LIGHT COMPANY
PEND OREILLE PUD #1
PORTLAND GENERAL ELECTRIC CO.
PUGET SOUND POWER & LIGHT CO.
SEATTLE CITY LIGHT
TACOMA CITY LIGHT
THE MONTANA POWER COMPANY
THE WASHINGTON WATER POWER CO.
BRITISH COLUMBIA
CONTINENTAL DIVIDE
WASHINGTON
MONTANA
IDAHO
OREGON
CALIFORNIA
NEVADA
UTAH
PACIFIC OCEAN

Exhibit 1

plants at Chelan, Rocky Reach and Rock Island; Grant PUD plants at Wanapum and Priest Rapids; and Idaho Power Company plants at Brownlee and Oxbow. The plants at Rocky Reach, Wanapum, Oxbow, Ice Harbor and John Day are under construction. The Wells Plant would become part of the base system when constructed. Proposed development of the Ben Franklin and Libby Plants would be covered in the Treaty itself. There are seven different utility ownerships involved in the 22 plants listed above. There are even more utilities with a direct interest, since long-term purchase contracts have been signed for output of some plants.

The "Other Resources" are made up from most of the remaining plants in the U. S. Pacific Northwest. Some of these plants are on Columbia River tributaries and the remainder are in coastal watersheds. These include: Idaho Power Company plants in the upper Snake River Basin; The Washington Water Power Company plants on the Spokane River; Portland General Electric Company plants on the Deschutes and Clackamas Rivers; Federal plants on the Willamette River and tributaries and in southern Idaho; Pacific Power & Light Company plants on the Lewis River; Tacoma City Light plants on the Cowlitz, Nisqually and Skokomish Rivers; Seattle City Light plants on the Skagit River; and Puget Sound Power & Light Company plants on the White and Baker Rivers. There are numerous other smaller utility plants scattered throughout the area. Hydro plants in this group which are not existing at the present time, but which are either under construction or licensed, include Mayfield, Mossyrock, Cougar, Hills Creek, Green Peter, Foster, Carmen-Smith and Round Butte.

In addition, there are several thermal plants located chiefly in the coastal area. Major utility plants include Shuffleton, Lake Union, Georgetown, Tacoma No. 1 and No. 2, Lincoln, Station L, Cowlitz Steam and Eugene steam.

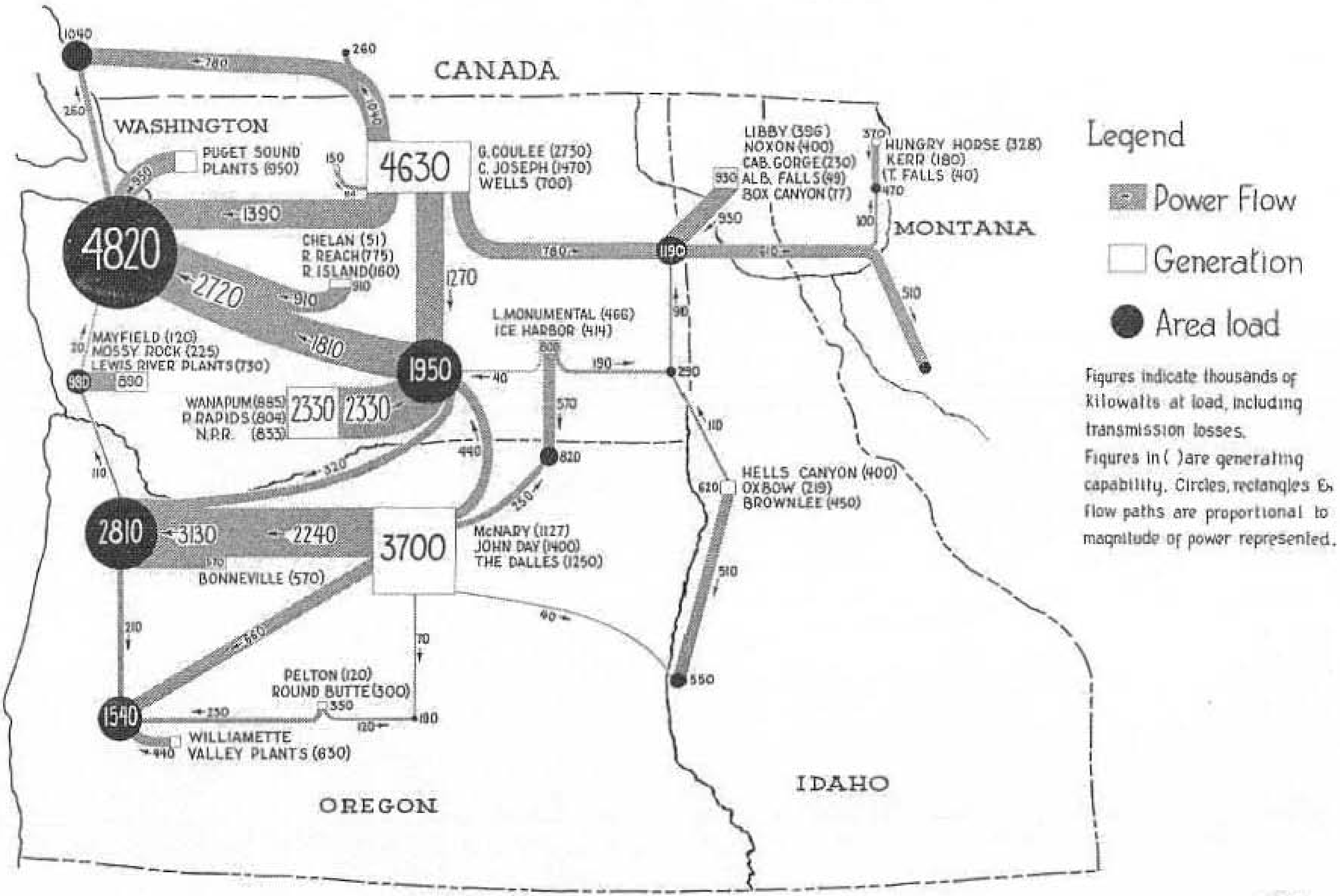
Among the "Other Resources", nine different utility ownerships are involved.

The "Other Resources" assumed to be existing or under construction at the time of treaty ratification have an average generating capability during the seven-month critical period of 1,471 megawatts. An additional 389 average megawatts of thermal capability is also available. This total of 1,860 average megawatts compares to 6,669 average megawatts of capability during the same critical period in the base system, or approximately 22 percent of the total. The total area capability if 8,529 average megawatts, without Canadian storage, is broken down into 4,600 average megawatts of Federal, or 54 percent of the total, and 3,929 average megawatts of non-Federal, or 46 percent of the total.

Exhibit 2 illustrates possible power flows from generating plants to load centers throughout the area. The load and generation level represented on this chart corresponds to a peak load condition in about 1970 and after the 15.5 million acre-feet of Canadian storage is in operation. Load areas are shown by the black circles with the size of the circle proportioned to the load. Generating plants have been lumped together and shown by the rectangular blocks. Power flows from generating plants to load centers are shown by the cross-hatched paths. The requirement for transfer of large blocks of power and energy will necessarily require adequate transmission facilities. The chart also indicates that approximately 60 percent of the estimated load requirements occur west of the Cascades compared to the 57 percent in 1960.

BONNEVILLE POWER ADMINISTRATION

# EXAMPLE OF PEAK POWER FLOW FOR NORTHWEST POWER POOL INCLUDING CANADIAN STORAGE - JANUARY 1970




Figures indicate thousands of kilowatts at load, including transmission losses.
Figures in ( ) are generating capability. Circles, rectangles & flow paths are proportional to magnitude of power represented.

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All of the interconnected utilities and electric systems in the area are part of the Northwest Power Pool. Exhibit 3 indicates the interconnected utilities which are participating directly in the Operating Committee at the present time, with each of the 13 utilities shown having appointed one representative on the Committee. Public agency utilities, private utilities and the Federal system, represented by Bonneville Power Administration, are shown by the different shaded discs. Since its formation nearly 20 years ago, the Pool Operating Committee has functioned on a purely voluntary basis. Any coordination that has been achieved among the utilities has been through voluntary cooperation among the various members. There has never been any formal contract or agreement binding the members in the Power Pool. While many benefits have been obtained through voluntary coordination in the past, some of those benefits have been on a non-firm basis. The chart also indicates by code the many operating sub-groups within the Pool itself. These sub-groups have evolved primarily through the various contractual relations which have developed between the utilities over the years.

OPERATING COMMITTEE AND OPERATING GROUPS IN NORTHWEST POWER POOL

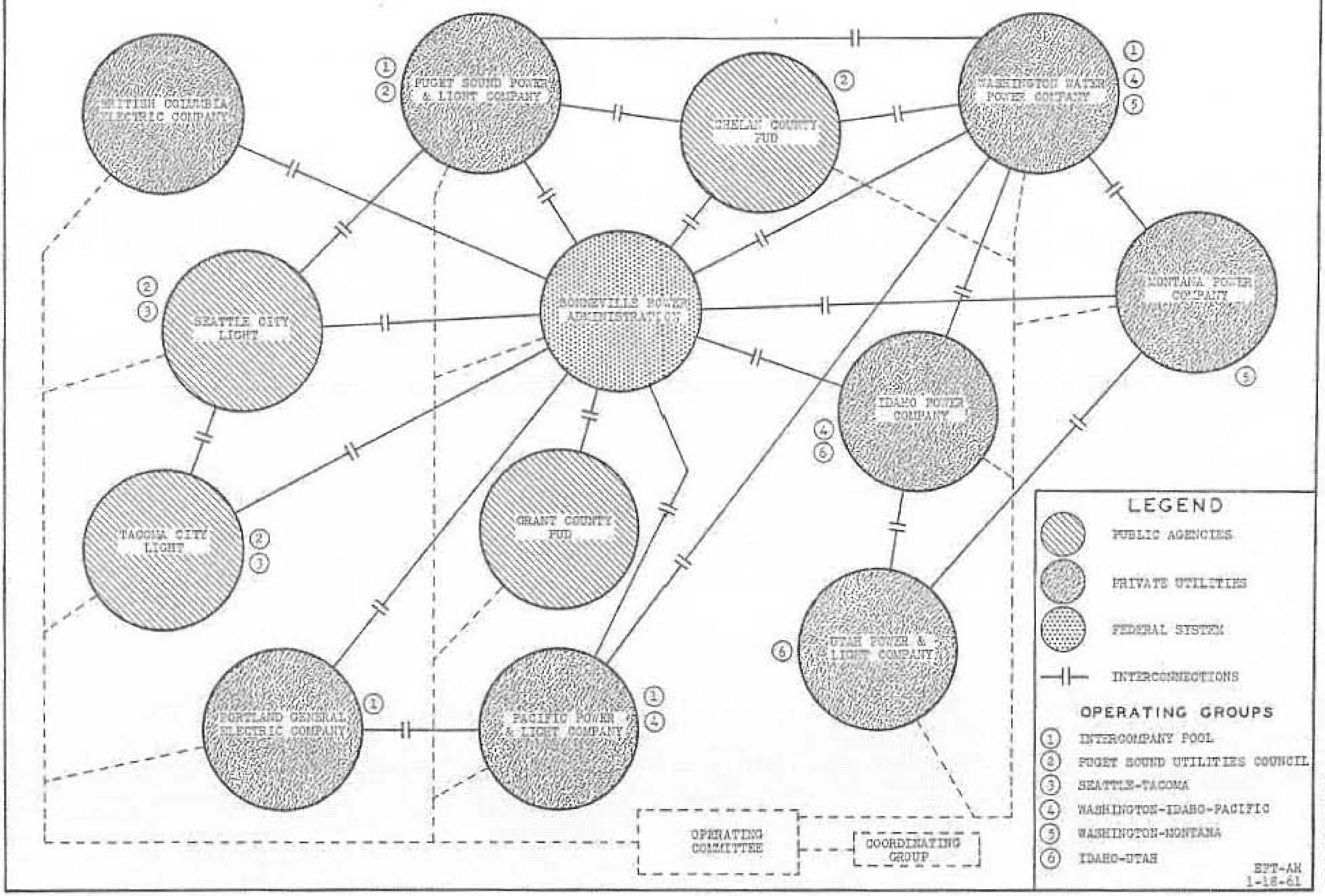



Exhibit 3

# FUNDAMENTALS OF STORAGE USE AND SYSTEM COORDINATION

C. E. Mohler, General Engineer
Bonneville Power Administration
Portland, Oregon

The benefits of coordinated operation arise from a variety of fundamental sources. In actual situations these sources occur in combinations and permutations which obscure their individual functioning. The purpose here is to isolate certain individual sources of benefits by use of simplified hypothetical situations so that these sources can be examined and understood more fully. Although each of these hypothetical situations has its counterpart within some more complex power situation in the Pacific Northwest, specific examples are beyond the scope of this discussion.

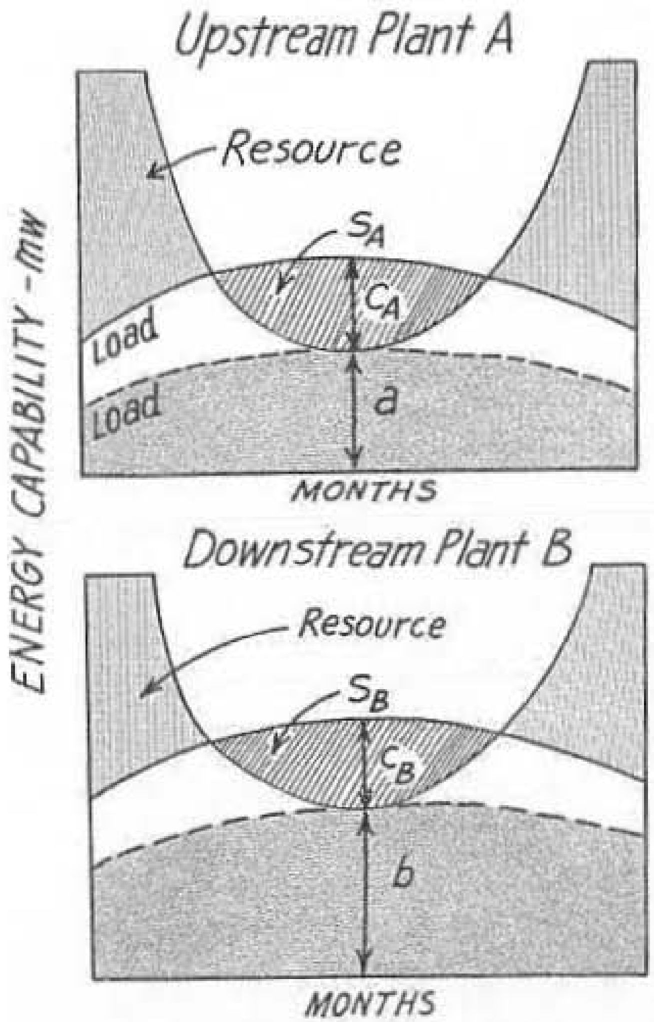
Coordination can be defined as the operation of diverse power facilities to produce maximum firm benefits at minimum expense. The facilities may be diverse as to location, or diverse as to ownership, or both. Achievement of any of three results will constitute coordination. First, if there is an increase in usable power, either kilowatts of peaking or kilowatthours of energy, coordination is achieved. Second, if there is no increase in power capability, but the cost of power production is decreased, coordination is achieved. Third, if power capability is neither increased nor cost of production decreased, but the certainty of the power capability is increased, this also is coordination. This third achievement is the most difficult and the most important as it depends upon binding agreements between the coordinating utilities.

The hypothetical situation illustrated by Exhibit 4 is not one of coordination but is simple use of storage. The chart illustrates the loads and resources of two utilities. The vertical scale shows the amount of energy load and resources in average megawatts, while the horizontal scale shows the time of year. As shown, the upstream utility has a high capability at the beginning and end of the year, but in the mid-part of the year capability is low. This low capability is supplemented by the release of reservoir storage. The storage is released so that the mid-year capability fits the load requirements shown by the chart, with the result that the load designated as "a" is carried from streamflow and additional load designated as "$C_A$" is carried from the storage. To carry the additional load, storage sufficient to generate $S_A$ kilowatthours is released.

The downstream utility, as shown on Exhibit 4, has a load and resource pattern similar to that of the upstream utility, in that resources are lowest in the mid-part of the year while loads are highest at that time. Operated by itself the downstream utility can carry a firm load which is limited by its minimum resource designated as "b" on the chart. In the situation shown, however, the two utilities operate on the same river, and as they have the same load resource pattern, the storage relases by the upstream utility are completely usable by the downstream utility. This storage is sufficient to generate $S_B$ kilowatthours with the result that an additional load designated as "$C_B$" can be carried by the downstream utility.

On Exhibit 5, the benefit from annual streamflow diversity is shown. The vertical scale indicates monthly energy capability in megawatts, while the horizontal scale indicates time extending over a period of about five years.

# STORAGE




Total capability without storage $a+b$

Capability at plant A from release of storage S at plant A $C_A$

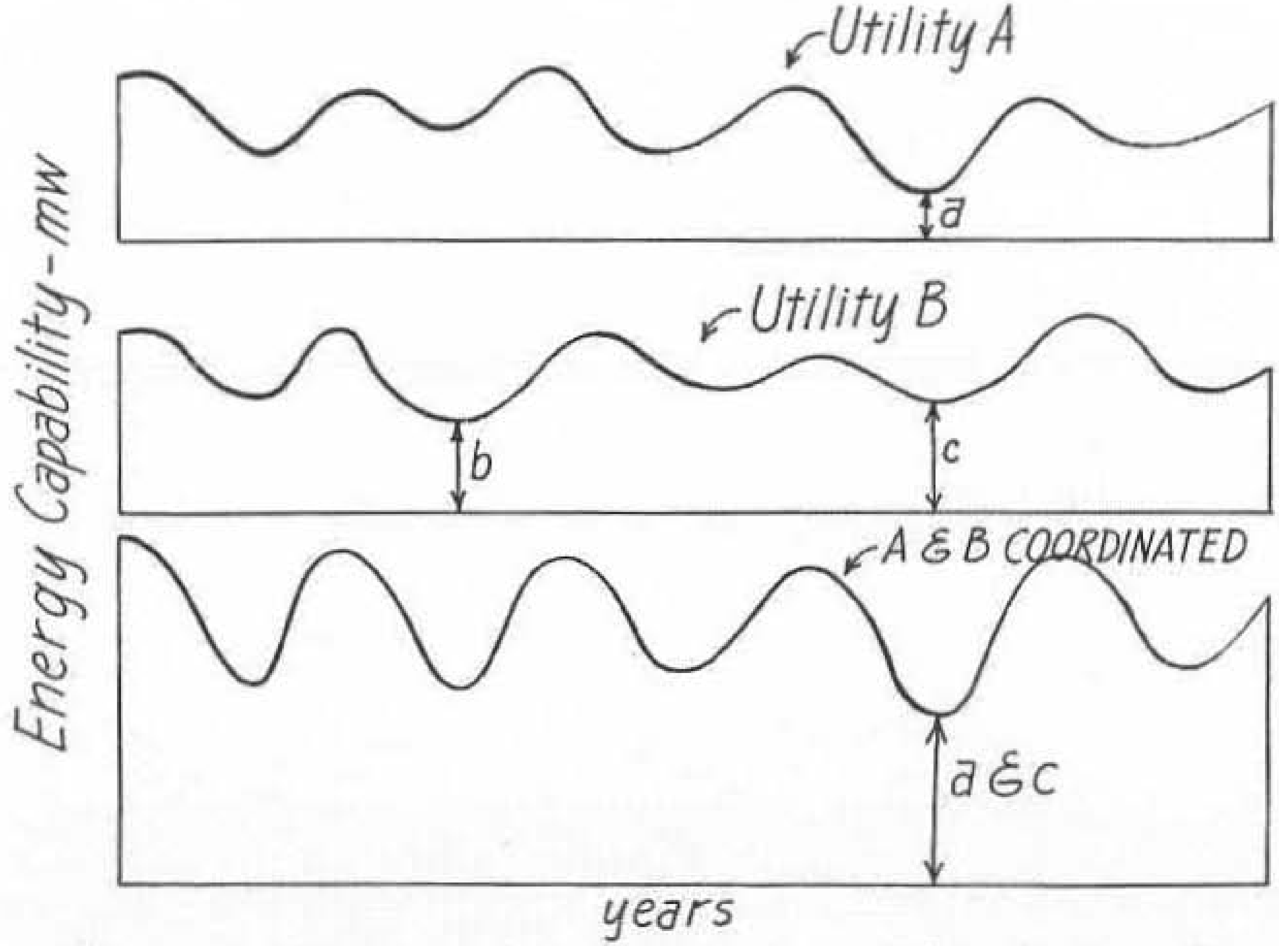
Capability at Plant B from release of storage S at plant A $C_B$

Total capability with use of storage $a+b+C_A+C_B$

Capability gain from storage $C_A + C_B$

EXHIBIT 5

# ANNUAL STREAMFLOW DIVERSITY



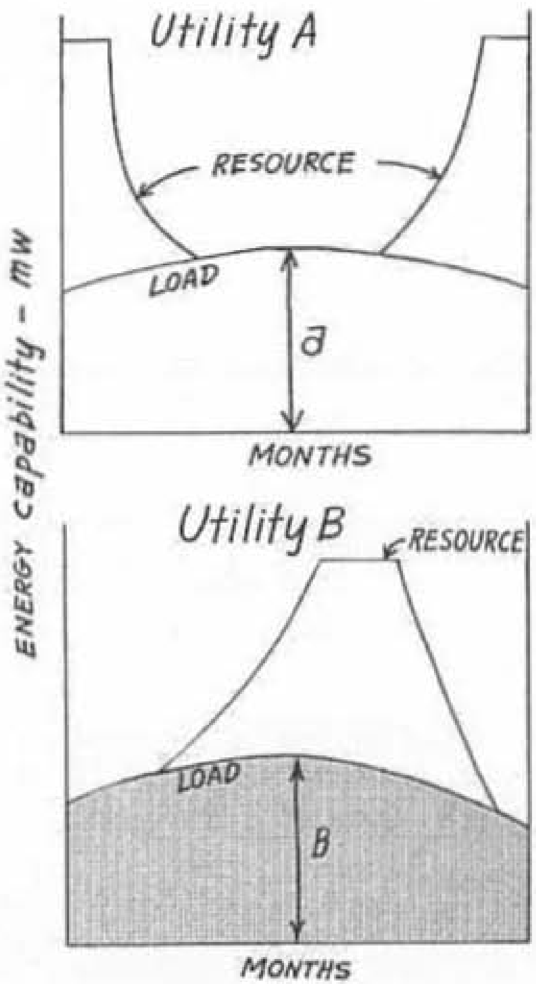

Total capability isolated a+b
Total capability coordinated a+c

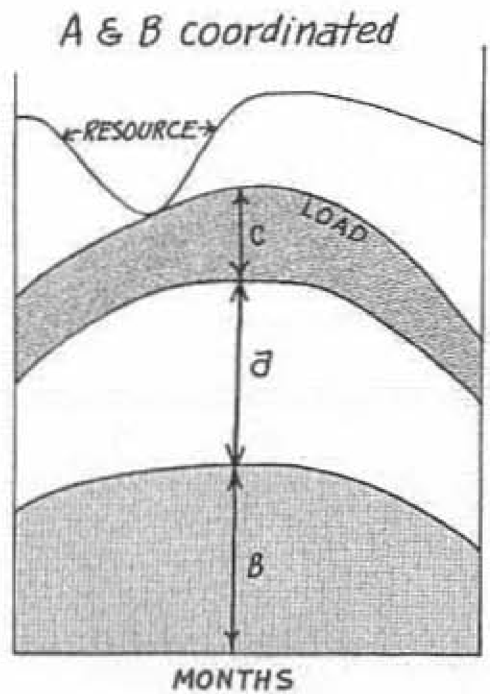
c>b, ∴ a+c>a+b
∴ coordination is of benefit

Shown at the top is the capability of Utility A which varies with the annual streamflow cycle. The firm load which Utility A can carry under isolated operation is limited by the capability during minimum streamflow. This capability is indicated as "a" on the chart. Similarly, the load which Utility B can carry under isolated operation is indicated as "b" on the mid-section of the chart, and the load which both can carry is "a" plus "b". If the two utilities are interconnected and operated in a coordinated manner, their resources are directly additive month-by-month with the results shown by the lowest section of the chart. The firm load which they can carry is limited to their capability during minimum combined streamflow. This minimum capability is "a" plus "c" with "c" being the capability of Utility B concurrent with "a". As "c" is greater than "b", "a" plus "c" is greater than "a" plus "b" and there is a benefit from coordination. It might be noted that the concurrence of the combined critical period with one of the two isolated critical periods is a common occurrence but by no means a universal one.

On Exhibit 6 is shown the benefit from seasonal streamflow diversity which is diversity with regard to the month in which streamflow occurs rather than the year in which it occurs. The vertical scale indicates energy in average megawatts while the horizontal scale shows time of year. As shown on the left, Utility A under isolated operation has a high capability at the beginning and end of the year with a much lower capability during the mid-part of the year. The load has the opposite pattern being high in the mid-part of the year when it is limited to the amount shown as "a" by available resources. Utility B under isolated operation has a similar load pattern but its resources are highest in

# SEASONAL STREAMFLOW DIVERSITY




Total capability isolated a+b
Total capability coordinated a+b+c
a+b+c > a+b
∴ coordination is of benefit

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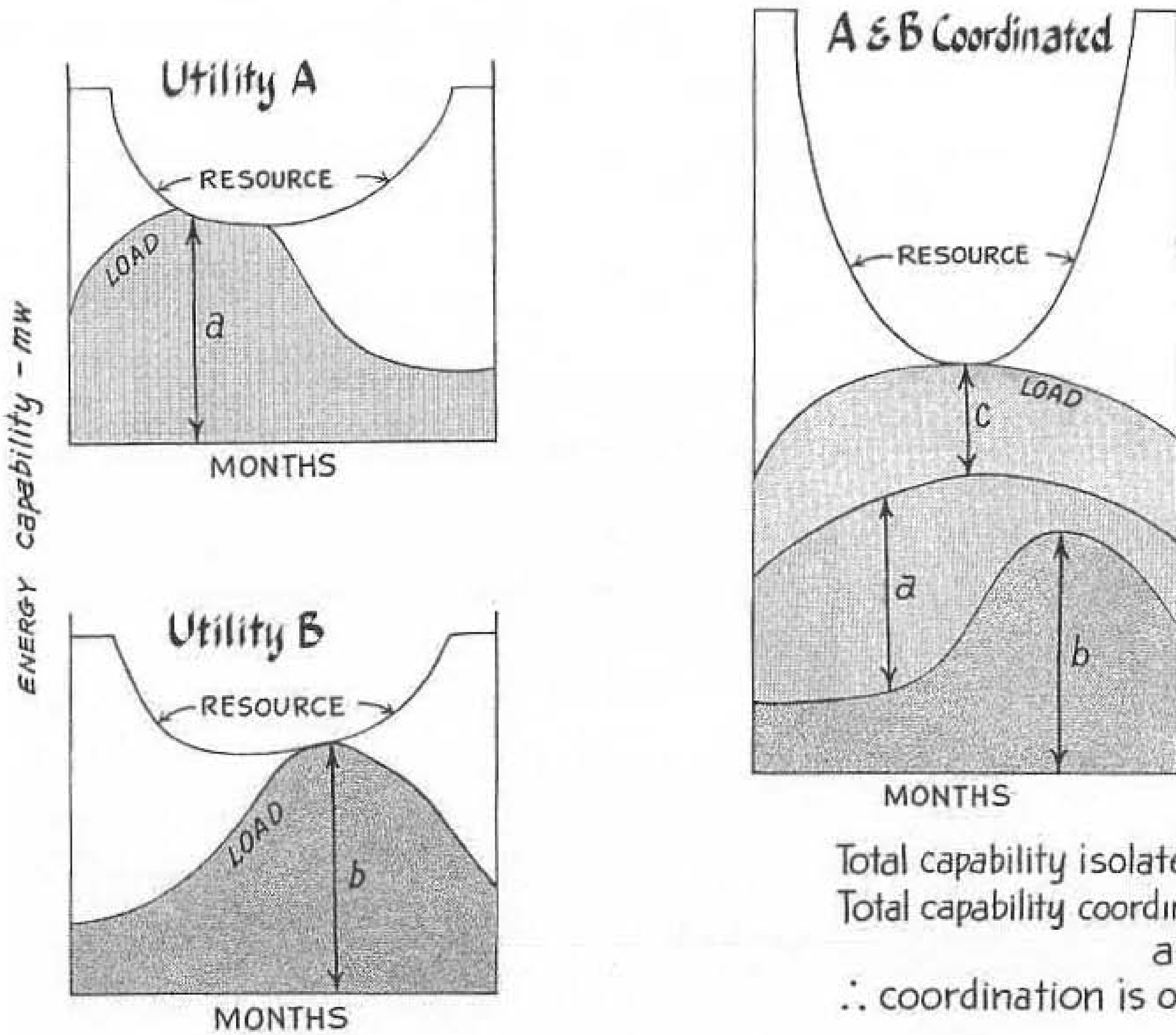
the mid-part of the year with the result that the load shown as "b" can be carried. If the two utilities are interconnected and operated in a coordinated manner, their resources are directly additive month by month with the results shown by the right-hand portion of the chart. Also shown there are the loads "a" and "b" which are carried under isolated operation. As shown, the coordinated resource exceeds the sum of these two loads. The added load which can be carried on a firm basis is shown as "c" which is the benefit from coordination.

On Exhibit 7 is shown the benefit from energy load diversity. The scales are the same as on Exhibits 4 and 6. Also,as on Exhibit 6, isolated operation is shown on the left portion of the chart, while coordinated operation is shown on the right portion of the chart. Under isolated operation, both utilities have the same pattern of resources with a low mid-year capability limiting the firm load which can be carried. The energy load patterns have diversity, however, with Utility A having its highest load in the first third of the year while Utility B has its highest load in the second third of the year. These loads are designated as "a" and "b", respectively, on the left portion of the chart. The addition of these loads month by month is shown on the right, together with a similar addition of resources as a result of coordinated operation. As shown, the loads complement each other with the result that the total resource exceeds the sum of the isolated loads by an amount designated as "c". This is the additional load which can be carried and is therefore the benefit from coordination.

On Exhibit 8 is shown coordination through shaping secondary energy resources to a firm load. The scales are the same as shown on Exhibits 4, 6 and 7, with isolated operation shown on the left portion of the chart. Under

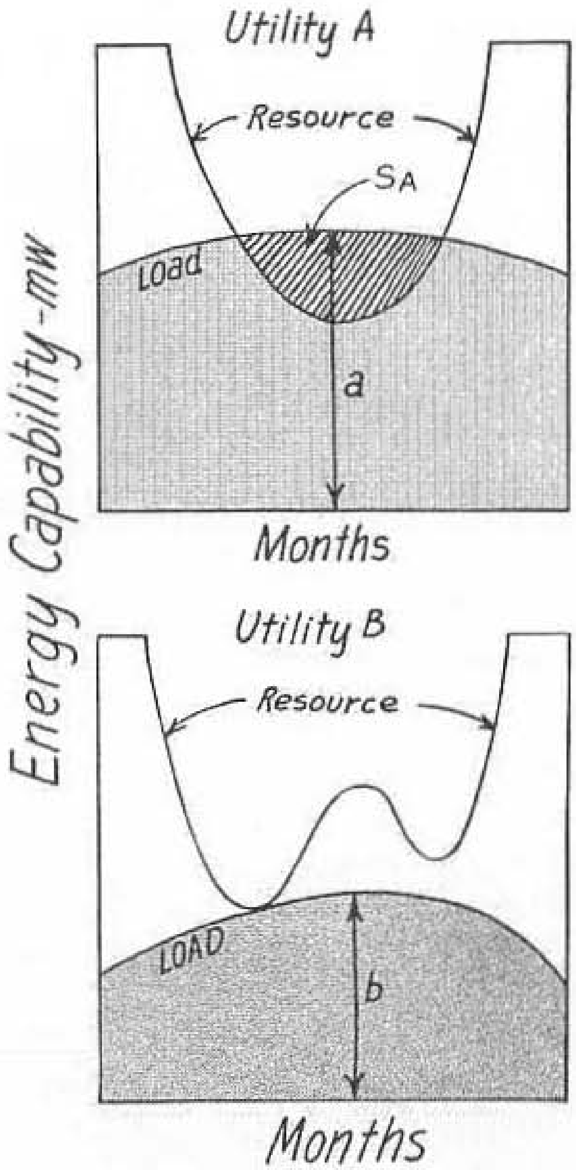
# LOAD DIVERSITY

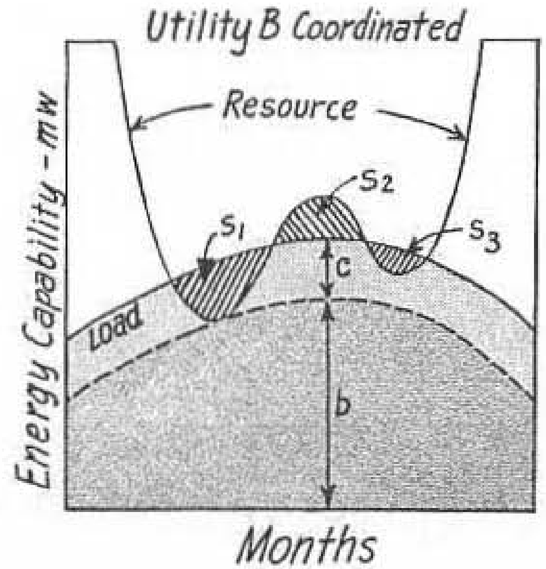



Total capability isolated a+b
Total capability coordinated a+b+c
a+b+c > a+b
∴ coordination is of benefit

BPA DEC. 1960

# SHAPING RESOURCE TO LOAD




| | |
|---|---|
| Total capability isolated | $a+b$ |
| Total use of storage isolated | $S_A$ |
| Coordinated use of storage by B | $S_1 - S_2 + S_3 = 0$ |
| Total use of storage coordinated | $S_A$ |
| Total capability coordinated | $a+b+c$ |

$a+b+c > a+b$ and use of storage is no greater

∴ Coordination is of benefit

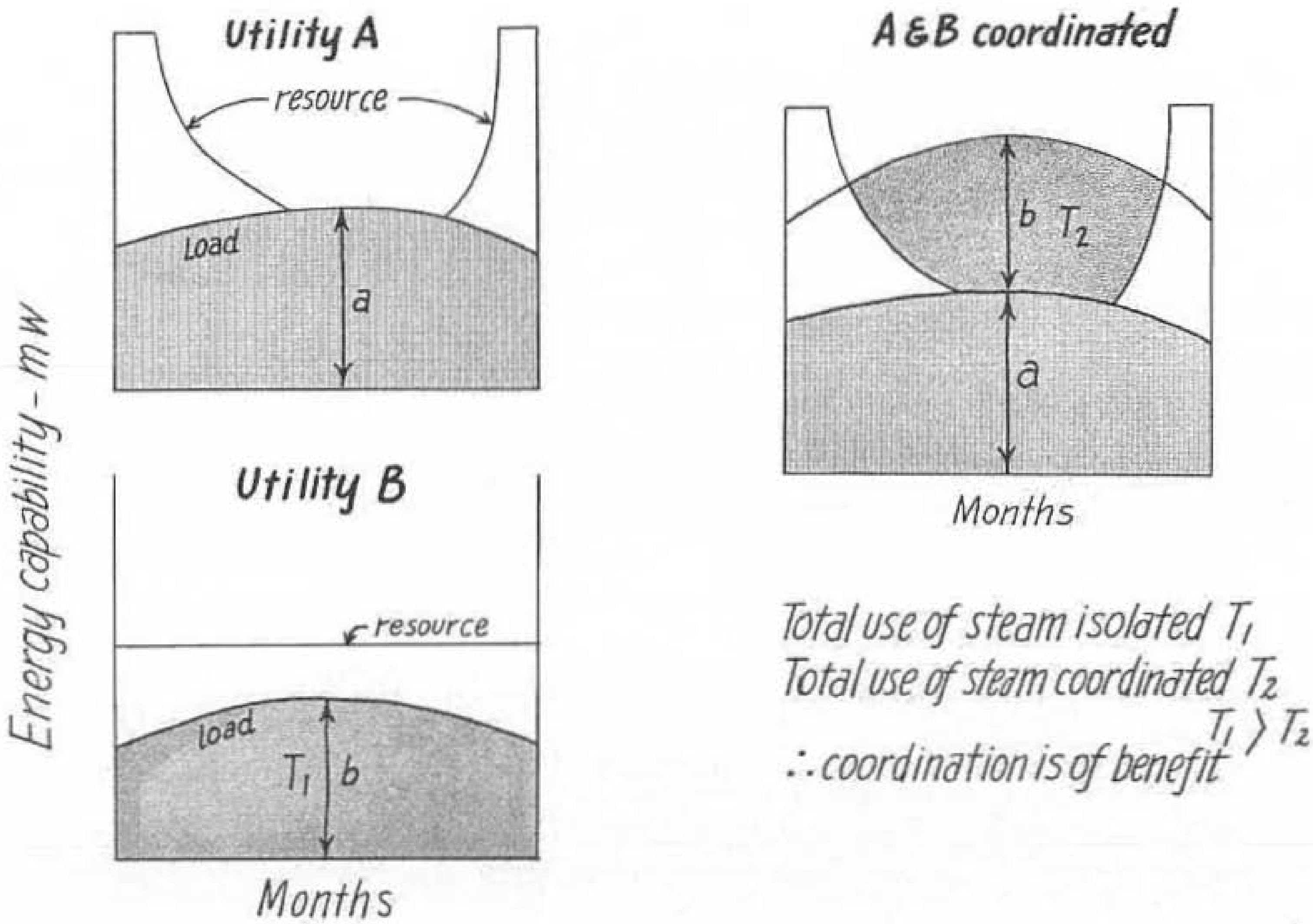
isolated operation, both utilities have the same general pattern of loads and resources with the firm load being limited by low mid-year capability. Utility A, however, regulates and supplements its mid-year capability by release of reservoir storage sufficient to generate $S_A$ kilowatthours with the result that the load designated as "a" is carried. The load designated as "b" which Utility B can carry under isolated operation is limited by the minimum energy capability which occurs early in the season.

On the right-hand portion of the chart is shown the capability of Utility B when operated in coordination with Utility A. In the early part of the season, when the capability of Utility B is at a minimum, $S_1$ kilowatthours of energy are received from Utility A as the result of accelerated storage release. Later in the season, $S_2$ kilowatthours are returned to Utility A while still later, $S_3$ kilowatthours are received from Utility A. As shown, this exchange of energy will permit Utility B to carry an additional load designated as "c" which is the benefit from coordination. If the algebraic sum of $S_1$, $S_2$ and $S_3$ is zero, as shown, the total use of storage by Utility A may not be increased, and the benefit of coordination may be secured without any material increment of cost.

On Exhibit 9 is shown the benefit of steam displacement. The scales are the same as shown on Charts 4, 6, 7 and 8, with isolated operation shown on the left portion of the chart. Under isolated operation, Utility A has the same load-resource pattern shown previously with the firm load designated as "a" being limited by low mid-year capability. The load of Utility B, designated as "b", has a similar pattern to that of Utility A; however, the energy resource of Utility B is in excess of the load in all months as sufficient steam generating capacity must be provided to carry the maximum momentary load.

EXHIBIT 9

# STEAM DISPLACEMENT



If Utilities A and B are interconnected, the load-resource relationship will be as shown on the right-hand portion of the chart. If the total load of "a" plus "b" is carried, over very roughly one-third of the year no steam generated energy is required, as the load can be carried from the hydro resources of Utility A. The cost saving through the reduced consumption of fuel is the benefit from coordination. This benefit is measurable in cost in contrast with the previously illustrated benefits which were measurable in increased firm capability.

Other sources of coordination benefits could be illustrated in addition to those shown on Exhibits 4 through 9. In the same manner that benefits are secured through energy load diversity, benefits can also be secured through diversity in peak loads. A difference of as little as one hour in time of peak load of two utilities can result in a sizable benefit if the firm load is limited by peak resources. A savings in transmission costs can be realized if there is an interconnection between two utilities which would otherwise need to plan for power flows in opposite directions. Generator maintenance outages can be scheduled more economically under coordinated operation as surplus capability of one utility can be used to carry part of the load of another utility which finds it necessary to take out units for maintenance. Likewise, coordination affects economies in reserve generating capacity. As the percentage of capacity required for reserve is a function of the size of system and number of generators, interconnection has the effect of increasing both of these factors and thus provides a reduction in the required reserves.

A coordination which will undoubtedly receive greater attention in the future in the Pacific Northwest is in pondage operation. The fluctuations in hourly loads through the week require the operation of storage at plants which have insufficient storage for seasonal use. Under coordinated operation this daily storage, termed pondage, can be drawn so as to preserve a maximum energy capability for the coordinated systems.

In discussion of these examples, it becomes apparent that certain physical facilities are essential if coordination is to be achieved. The most universal of these is transmission capacity. In all the situations which were discussed, both those which were illustrated by charts and those which were not, transmission capacity is necessary to carry the power or energy which is exchanged to make coordination productive. Virtually all this transmission capacity can be provided from the capacity which is constructed fundamentally to carry the plant generation to load centers. The principal and important requirement is therefore transmission interconnection between utility systems.

Another facility essential for most coordination benefits is reservoir storage. As illustrated by the charts, coordination frequently entails the changing of the time-availability of energy. Reservoir storage provides the necessary flexibility to accomplish this. Where the reservoir is upstream from the facility being coordinated, the coordination is achieved by the releasing or withholding of water -- sometimes designated as hydraulic coordination. However, as illustrated in the chart shaping resources to load, coordination can also be achieved through use of a reservoir in another river basin -- sometimes designated as electrical coordination.

Another facility necessary for coordination is adequate generating capacity. Under coordinated operation it is frequently necessary to evacuate a reservoir over a much briefer period than under isolated operation. Power plants at the reservoir and immediately downstream must, of course, have adequate capacity to utilize the storage release if some of it is not to be wasted. Under coordinated operation there is a wider opportunity to select the best plants to carry the peak of the load with the result that a greater capacity is required at these plants. Some plants are inherently more suitable for peaking operation because of a small head loss with storage drawdown, availability of reregulating capacity downstream, proximity to load centers, or other reasons. Some of these best plants may not be available to a utility which is operating isolated.

In summary, the benefits of coordinated operation arise from a variety of fundamental sources. These include diversities of streamflow and load, both peak and energy, and include the pooling of power facilities to reduce the expense of production. Transmission interconnections, reservoir storage, and adequate generating capacity play an important part in these sources of coordination benefits. From these sources the benefits appear in the form of an increase in power capability or a decrease in the cost of production.

## POWER GENERATION RESULTING FROM CANADIAN STORAGE

David J. Lewis, Chief of Power Section
Corps of Engineers
Portland, Oregon

The studies which have been made to determine the effects of the 15.5 million acre-feet of storage on the load-carrying ability of the Northwest, have assumed that the projects were fully coordinated and have thereby taken full advantage of the diversities discussed above.

The results of the studies are depicted for the 1970 conditions on Exhibit 10. The cross-hatched columns on the right indicate the power capabilities of the base system which, as previously discussed, include those projects on the Columbia River and principal tributaries which are in operation or under construction. The columns on the left indicate the capability of these projects after the addition of the Canadian storage. The pair of columns on the left shows the dependable capacity, determined by dividing the prime by the system load factor, with the gain due to the Canadian storage being the difference between the tops of the two columns or 2,625,000 kilowatts. The offset portion of the left-hand column (1,312,000 kilowatts) is that amount which is given to Canada, or one-half of the gain. The chart indicates two segments of this power given to Canada, the lower one being that produced at Federal projects and the upper segment that of the non-Federal projects.

Passing over the central pair marked "prime" temporarily, we have the average usable energy indicated on the right. Again, one-half the total gain of 1,525,000 kilowatts, or 763,000 kilowatts, is given to Canada and one-half is retained by the United States.

# COORDINATED SYSTEM POWER CAPABILITY SHOWING SYSTEM TOTAL WITH & WITHOUT CANADIAN STORAGE AND SHARE OF GAIN ASSIGNED TO CANADA

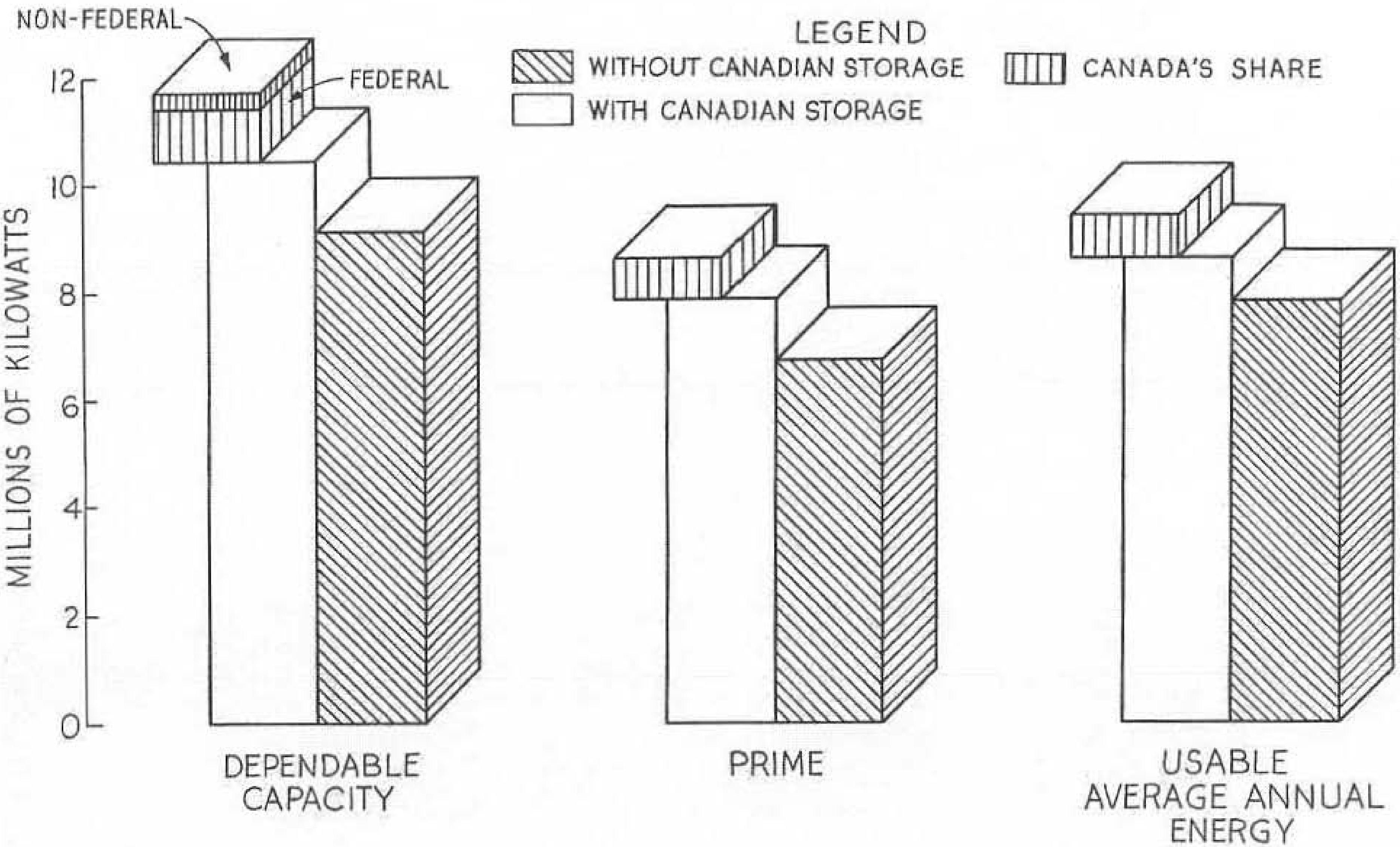



Exhibit 10

Observing the central pair, which is the average energy during the critical period, or prime, we see that the offset block of energy is equal to the block of average energy given to Canada. This demonstrates the provision of the Treaty that the energy delivered to Canada will be in equal monthly amounts. Since the gain in energy during the critical period (1,920,000 kilowatts) is greater than the average, and the amount given to Canada is equal to one-half the average, the amount of prime remaining in the United States is 1,157,000 kilowatts and greater than half the gain. The effect of this difference in the division of prime becomes more significant as we get into years beyond 1970.

The factors affecting the computation of prime and dependable capacity result in their being relatively stable amounts for many years. The only changing factors which affect the computed amount of prime significantly are the load shape and the flows which will be modified by the diversions and return flows of future non-power development.

The energy, as computed by the agreement, however, may change significantly in the first few year as the United States develops a greater use for its secondary energy and will change gradually as additional generating units are added to base system projects. The use of secondary might be increased by additional interconnections with other areas and will be increased as new steam plants provide a steam replacement market for secondary hydro energy.

Since the prime, as computed in the agreement, stays relatively constant for many years and the average energy declines rapidly, the proportion of prime remaining in the United States will increase.

Exhibit 11 shows the relationship of storage to the critical period. The maximum possible monthly generation for the 1936-37 year is indicated on the

# CANADIAN STORAGE IN RELATION TO CRITICAL PERIOD

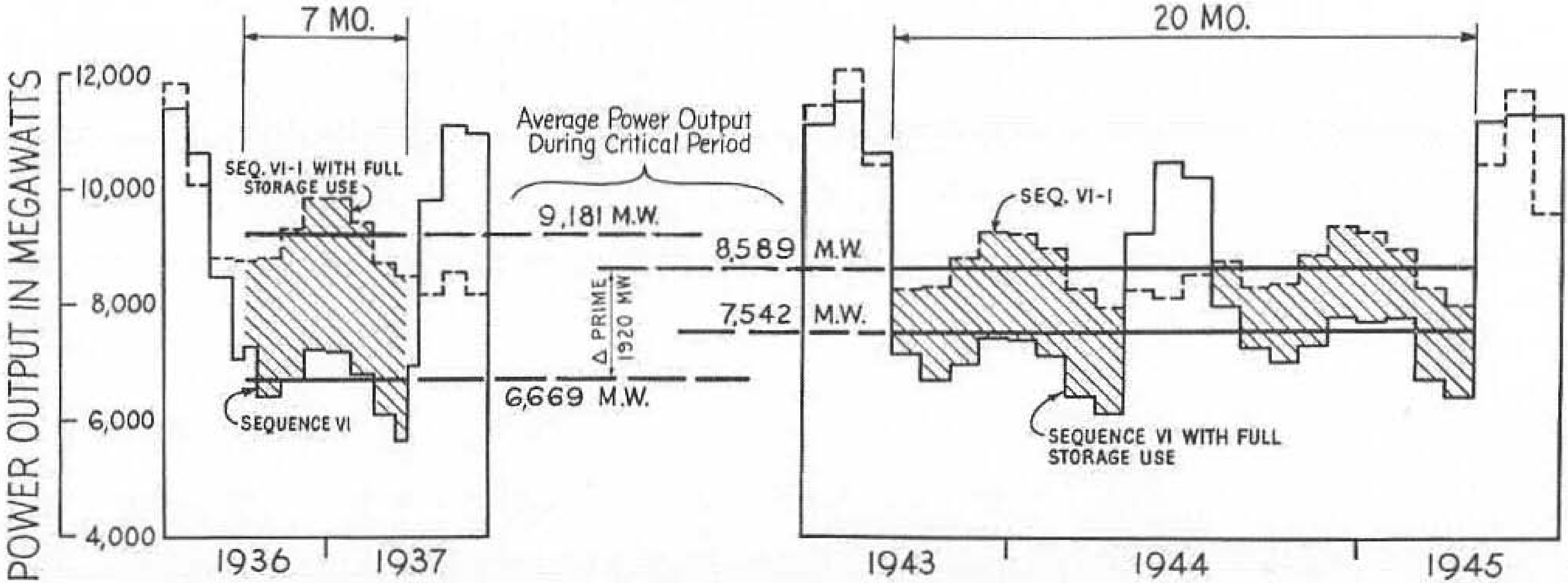



Exhibit 11

left of the chart, both with and without Canadian storage, and that of the 1943-45 period is shown on the right. The irregular shape of the generation reflects the character of the load, and the straight lines indicate the average generation over the critical months. The solid line indicates the maximum potential generation of the base system without Canadian storage, and the dashed lines indicate the maximum potential generation with Canadian storage. The cross-hatched area indicates the part of the generation which results directly from Canadian storage releases.

It might be observed that the average generation without Canadian storage is limited to 6,669 megawatts in the 1936-37 period, but an average generation of 7,542 megawatts would be possible in the 1943-45 period. As Canadian storage is added, the possible average generation in the 1936-37 period is increased to 9,181 megawatts, but in the 1943-45 period, where it must be used over a 20-month rather than a seven-month period, the potential is limited to 8,589 megawatts.

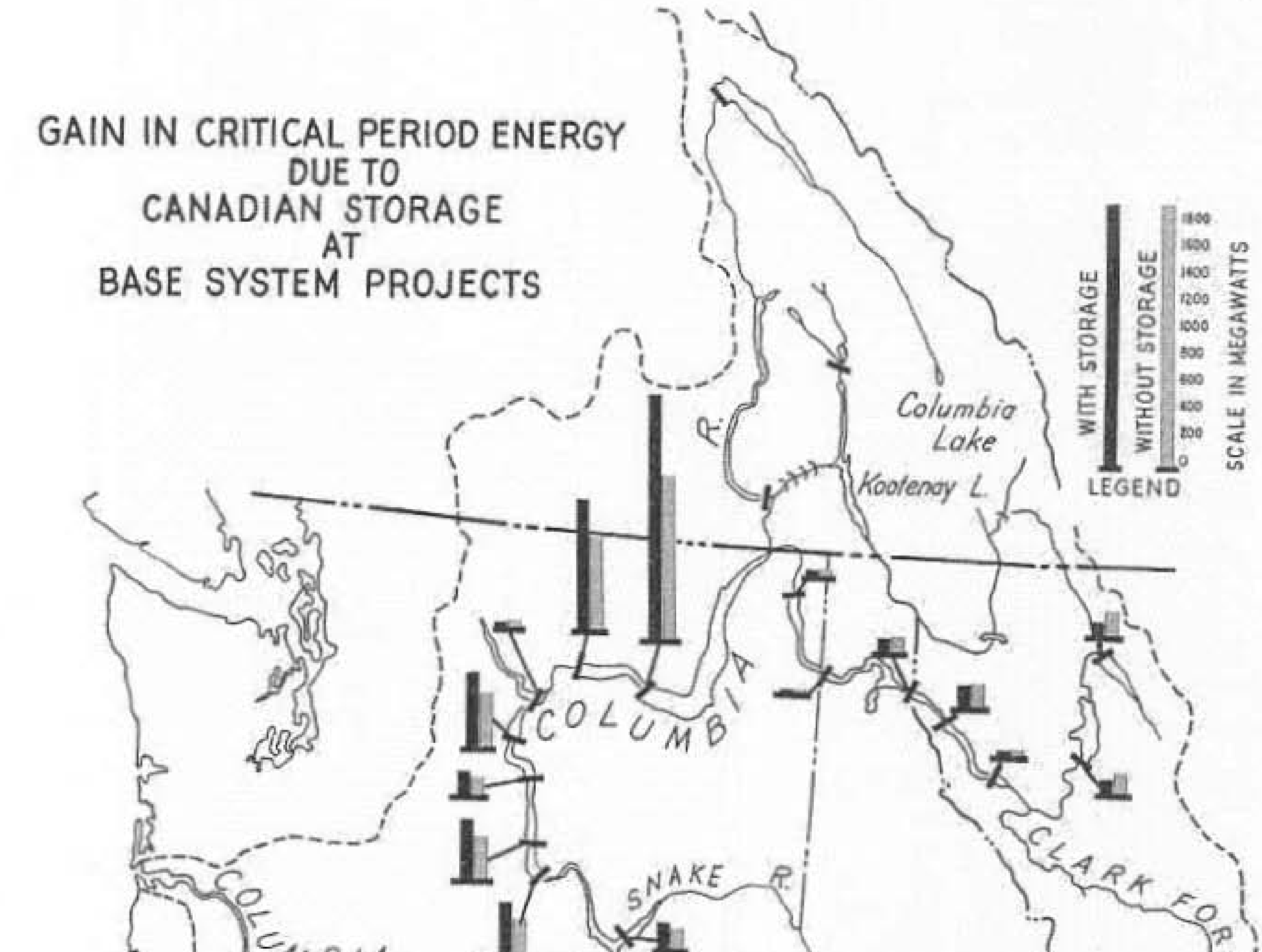
In each case, the lesser figure established the limit of load which can be carried with assurance and therefore establishes the dependable load carrying ability and critical period. When Canadian storage is added, therefore, the load carrying ability increases from the 6,669 megawatts of 1936-37 to the 8,589 megawatts of 1943-45, with a resulting gain of 1,920 megawatts. Of this 1,920 megawatts, only 1,047 megawatts is directly attributable to storage and the remainder is due to the increased natural streamflow during the longer period.

As a result of the change in critical period, storage from cyclic reservoirs, such as Hungry Horse, must be withdrawn at a lesser rate over a longer period of time after Canadian storage is added. As a result, some projects will lose in prime power capability as others gain. Exhibit 12 indicates the prime capability of each of the base system projects, the cross-hatched bar on the right indicating the capability without Canadian storage and the black bar on the left indicating the capability with Canadian storage. It will be noted that all projects lying directly downstream from Canadian storage increase substantially. Prime of all projects on the Clark Fork and Pend Oreille, however, is reduced as indicated by the shorter black bars. On the Snake River, Brownlee and Oxbow, which also enjoy a substantial amount of regulation without Canadian storage, are reduced, but Ice Harbor, coming as it does in a reach of the river below large uncontrolled tributaries, can take advantage of the higher natural flows in 1943-45, with a resulting increase in prime power. It is this difference, with some projects gaining and some losing, which creates many of the problems of the coordination agreement.

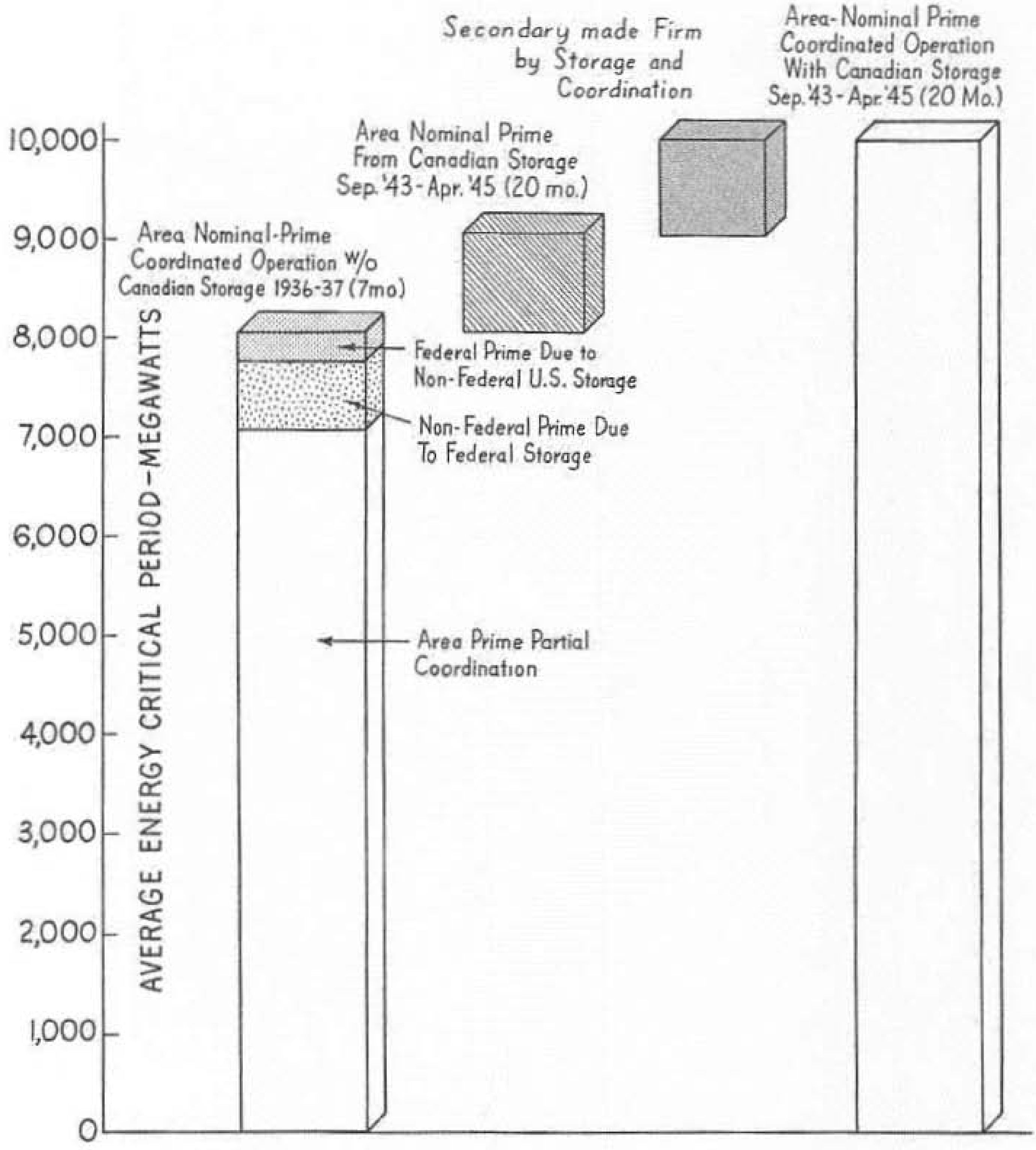
Up to this point, all the discussion has assumed coordinated operation. Exhibit 13 attempts to distinguish between the parts of the total generation which may be considered firm energy without coordination agreement, and those parts which require coordination to be firm energy. The column on the left indicates the Northwest's potential prime power, including not only the base system projects, but also the other resources.

The two segments at the top of this column indicate the part of this potential which cannot be considered firm because there is no obligation on the part of reservoir owners to release the storage necessary to produce this segment. The finely stippled block at the top indicates the generation at Federal

## GAIN IN CRITICAL PERIOD ENERGY DUE TO CANADIAN STORAGE AT BASE SYSTEM PROJECTS



# GAIN IN CRITICAL PERIOD ENERGY DUE TO CANADIAN STORAGE & COORDINATED OPERATION



projects from non-Federal storage, for which there is no contractual obligation, and the more coarsely dotted block below it indicates the generation at non-Federal projects from Federal storage, for which there is no contractual obligation.

Moving to the right, there is a cross-hatched block. This block indicates the increase in prime power at projects downstream from Canadian storage resulting from the additional critical period flow made possible by the release of that storage over a 20-month period. The next more finely cross-hatched block indicates an additional prime potential which is possible as a result of the combination of Canadian storage and coordination to take full advantage of the streamflow diversities. These two blocks added to the column on the left result in the column on the right, which indicates the total area potential with Canadian storage and coordination.

# THE PROBLEMS OF UNCOORDINATED OPERATION

A. P. O'Kelly, Attorney
The Washington Water Power Company
Spokane, Washington

The previous speakers have shown the advantages and desirability of the coordination of all reservoirs and all hydroelectric projects in the United States and the gains to the United States from the construction and coordinated operation of storage reservoirs in Canada. This coordination of all reservoirs and hydroelectric projects in the United States and these gains from Canadian storage can be achieved, but the problem as we see it is that as of today the coordination assumed in determining the benefits from Canadian storage has not been achieved. As pointed out by Mr. Timme, there is partial coordination through the Northwest Power Pool, within the Federal system, within an inter-company pool composed of the major investor-owned companies, between the two major municipal systems on the Washington Coast, between other individual systems by contract and by year-to-year, month-to-month and day-to-day arrangements of various sorts. The degree of coordination that exists is not easily measurable and it has been impossible to provide a figure that everyone can agree upon in the short time we have had to study this problem. However, it is agreed by all that the measure of coordination now existing falls far short of the coordination assumed in the proposed treaty.

At the present time, there are no firm long-term agreements between utilities providing for the holding of storage and the release of storage in such a manner that downstream projects can know when to expect water to be released from upstream reservoirs. Without this knowledge it is difficult, if not impossible, for the owner of a downstream project to sell firm power based on an assumed use of storage from an upstream reservoir which is under a different ownership. While much of this water has been and is being used today on a hand-to-mouth basis, a large quantity of water is going over the dams of the Northwest which could be used to make firm power. This spill or waste of water directly results from the use of storage primarily to fit the requirements of the system of the reservoir owners without regard to the requirements of the area as a whole.

In addition to the direct waste of storage, there is also a substantial waste of usable water because of the inability of systems with excess water during one period to generate electricity to permit other systems to store this excess water in available storage space in their reservoirs to convert this water into usable energy at a later time.

Coordinated operation for the benefit of the area entails maximum feasible use of the water flowing in the streams and rivers, but also entails the day-to-day and week-to-week operation of all systems so as to supply the power when the customers need it, i. e. when they push the switch that turns on the light or starts the motor. The water cannot be so closely controlled that it will show up at every plant on the river just when it is needed. The only way this can be accomplished is through exchanges of power between systems, but this must be done on the basis of a firm coordination agreement so that each system can always be assured that it will have the power when it is needed. There are some individual agreements between individual systems in the Northwest, but again they fall far short of the coordination assumed in the drafting of the proposed treaty.

What does this mean?

It means that the gains shown on this chart are not realized. The gains are, in fact, substantially less than shown. The block of power from coordination is theoretical. The two blocks of power added through Canadian storage are theoretical. They don't exist without coordination.

It means that non-Federal systems would not be able to count on the water coming down the river when they need it; they would not have the gains in firm power anticipated, and would not be willing to contribute to Canada their assumed one-fourth share of the power going to Canada.

It means that the Federal system would be faced with making the full payment to Canada without realizing the gains anticipated on the Federal system and with no assurance of contribution from the non-Federal systems.

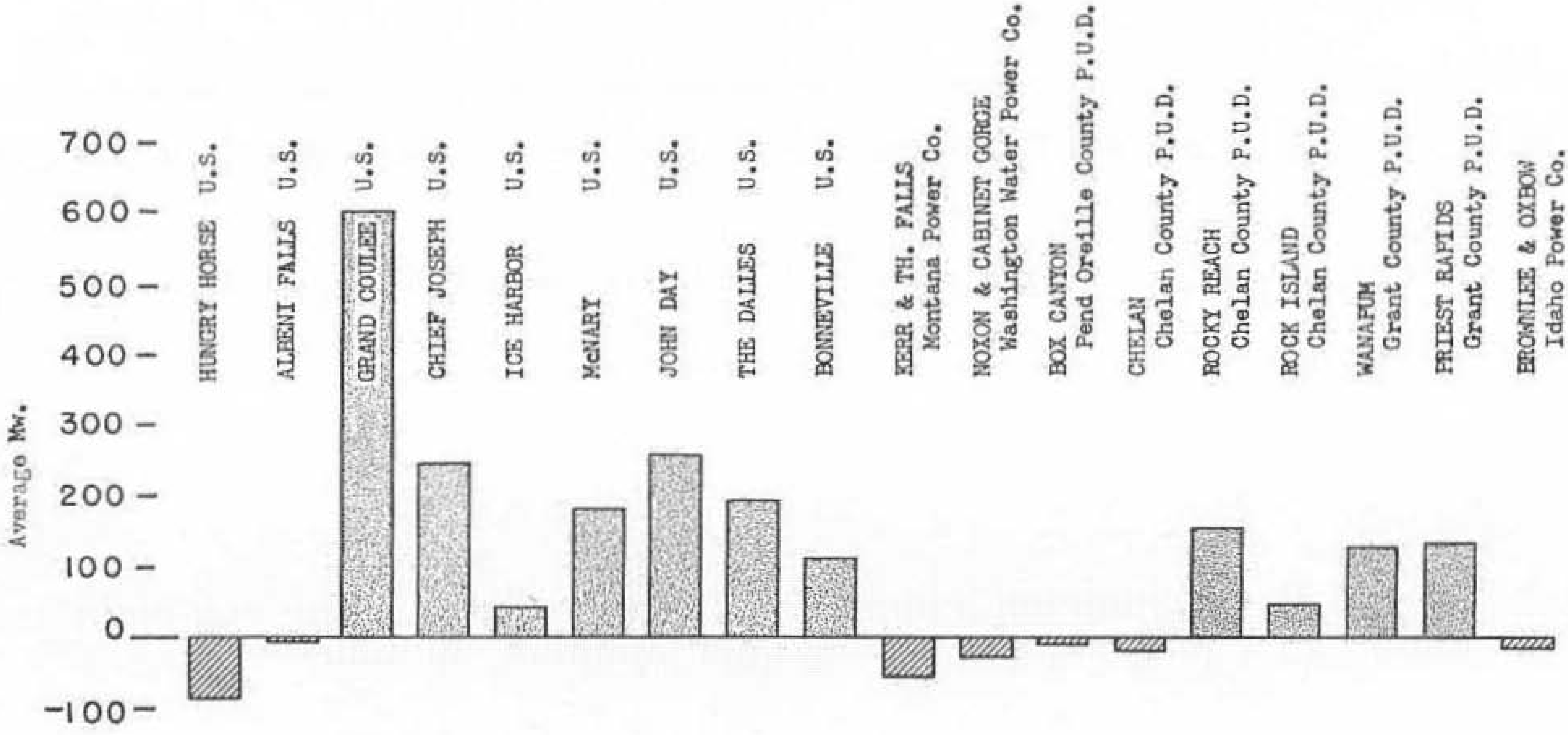
The Treaty also has the rather novel effect of reducing the ability of some systems off the main stream of the Columbia to carry firm load. The next charts show the gains and losses in firm energy resulting from Canadian storage under the assumption that there now is and will be full coordinated operation.

Exhibit 14 shows the gains and losses on the so-called "Base System" which were used in computing payments to Canada. Exhibit 15 shows the gains and losses on the other hydro systems in the Northwest. It was necessary to use different scale for the two charts because of the difference in magnitude between the "Base System" and the other hydro systems.

EXHIBIT 14

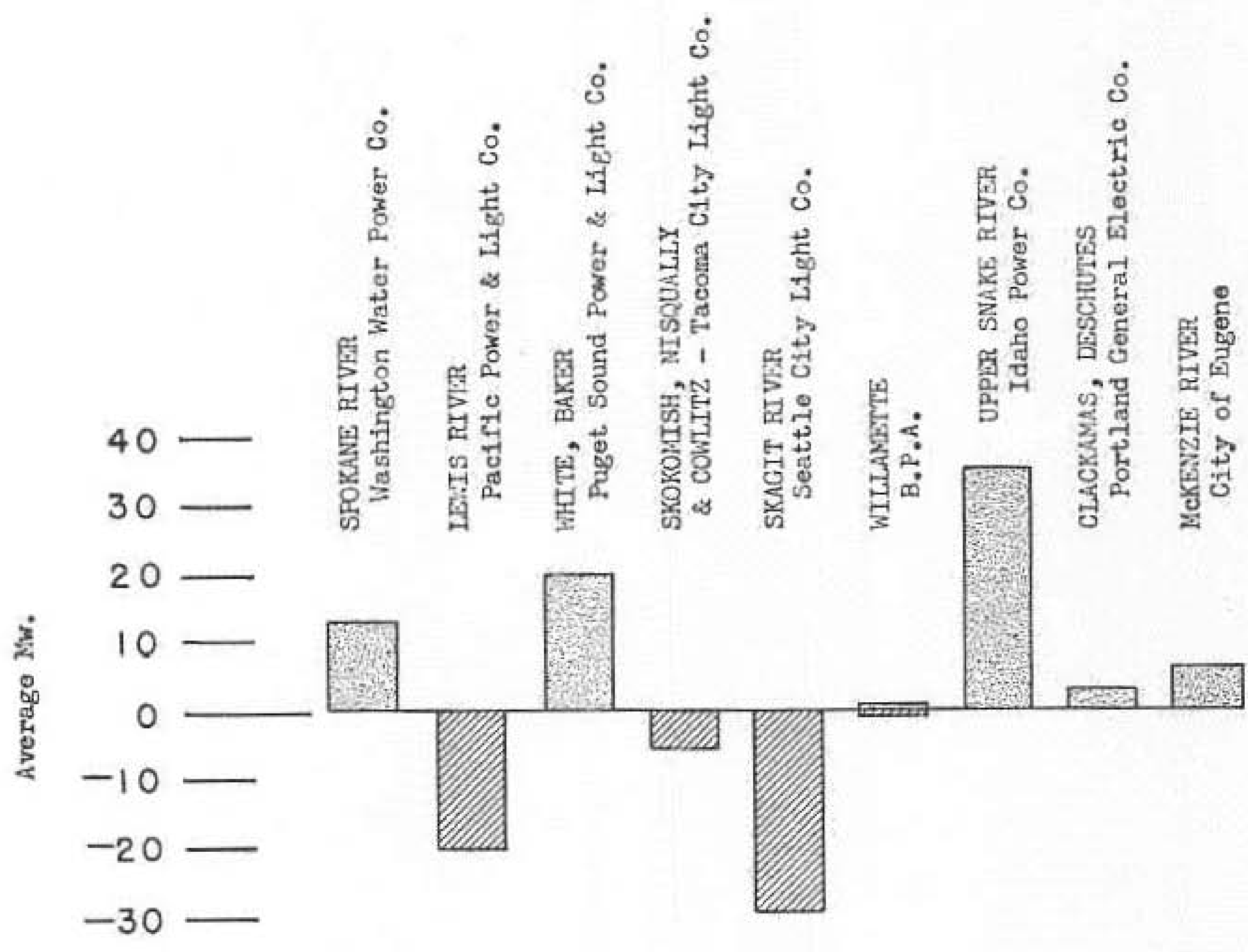
# INCREASES OR DECREASES IN FIRM ENERGY WITH CANADIAN STORAGE ASSUMES COORDINATION OF ALL RESOURCES

## *BASE SYSTEM PROJECTS*



# INCREASES OR DECREASES IN FIRM ENERGY WITH CANADIAN STORAGE
## ASSUMES COORDINATION OF ALL RESOURCES

### *OTHER HYDRO PROJECTS*



In the computation of the net benefits to the United States from the Treaty, the losses to projects, both Federal and non-Federal, in the "Base System" were taken as a credit, thus reducing the required deliveries of power to Canada. The gains and losses on projects not considered as part of the so-called "Base System" were considered to have balanced out. The net result of the gains and losses to different systems is extremely inequitable as between projects and ownerships in the United States. Some projects will actually be assumed to return to Canada less than one-half of the assumed benefits from Canadian storage since they will have received a credit for the losses at other projects; others will in fact suffer a loss for which they will not be compensated. These inequities can be corrected adequately only through an overall coordination agreement. In addition, without full coordinated operation the amounts of gains and losses shown would be substantially changed. Some of the gains would be decreased and the losses would be increased -- in some instances, doubled, resulting in billions of kilowatthours being wasted. On some individual systems the losses could result in very substantial increased expenses which would eventually result in higher rates being charged the customers of those systems. It would be a paradox if this Treaty which promises so much to the United States should result in hardship to individual citizens of the Northwest.

The Treaty assumes coordination. There seems to be no dispute as to the need for coordination. The "Analysis and Progress Report" published by the U. S. Negotiators recognizes the need for a coordination contract. Coordination would be highly beneficial and is imperative for the proper development of the Columbia Basin with or without the Canadian Treaty. We have long known the need for coordination and have been working on this problem for a number of years. The Canadian Treaty emphasizes the problem that already exists and could have disastrous effects on some or all of the utilities without coordination. Coordination must be the first order of business, and the generating utilities in the Northwest are willing to exert every effort to solve the problems of coordination promptly so as not to raise unnecessary complications to the ratification of the Treaty.

# BASIC FUNDAMENTALS OF AGREEMENT FOR COORDINATED OPERATION

Darrell E. Ries, Attorney
Grant County PUD
Ephrata, Washington

The benefits to be gained in the Northwest through operation of hydroelectric resources in a coordinated manner have been demonstrated, as well as have been the problems resulting and which will result from failure to operate in a coordinated manner. Because of the varied interests and ownerships involved, the vehicle necessary to put a coordinated operation into effect is necessarily complex. It has become apparent, after much study, that coordination can be attained most expeditiously and readily through contractual arrangements which will define and set forth the framework of the coordinated operation and the rights and obligations of the parties.

The utility representatives working on the matter have devoted great time and effort to the development of principles to be embodied in such an agreement and have made considerable progress toward developing the detailed contractual provisions necessary to effectuate such principles. While the work at this time is far from complete, the most recent draft of the proposed contract not only sets forth the principles but also contains much of the detail. We are leaving with you copies of this last draft for your information and study.

I would, in addition, like to explain, in general terms, the basic fundamentals of the contract as developed to this date. Before doing so, however, it should be made clear that there is not firm agreement among the parties in some of the particulars and that the terms are still subject to negotiation and refinement.

We conceive that all of the generating utilities in the Northwest, including the United States, shall enter into an agreement to provide for coordinated operation of their various resources. We have provided for a term of basically 60 years, which is a similar term as that of the proposed Canadian Treaty. The agreement would, however, be subject to an earlier termination in the event of changed conditions requiring the dedication of area hydro resources to the production of peaking capacity rather than the production of firm.

Since it is felt essential that coordination must be accomplished under some plan where each party maintains control of and operates its own projects, we have developed the proposed agreement upon the premise that certain guide lines of the coordinated operation will be set down on a cooperative basis and that each party maintains full control of the operations of its projects within those guide lines. To accomplish this, the agreement is to provide that each party will appoint a representative to a committee to be known as the Coordinating Committee. That Committee will act as the agent of the parties and will analyze and interpret the factual data supplied by the parties in order to arrive at an appropriate determination of the guide lines for the coordinated operation. Basically, these guide lines will be firm load carrying capabilities, reservoir curves and required reserves. Decisions of the Coordinating Committee must be unanimous, except in the case of emergency, and in the event the Committee is unable to agree on a question of fact, then that question of fact may be submitted to a stated arbitration procedure. It is the intent that once the Committee has set the so-called guide lines, each party will operate his system and projects in conformity with the guide lines or supply power and energy in lieu of such operation. Each system is to maintain a portion of the necessary capacity reserves.

One of the guide lines for the coordinated operation is the firm load carrying capability of each system. Basically, firm load carrying capability means the computed ability of a system to carry a load on a firm basis with full release of stored water. This computation is to be made by the Coordinating Committee from data supplied each year by each party. Since a system's firm load carrying capability is tied to some extent to the system's ability to produce energy during a critical period, and the lengthening of the critical period resulting from the introduction of Canadian storage necessitates releases over a longer period in some non-base system reservoirs, thus reducing the ability of that system to meet firm loads, the Canadian storage actually causes a loss to some systems. In order to avoid such losses, the agreement is to provide that the reduction to the capability of such systems is to be made up from the capabilities at plants which gain from the Canadian storage before the determination of firm load carrying capabilities. Of course, the reductions will be computed from time to time so that only the losses caused by Canadian storage, and not additional storage in the United States, will be restored. When the Coordinating Committee has determined the firm load carrying capability of a system it will be entitled to have that capability maintained by the coordinated operation through the release of stored water or through delivery or exchange of energy.

Under the agreement the resources of the coordinated system are to be operated to produce the optimum firm load carrying capability for the area. This is to be accomplished by the storage and release of waters by the reservoirs of the coordinated system or the supplying of power and energy in lieu of such releases or by the transfer and exchange of energy.

The Coordinating Committee, from regulation studies, will determine operating reservoir curves for each reservoir in the coordinated system, including Canadian reservoirs. These curves will reflect the energy which must be stored in one or all reservoirs at any point in time to assure firm load carrying capabilities. Each reservoir owner will be required to release water to the applicable reservoir curve when projects downstream require the release of such storage for maintenance of firm load carrying capability. In the event the reservoir owner elects not to release the water held above the reservoir curve he shall supply an equivalent amount of energy to the downstream project without cost. No reservoir is to be drafted below its curve except for the maintenance of firm load carrying capabilities.

If a system is unable, with full storage releases, to meet the firm load to which it is entitled under the coordinated operation, it shall request and take delivery of energy from any other system in the coordination which is capable of producing excess energy in order that the former system may meet its firm load. The manner and method of making these transfers and the procedure for return or payment for this transferred energy is more readily understood if illustrated, and further explanation and illustration will be presented to you at the conclusion of my discussion.

In addition to the releases of stored water for the production of firm and for the maintenance of firm load carrying capability, the agreement is to provide for the release of water from all reservoirs, including the Canadian reservoirs, for the production of useful secondary energy. If reservoir owner has stored in his reservoir, water in excess of that required for the maintenance of the firm load carrying capabilities, he is required to release that excess water upon request of a downstream project so that the downstream project may use it in the production of secondary energy. If the reservoir owner elects not to release pursuant to the request, he must supply the downstream owner, without cost, an amount of energy equivalent to that which could be generated with the withheld water at the downstream plant. When the water so withheld is released through the downstream plant, the energy must be returned to the reservoir owner if useful to maintain the reservoir curve or to refill the reservoir.

While details pertaining to transmission are still embryonic, it is intended that existing transmission facilities be operated in a manner as to fulfill and accomplish the objectives of the coordinated agreement. Transmission is first dedicated to transmission of power of the owner of the lines and transmission capacity under firm contracts and then to operation under the coordination agreement. If transmission capacity is inadequate, it is up to the party requiring additional transmission to provide it or to reduce his firm load carrying capability.

Under the proposed treaty with Canada, the United States is required to return to Canada one-half of the increase in dependable hydroelectric capacity and one-half of the increased average annual usable hydroelectric energy output resulting to the base system plants from the Canadian storage. By the covenants in the agreement, all parties thereto will share in this obligation to Canada in the proportion that the increase in capacity or energy at each project from Canadian storage shall bear to the total of such increases throughout the coordinated system. Non-Federal power and energy under this obligation will be delivered to the Federal system for delivery to Canada. It is understood that the United States will make capacity available for delivery to Canada at the Bonneville "F" rate which is now $9.00 per kilowatt year, and this understanding has been incorporated in the agreement. The agreement also contains a provision to provide that any advantage which might be obtained for a project to be constructed between Priest Rapids and McNary shall be retained by that project and not the coordinated system as a whole.

The principle has been accepted that each reservoir owner who dedicates his reservoir to the coordinated operation shall be entitled to receive each year a portion of the annual costs of the reservoir from the downstream plants. The determination of the costs and the proper allocation of them at site and downstream, as well as adjustment for diversity in ownership costs, is based on a complex formula. This will be explained more fully and in detail with the aid of charts and diagrams at the conclusion of my remarks.

I have mentioned the fundamentals of the proposed agreement. There are, in addition, pertinent provisions dealing with charges for power, various savings clauses and provisions for bringing in new parties which will not be explained in detail but which you will want to examine as you read the draft presented to you.

As mentioned earlier, I am to be followed by more detailed discussion on matters pertaining to the transfer and exchange of energy for maintenance of firm load carrying capability and the determination of annual costs to be paid the reservoir by downstream plants.

## ENERGY EXCHANGES ANTICIPATED UNDER COORDINATED OPERATION

Eric Brundage, Power Analyst
Seattle City Light
Seattle, Washington

The utilities in the Pacific Northwest area have made a study of the resources of the area, including the storage in Canada which is contemplated by the proposed treaty, in order to determine the extent of energy exchanges which may be required under coordinated operation. Because of the limited time available, two separate and distinct water regulation studies which were available were used as a basis for determining the resources. The regulation study for the base system plants was the Sequence VI-I study prepared jointly by the Corps of Engineers and the Bonneville Power Administration. Regulation studies which had been prepared by the Coordinating Group of the Northwest Power Pool were used for the resources in the area outside the base system which have been referred to as "Other Resources". The Sequence VI-I study for the main stem of the Columbia River included utilization of the storage in Canada which is contemplated under the proposed treaty.

The studies were conducted and developed under the general principles of coordination which have been outlined by Mr. Ries. There were two assumptions made in developing the study which should be pointed out. First, the resources were calculated on the basis of projects that are now in existence or under construction with, of course, the exception of the three large Canadian storage projects. This means, of course, that no new resources are in the picture other than the Canadian storage. The second assumption was that the firm loads to be carried would be equal to the firm load carrying capability of the coordinated system. The firm loads used in this study therefore represent a load level which approximates present load estimates for the year 1970-71. Because of these assumptions, the exchanges which appear to be necessary to maintain firm load carrying capability probably represent maximums.

A graphic illustration of the exchanges of energy developed by this study has been prepared. Exhibit 16 lists each utility system in the area. The vertical divisions on the chart indicate average megawatts of exchange on each system. Each system has a horizontal line marked zero. Energy delivered out of the system is indicated above the zero line, while energy received into a system is indicated below the zero line. The horizontal divisions represent time by months. The energy exchanges involved are divided into two major types: first, those required to maintain firm load carrying capability; and second, those required to supply secondary loads.

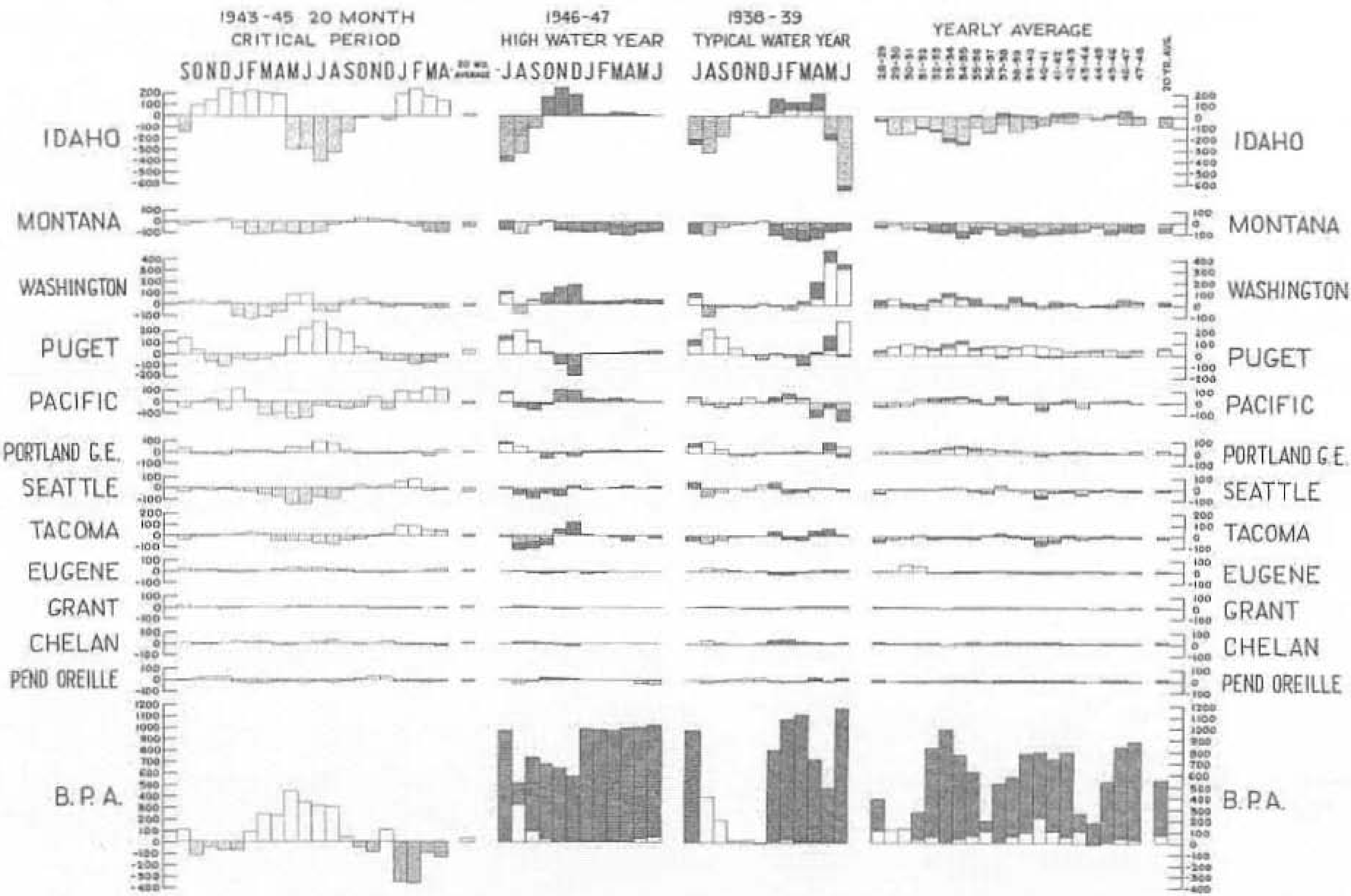
The exchanges set forth on the chart are coded as follows: energy delivered out of a system for maintaining firm load carrying capability on some other system is indicated as (+); energy received into a system to maintain the firm load carrying capability of that system is indicated as (-). Exchanges into or out of system for purposes of supplying secondary energy loads are shown cross-hatched. Such secondary exchanges appearing above the zero line represent energy delivered out of a system, while those below the zero line indicate energy received into a system.

This chart is divided into several sections. The first section, proceeding from left to right, indicates exchanges necessary under coordinated operation

EXHIBIT 16

# FIRM AND SECONDARY ENERGY TRANSFERS

## AVERAGE MEGAWATTS



over the 20-month critical period for the area, extending from September, 1943 through April, 1945. All exchanges during this period are made for the purpose of maintaining firm load carrying capability in the area. Immediately following the 20-month period is an indication, in average megawatts for the period, of exchange for each system, the position of the vertical bars with respect to the zero line indicating whether that system had a net exchange of either a delivery or a receipt.

It can be seen here that during this period, some of the systems require a receipt of exchange energy to achieve their firm load carrying capability. These are the systems that suffer a loss of such capability by reason of the Canadian storage causing a shift of the ciritcal streamflow period from seven months in the 1936-37 water year to twenty months in 1943 through 1945 water years. Other systems have an excess of capability under this condition which must be used to supply the deficient systems with energy to maintain their respective firm load carrying capabilities.

It is anticipated that each of these systems which require energy exchanges from other systems and which do not have sufficient energy resources to return such energy exchanges during the critical period, will have to purchase the energy that they have been unable to return. In other words, this means that the losses on certain systems of firm load carrying capability caused by the lengthening of the critical streamflow period will be guaranteed to be made up from those systems which gain. The second section of Exhibit 16 indicates exchanges which would take place with a high water year. Under this condition, capabilities are high, and substantial amounts of secondary exchanges are shown to be available. Secondary exchanges of energy will be made to the extent available which will allow each utility system to carry its secondary load. In the study which developed the anticipated exchanges, secondary loads consist of energy used to substitute for thermal generated energy; energy used for supplying industrial loads which may be interrupted on notice; energy transferred out of the area for the purpose of substituting for thermal generated energy; and energy which may be stored in reservoirs to be used for protection of future firm load carrying capability or the future substitution for thermal generated energy.

The third section indicates a typical year which approaches average conditions during the 20-year period. Here again, the secondary energy is available, but in more moderate quantities. At this point it is considered important to note that even in a high water year and in the typical year some exchanges of energy are required to maintain the firm load carrying capability of certain systems.

The fourth and final section of the chart indicates the average annual exchange, showing deliveries and receipts of energy on each system for the 20 years of record studied.

It is anticipated that the settlement of any imbalances of exchange energy between systems at certain intervals, which will be defined, will be achieved by a series of rates for hydro energy and also for thermal generated energy. Such rates have not been developed, but it is anticipated that the rates for hydro may be the then current prevailing rate for secondary hydro generated energy; and rates for thermal generated energy will be based on the incremental cost of such energy plus a fixed amount per kilowatthour or a percentage to cover out-of-pocket overhead costs, but with no provision for the inclusion of fixed charges.

It is also anticipated that some rates may be developed to cover use of generating and storage facilities for transforming of unusable energy into usable energy through storage of energy in reservoirs. This whole question of charges for energy transfers and transmission thereof is a field which requires considerable study and review and development by all parties concerned.

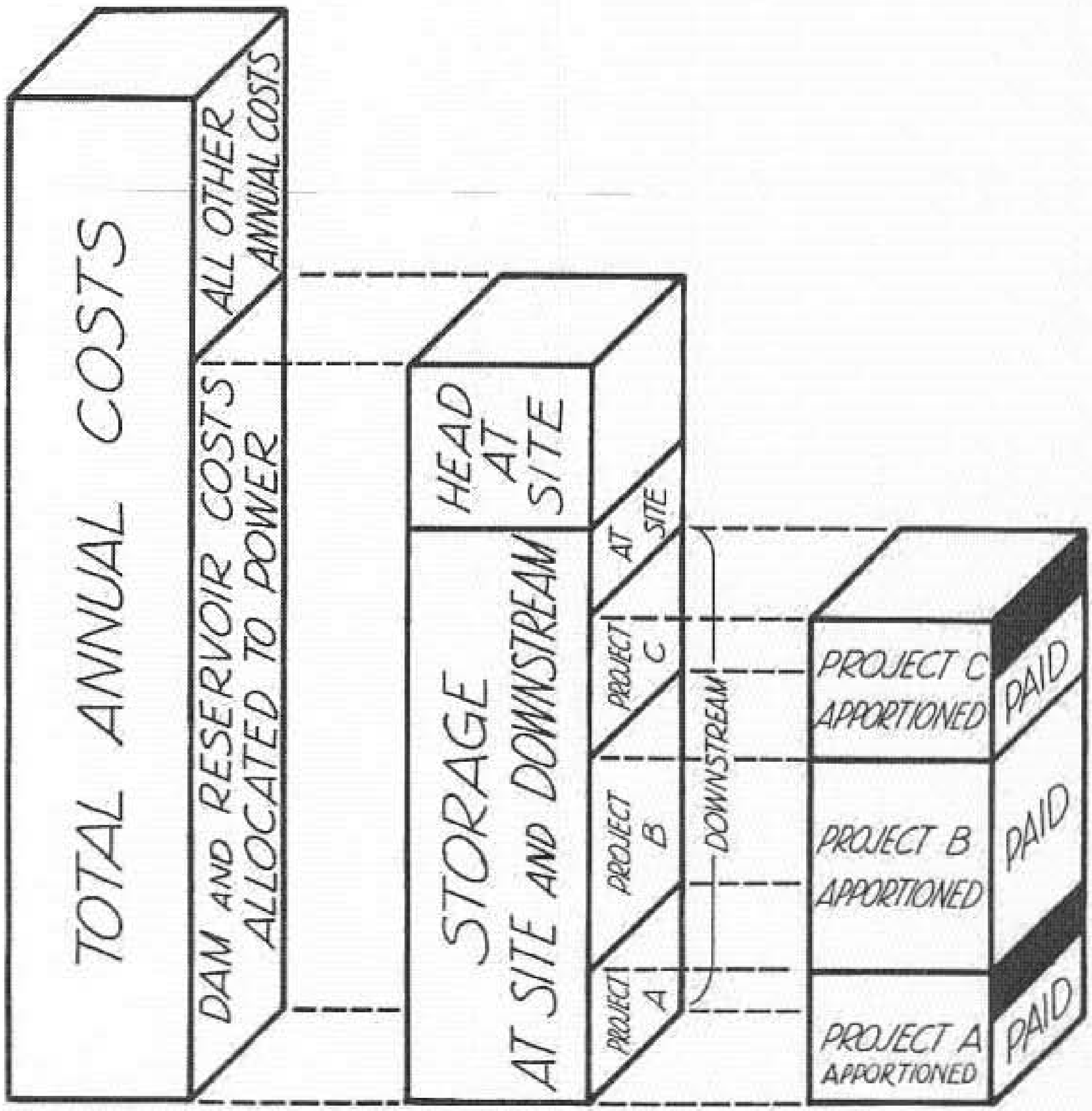
# COORDINATION PAYMENTS FOR UPSTREAM STORAGE IN THE UNITED STATES

Robert B. Gallup, Principal Engineer
R. W. Beck and Associates
Seattle, Washington

The coordination principles governing operation of reservoirs in the Pacific Northwest for benefit of the entire region must include payments to the owners of the reservoirs for the benefits provided by the reservoir storage to the downstream projects. The coordination principles propose that the costs of reservoir storage be apportioned among the parties benefiting from the reservoir in proportion to the critical-period energy benefits received from the use of the stored water. A limit is placed on the amount to be paid to an upstream owner by the owner of a downstream project. This limit is the value to the downstream owner of the benefits provided.

The method of determining the proportion of the annual cost of the upstream reservoir which is chargeable to the various projects benefited by that reservoir is shown diagrammatically on Exhibit 17 entitled "Apportionment of Dam and Reservoir Costs - Storage Project". First, the total annual costs of a storage project are determined and allocated to their various functions such as irrigation, flood control, and power. The portion allocated to power is further allocated to direct power features and to joint costs. The joint costs, or in other words the dam and reservoir costs, allocated to power, are then apportioned between the two functions provided by the dam and reservoir, namely, head at the reservoir site and storage at-site and downstream. The portion

# APPORTIONMENT OF DAM AND RESERVOIR COSTS
## STORAGE PROJECT



The portion allocated to storage at-site and downstream is then apportioned between the at-site project and each of the downstream projects in proportion to the critical-year energy gain at each project from storage. The amounts apportioned to each of the downstream projects are then measured against what is known as the "alternative cost limitation" to determine if the apportioned amount exceeds the "value" of the benefits received. If the amount approtioned to any project is in excess of the value received, as measured by the alternative cost limitation, the amount of payment by the owner of that project to the upstream owner will be limited to the value received.

The determination of the alternative cost limitation, as it applies to a particular downstream owner, is made by first computing the annual costs of each storage reservoir located in the United States' portion of the Columbia River Basin under the assumption that the owner of the downstream project owns each such storage reservoir. The next step is to determine the total gain in critical-period energy capability accruing to all projects in the United States as a result of operation of each such storage reservoir.

The sum of the annual costs of all such storage reservoirs, as so determined, will then be divided by the sum of the critical-period energy capability benefits from all storage reservoirs, and the result will be the alternative cost limitation per kilowatthour of critical-period energy benefit from storage applicable to the owner of the downstream project. This alternative cost limitation is assumed to be the value to the downstream owner of stored water per kilowatthour of benefit received.

In order to provide an example of the payments which would be made under the proposed coordination principles, sample payments and receipts which would result from the coordination principle outlined have been computed considering those existing, under construction or licensed, hydroelectric projects in the United States on the Columbia River and its tributaries.

Exhibit 18 entitled "Actual and Alternative Costs" summarizes the results of our computations. Shown on that chart as vertical bars are the actual costs of each storage project, existing, under construction, and licensed, in terms of mills per kilowatthour for critical-period energy benefits. Also shown on that chart are the alternative cost limitations applicable to each class of owner in the Pacific Northwest, namely, the private non-Federal, public non-Federal, Bureau of Reclamation and Corps of Engineers.

Reference to the chart will show that the alternative cost of storage to public non-Federal, Bureau of Reclamation and Corps of Engineers downstream projects is less than the actual cost of the Coeur d'Alene, Long Lake and Brownlee benefits provided; thus, the payments by these three classes of customer to the owners of those three projects will be limited by the alternative cost limitation, and the owners of the projects will not receive full reimbursement of their costs of providing storage downstream.

As another example, the alternative cost for all ownerships are well above the actual costs of the Kerr Reservoir and thus, the payments to The Montana Power Company, owner of the Kerr Reservoir, would be limited by the actual cost of the Kerr Reservoir in terms of cost per kilowatthour of benefits provided.

# ACTUAL AND ALTERNATIVE COSTS
## MILLS/KWH
## STORAGE PROJECTS AND OWNERSHIPS IN PACIFIC NORTHWEST
### PROJECTS EXISTING, UNDER CONSTRUCTION AND LICENSED

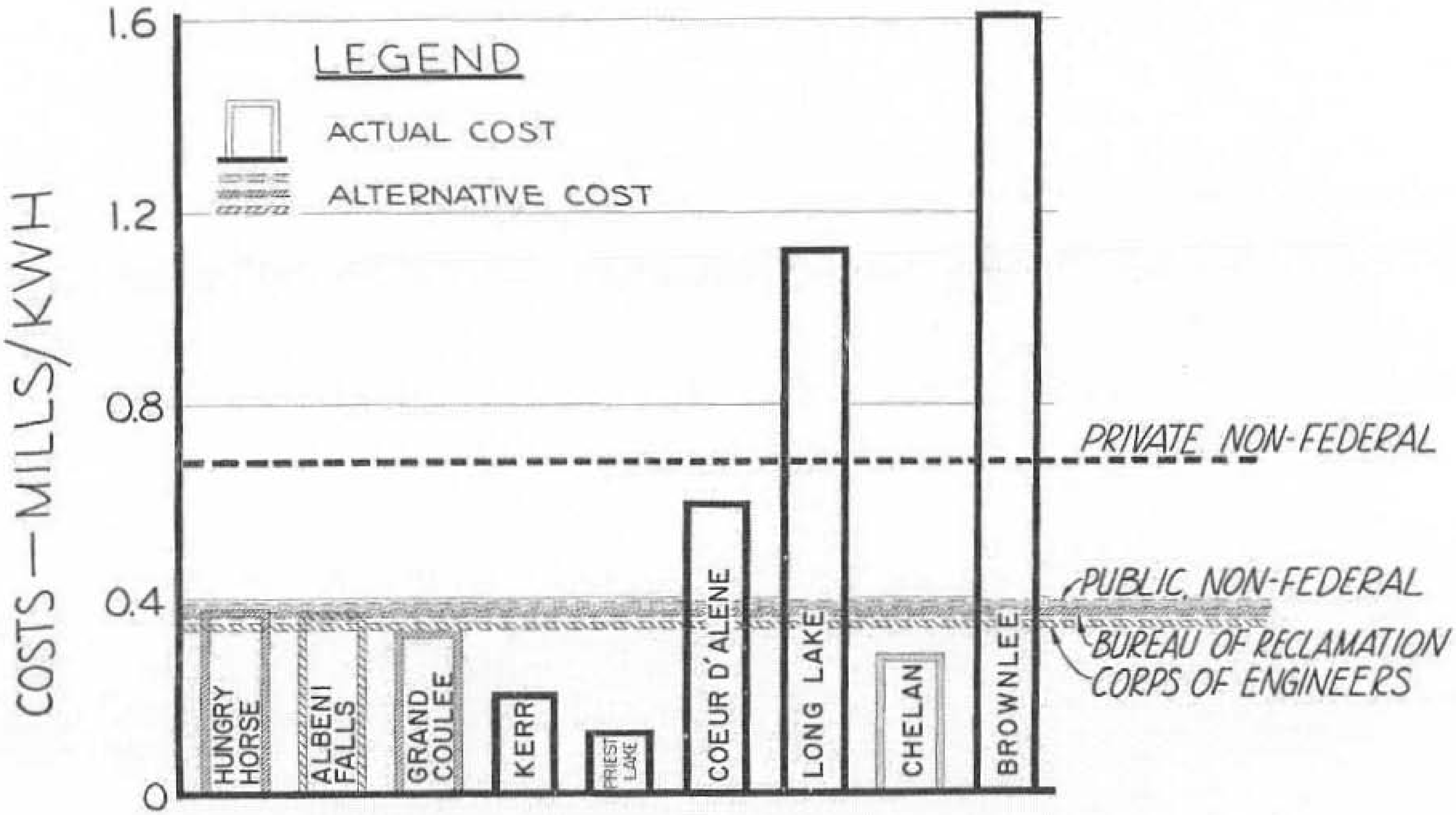


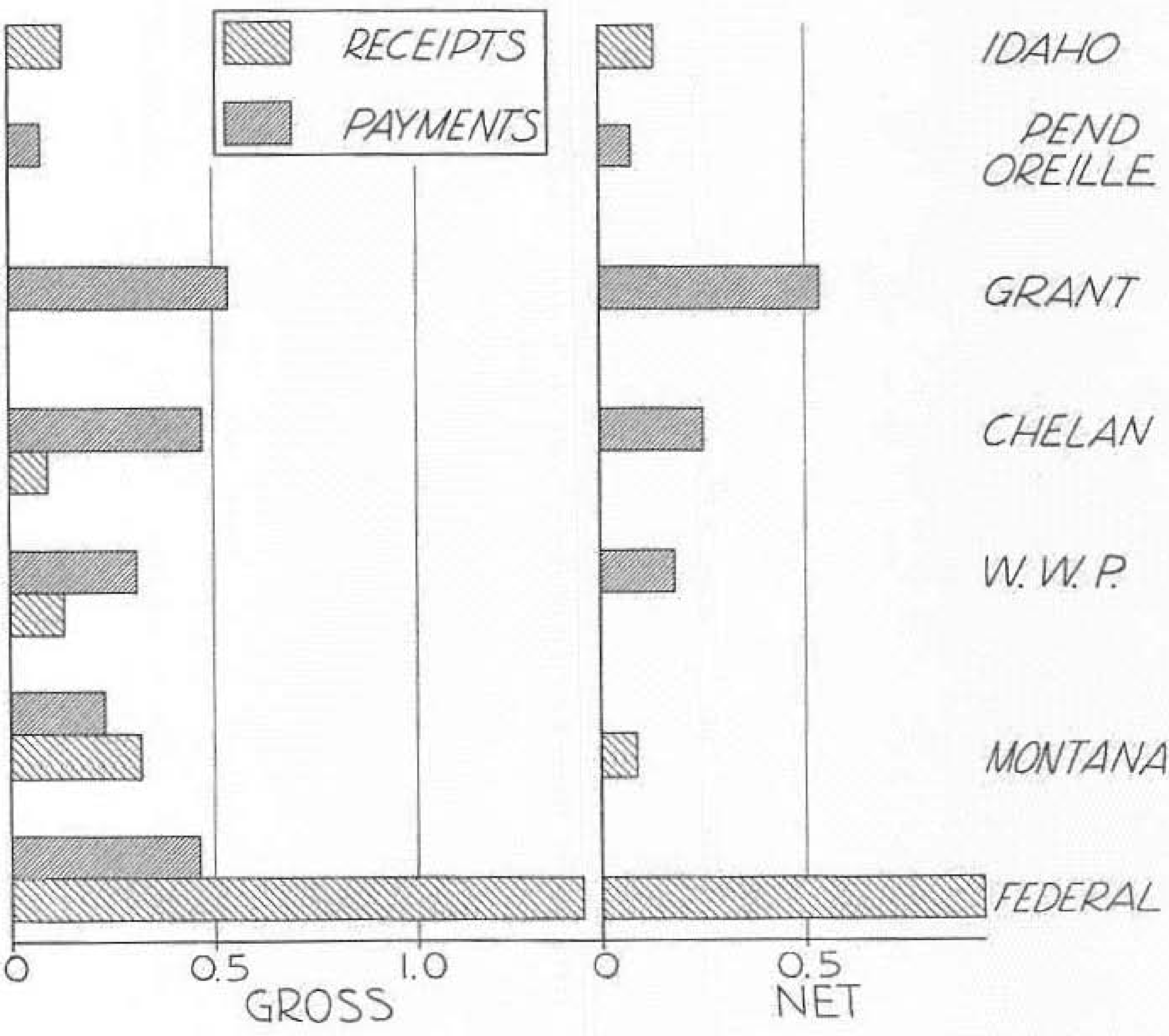
Exhibit 19 entitled "Payments and Receipts for Storage Benefits" illustrates the payments that would be made by each owner and the receipts that would be realized by each owner based on operation of the projects existing, under construction, and licensed in the United States. Reference to the chart will show that the Federal Government will receive a net of approximately $1,000,000 each year for the benefits provided by the Federal system to the non-Federal system. The Montana Power Company and The Idaho Power Company both have a small amount of net receipts for benefits provided, while The Washington Water Power Company and the Pend Oreille, Grant and Chelan Public Utility Districts all have net payments for benefits received.

It should be pointed out that these payments will be made each year even though during many years coordinated operation will not provide as many kilowatthours of benefit as it provides during the critical water year. However, payments are apportioned between owners on the basis of critical-year energy gain because the primary objective of coordination is to increase the dependable capacity of the coordinated system, and the gain in critical-period energy is a measure of this gain in dependable capacity.

The amounts shown on Exhibits 18 and 19 were based upon factors developed by the Federal Power Commission for use in its current Upstream Benefits study on the Columbia River. These basic factors were applied to 1956 costs, except in the case of Brownlee Reservoir where estimated costs were used. The division of annual costs of storage reservoirs between head-at-site and storage has been made by an energy-benefit method generally considered acceptable for this purpose.

# PAYMENTS AND RECEIPTS FOR STORAGE BENEFITS

## PROJECTS EXISTING, UNDER CONSTRUCTION AND LICENSED




MILLIONS OF DOLLARS

Actual costs during the period under investigation would be used for actual computations and thus, the amounts shown on Exhibits 18 and 19 should be considered for illustrative purposes only.

## CLOSING REMARKS

Gordon C. Culp

Various members of our group have explained the present physical and operational conditions in the Pacific Northwest. They have described the types and approximate amounts of benefits that can be secured under the type of Treaty that is proposed, if the coordination assumed by the Treaty is achieved. We have also tried to convey the strongest conviction of the majority of the group -- the conviction that the problems of dependable and enforceable coordination must be solved before the Senate takes its final action on the Treaty.

We have also reported our progress toward a contract to provide such dependable coordination. As you will see from the discussion by Messrs. Ries, Brundage and Gallup and from a glance at the preliminary contract draft in its present form the group has been working in the hard area of specific terms, rules, and procedures as well as in the area of general principles. The draft has the specific approval of no one, but everyone is working on it, working together and working hard to find the specific language which will effect a fair, efficient, and enforceable method of operation through which the full benefits of the Treaty can be realized and distributed. The group believes that all remaining problems can soon be solved through additional thought and compromise.

We believe that much has been complished. Much still remains to be done. The remaining work falls into several general zones -- they are as follows:

1- The devaluation of some systems through loss of dependable capacity and, perhaps, usable energy as a result of Canadian storage; and the distribution of responsibility to restore such losses.

2- The increased exposure to steam generated energy due to the use of Canadian storage, including the problems of interchanging hydro energy for steam energy.

3- Establishment of equitable transmission charges.

4- Fair sharing of the costs of new, high-cost storage facilities.

5- Operating problems which are peculiar to the systems which are located partially within and partially outside the Pacific Northwest area.

6- Accommodating the requirements of existing contracts binding one or more of the parties.

7- The nature and scope of legislation which will be required to authorize the contract.

Some of these problems are formidable. But the group recognizes the tremendous benefits which will result from a proper solution and, conversely, the varying degrees of disaster which could result if an agreed plan of coordination were not achieved. It is well worth all of the thought and negotiation that is required.

The affected generating utilities of the Pacific Northwest strongly desire to continue their negotiations among themselves and with the appropriate governmental agencies. They very much appreciate the splendid technical help and advice that has been most generously provided by representatives of the three departments represented on the American negotiating team. They now request that the government go one step further by authorizing one or more persons to negotiate on this matter on behalf of the government. If the negotiations can now fully include the government, we believe that a contract can be prepared before the time comes for the Senate to take its final action on the Treaty.