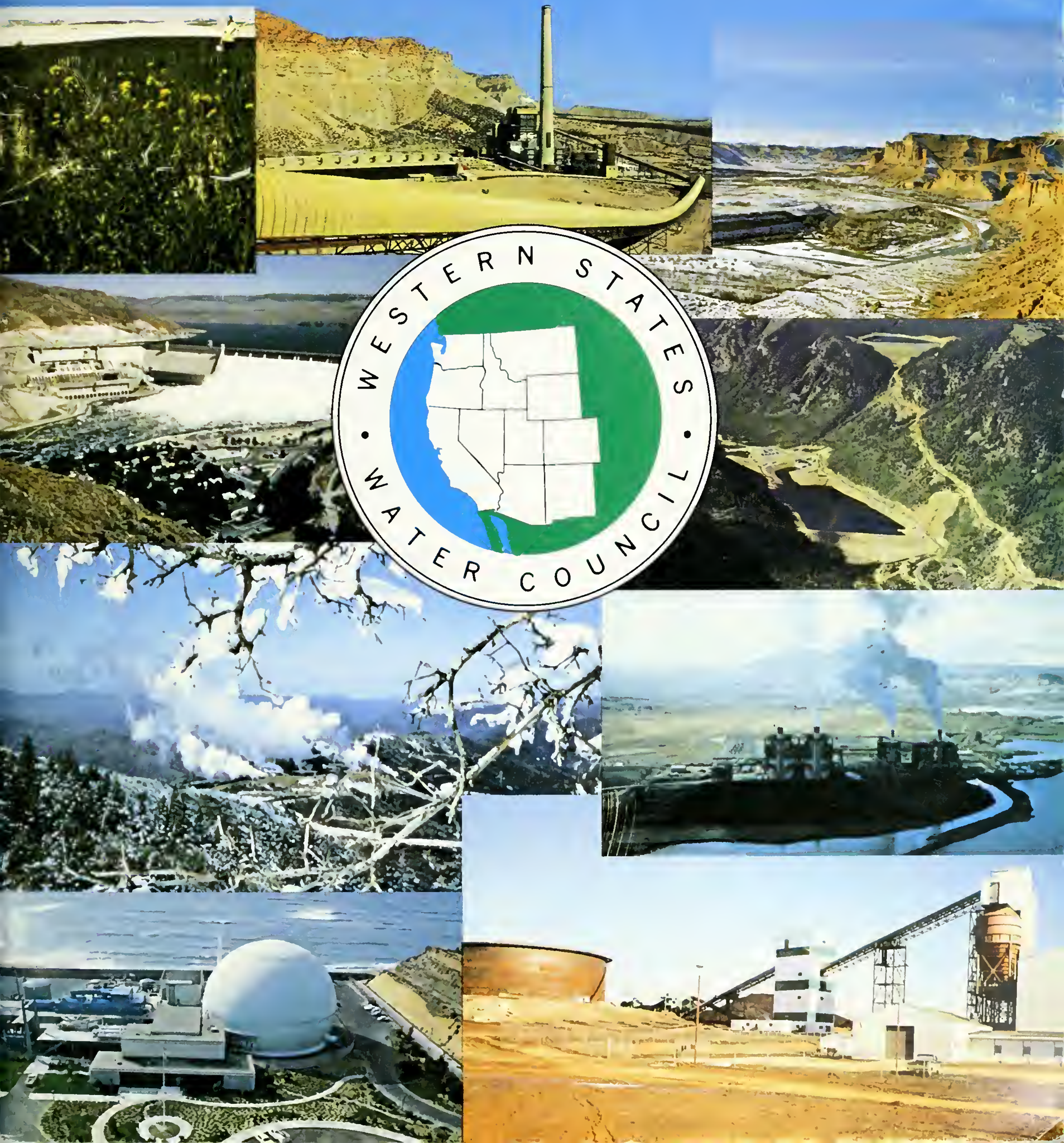
WESTERN STATES WATER REQUIREMENTS FOR ENERGY DEVELOPMENT TO 1990



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WESTERN STATES WATER REQUIREMENTS FOR ENERGY DEVELOPMENT TO 1990

Western States Water Council
Room 1725 University Club Building
Salt Lake City, Utah
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The Western States Council is indebted to Chairman Don Paff and the members of the Water Resources Committee for their efforts in conceiving and preparing, reviewing and presenting this timely report. Representatives of all states reviewed and commented on draft documents. Consultants to the Council, Lawrence E. Wilkinson and Roland Palmer provided valuable information and advice, prepared some of the manuscripts and reviewed the report. Dr. Emery Castle, Oregon State University, contributed some valuable observations concerning the economics of water utilization. Additional writing of the text was undertaken by Council staff members Jack A. Barnett and D. Craig Bell. Also, Fae Drake, Report Specialist for the Council, contributed many hours in typing manuscripts and preparing the report for publication.

Basic energy need information was derived from a report entitled "Energy Resource Development for the West," prepared by the Western Interstate Nuclear Board. The Western States Water Council wants to compliment the Western Interstate Nuclear Board on this valuable and timely publication and express appreciation for the use that this report has been to the Council in the analysis of the need of water for energy development. Circular 703 of the U.S. Geological Survey entitled "Water Demands for Expanding Water Development" was used as a basic reference and the Council wishes to thank the authors, George H. Davis and Leonard A. Wood for their contribution.

WESTERN STATES WATER REQUIREMENTS FOR ENERGY DEVELOPMENT TO 1990

Western States Water Council

PURPOSE AND SCOPE

This report has been prepared by the Water Resources Committee of the Western States Water Council with the assistance of consultants and the staff of the Western States Water Council. It was prepared to help the Western States, individually and collectively, assess the potential demands for water related to the development of western energy resources. It is not intended that this effort be considered as an energy study. The report draws freely on existing energy studies as a base for energy demands and existing data were supplemented or updated only as it appeared necessary in response to changing needs and plans in the energy resource field.

This report focuses on the water for energy needs only to 1990. This time frame is due in part to the declaration of the federal government of its intentions to become much more energy self sufficient during the next decade. This federal effort is commonly known as "Project Independence." Therefore, in a time sense, this report is limited. It is recognized that the projections for energy demands and the associated water needs will expand in the decades that follow 1990, but this report does not predict, estimate or identify these longer range needs.

The study is limited to the water needed for energy resource development in the eleven Western States that are members of the Western States Water Council. The Western States Water Council is an organization created by the Western Governors Conference in 1965. Council members, as appointed by the Governors, represent the States of Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, Oregon, Utah, Washington, and Wyoming.

Effective planning and use of the limited water resources of the West has been accomplished by all of the States of the West and their planning efforts continue. Wise water utilization will result only from planning that considers fully all the potential uses of water. Planning for a single purpose is not effective. However, this study of the needs of water for energy is not a plan but simply a preliminary estimate of potential demands.

No effort was made in this report to assess the availability of water across the West or in selected drainages. Each of the Western States have documented the water resources available within its boundaries. The States are aware of the quantities and qualities of the water available and have the best information as to compacts, water rights, policies and other factors that will, in part, shape the control and use of their waters.

This report cannot be a final product as plans and predictions for the future relating to energy and water needs are constantly changing. This subject is dynamic and this can only be considered as a status report. It is prepared for informational purposes in advance of any definitive or detailed release by the federal government as to the nature of the federal efforts with respect to "Project Independence" and the associated planned national demands on western energy resources. It is anticipated that changes or modifications to this report or the publication of additional reports will be necessary, in time, if the Western States are to continue to be appraised of the impact on water resources by the energy demands thrust on the West.

INTRODUCTION

General

Man has increased his productivity and greatly increased his living comfort by the harnessing of energy in various forms. In our modern and progressing societies, the use of energy is growing at a significantly accelerating rate. The United States, more than any other nation, has become dependent upon energy conversion for the advancement of its society. Our nation with less than 6% of the world's population is using more than 33% of the global energy resources that are converted each year into goods and power. The United States has been able to rely upon foreign sources for 1/3 of the oil we use. This dependence upon other nations, by a nation that is abundantly blessed with energy resources, causes a trade deficit and has significant political ramifications. President Nixon proclaimed that a national goal is for the United States to be energy self-sufficient or independent by the year 1980. President Ford has stated his desire to continue on with efforts of "Project Independence" and the Federal Energy Administration is working towards desired independence by the late 1980's. To accomplish this task it appears that a significant amount of new energy resource development must occur in the Western United States.

This report relies heavily on two energy reports[1,2] as a framework in the analysis of the water that is needed for energy developments in the West to 1990. The water resources of the West have been the subject of multiple use resource planning by Western States for several years.

The Western States Water Council is composed of 33 members from the 11 Western States. Each State has three Council members appointed by the Governor of the State. These delegates meet on a regular basis to identify common water resource problems and to propose policy actions for the Western States. In the past the Western States Water Council (WSWC) has identified energy resource development as a potential large consumer of the limited available western water resources. When "Project Independence" was announced the potential of a significant national need for western water resources became more apparent and the potential time for these demands were accelerated.

The WSWC with this publication has evaluated the timing and the extent of the anticipated rush to western water resources as the nation attempts to become energy independent sometime between 1980 and 1990. This is the Council's first analysis of these anticipated demands on water resources.

Economic and Social Considerations

The use of water is influenced by both the public and private sector of the economy. There is a great tendency, however, for the non-economist to treat water as a public utility largely isolated from private market economies. Economists sometimes err in the opposite direction and assume that water is comparable to other goods and services that are freely traded in markets and are highly subject to market influences.

In fact, the real situation is between these two extremes. Much of the water development and sale in this nation has been by governmental organization. Water has been developed by public funds and some water uses are highly subsidized. Even so, the price and cost of water is reflected in and by the market in numerous ways. Water has also been developed by private investment. Water rights are bought and sold in the market place. In addition, numerous techniques, such as benefit-cost analysis, are used to estimate public and private economic considerations as decisions are made regarding water. When a problem arises, such as the current energy situation, which requires that the economics of water be treated, a tangle of public and private considerations prevail. Precise analysis is seldom possible, but there are some major considerations which can be identified that are helpful as various facets of the energy problem are analyzed.

The dollar return for water used for energy production is undoubtedly much higher than it is in many other uses, such as in irrigated agriculture where water is often priced at less than $20 per acre foot. There is more to the issue than this dollar comparison would lead one to believe. The social cost of water used for energy production is the value of all those uses that are sacrificed to make water available for energy. We are coming to realize that almost no diversion of water or new use can be introduced without a sacrifice being made. Even water "in stream" or "in aquifer" has some value to society. Separating out these values or "opportunity costs" is difficult and involved, yet new uses or diversions should be undertaken only when they can be justified.

These "opportunity costs" or potential sacrifices are of three general types. One type is the aesthetic value of uses which is not priced directly in the market place or commercial sector. In-stream uses, such as environmental enhancement and fisheries, provide examples. Our society has become increasingly conscious of these values in recent years. Even though they may not enter the market directly, they are not without economic value. The value of a homesite on the bank of an unpolluted river or lake provides an example of a direct economic benefit of such an "in place" use.

Another measure of "opportunity cost" is the commercial value of water that enters into some production process, such as irrigated agriculture. If all water uses were market-oriented and if all markets were operating perfectly, there would be little need to go beyond this "direct" or "first-round" opportunity cost.

There are also "indirect" opportunity costs that result from a water diversion. In the case of irrigated agriculture, rural communities may be highly dependent on the continued existence of water rights for irrigation. Further, the impact of reduced food production on the world food situation may represent an additional "opportunity cost."

Economists are not in agreement as to the appropriate method of dealing with indirect opportunity costs. Some believe they can be neglected and argue that only the direct effects need be given attention. Others maintain that markets do not work perfectly and that those effects that are induced by and stem from major changes in water uses should be taken into consideration. At a time when we have major public programs con-

[1] Energy Resource Development for the West, January 1974, Western Interstate Nuclear Board, P.O. Box 15038, Lakewood, Colorado 80215.

[2] Report of the Cornell Workshops on Major Issues of National Energy Research and Development Program, December 1973, Cornell Engineering School, Ithaca, N.Y.

cerned with rural development, and urban problems stemming from the concentration of people, it does not seem appropriate to completely neglect these indirect opportunity costs. Political, as well as possible economic factors, suggest that they should be considered.

The economics of energy may be less well understood than the economics of water. Certainly there is less literature on the demand, supply, and pricing of energy than there is for water. Yet the two have much in common. Both involve a mixture of public and private considerations. Both have probably been under-priced if all social costs of development and use are taken into consideration.

In the case of electrical energy, both public and private utilities function, but electrical energy is priced as a public utility. Because of this, the price which is charged is a result of an administrative rather than a market decision. Price reflects all costs of production of electrical power. Thus, any cost which is accepted by the appropriate administrative body as legitimate may be incorporated into the price. This is a point of considerable importance, because the cost of acquiring water to be used for the production of electrical energy can be included as a cost and passed on to the consumer as a part of the price of energy.

In the past a measure of market discipline has been imposed on the electrical energy industry by competition from other forms of energy. However, with the price of crude oil increasing rapidly, this discipline has lost much of its force. The resultant shift toward a greater use of electrical energy creates a greater "reimbursable" demand on water resources.

In the case of both water and power, there is a trend toward higher prices which will more accurately reflect their scarcity and real economic value in our society. There is, however, a real lack of knowledge and, hence, much disagreement on what effect higher prices will have on the consumption of water and power.

It is doubtful that an increased price of water would have any significant effect on the amount of water used for energy production. Even if the price of water is to increase substantially, the percentage that water costs bear to all costs will remain low. When this is coupled with a policy which permits these costs to be incorporated in the price and passed along to the consumer, there would appear to be little incentive to economize greatly on water, even though its price has increased. This same lack of cost sensitivity, however, does not apply to all water uses. Not knowing what the impact of higher energy prices will be on the amount of energy consumed, we must view projections of future use with great caution.

A study of future energy demand projections leads to the inescapable conclusion that present trends cannot continue indefinitely. Adjustment and change is inevitable. No one adjustment or breakthrough is likely to solve the "energy problem." Rather, a series of adjustments are probable as time passes. Social policy can be formulated to encourage and facilitate these adjustments in contrast to developing policy on the assumption that present trends are inevitable. For this reason, it is important that the values of water in those uses that will be sacrificed if water is diverted to energy production need to be brought into the open and reflected in decision making. While energy production has high priority in our society, it must be judged relative to other uses of resources. By doing this, adjustment will be encouraged, and the effect of greater energy scarcity can be reflected in the adoption of conservation measures and different styles of life. The Western Governors concluded at their conferenc in 1973 that there must be energy conservation practices implemented.

Concern over the physical availability of water undoubtedly will have a greater impact on conservation of water in energy production than will expected increases in the price of water. While energy production is of great importance to the continued existence of our economic system, an indefinite extrapolation of current trends should be discouraged. The potential water requirements vary widely when alternatives available in the use of water for energy are considered. The incentives generated by economic and administrative forces should prompt a complete review of all alternatives. It is apparent that the effect of proposed regulations, such as requiring wet cooling towers, discourages, or in some instances makes impossible, the imaginative consideration of alternatives. Such regulations are based on assumptions of (1) static technology and (2) constant conditions among sites. Such assumptions are not supported by the facts.

The Western States obviously have a responsibility to assist in meeting the social problems arising from the energy situation. The amount of water required and the kinds of institutional devices that are available for water allocation lead one to believe the problems can be met. However, it probably would be poor economics and poor social policy to attempt to modify basic institutions for water allocation or seek blanket solutions of any kind. There appears to be no substitute for a careful consideration of problems arising from individual situations. State and local officials are often best prepared to make the decisions on individual situations. By such a procedure, it is possible to balance economic, ecological, and national interest objectives in the context of a particular problem.

Unless planners and administrators recognize the energy industry's needs for water and its small dollar incentive for water conservation, much of the water resource planning in the past and in the future could be for naught.

With strategic planning of the energy developments in the nation the finite water resources of the Western States can be more judiciously used. With strategic water planning the States will be able to provide better input to the Federal Energy Administration on how great a burden the West can afford to bear in meeting the energy needs of the nation.

ENERGY NEEDS AND TOTAL ENERGY PRODUCTION OF THE WEST TO 1990

The energy production and consumption in the West as well as predictable future needs have been recently documented by the Western Interstate Nuclear Board (WINB). WINB found that, despite wide disparity among the Western States, the West in total was within 10% of being self-sufficient with respect to energy (not considering uranium production). The concept of western self-sufficiency is related to total energy units produced, as some energy resources will continue to be exported from the West while other resources will be imported. Regions of the West will import energy while other regions will export energy. The WINB publication[1] describes the size and location of all steam-electric plants scheduled for the West to 1982 and views the potential of new energy resources in three time frames.

Within the time frame of this WSWC study only geothermal energy and oil shale was added to the list of 'Developed Resources' that may in a limited way add some new energy. Breeders, solar energy, wind and others were all placed in a post 1990 period for any substantial ability to assist the West in meeting its energy needs.

Geothermal resource development is already a reality in one area of the Western United States; "The Geyser" area north of San Francisco. A significant amount of additional exploration is occurring by private firms throughout the West and the federal government is preparing for the release of funds in the next fiscal year that will greatly facilitate additional efforts in the search of geothermal energy. It is difficult at this time to assess how important geothermal resources will be, however, for the purposes of this report, it was assumed that some development will occur within the time framework considered.

The vast reserves of oil locked in oil shale in the West and primarily in the States of Colorado, Utah and Wyoming have been under study for many years. This report assumes that before 1990 meaningful production of oil shale will be accomplished. There are, however, many current uncertainties. There have been offered federal leases to oil shale lands in Colorado, Utah and Wyoming. Industry has successfully bid on the Colorado and Utah tracts. The bid prices were considered high however, and industry chose not to lease the Wyoming lands. Environment concerns are still being discussed and the availability of water resources for oil shale prototype development is still not clear. The White River appears to be one of the more probable sources of water, yet there is not at this point any firm plans to further develop this water resource and there does not exist a compact on the river between the States of Colorado and Utah. Currently there is an effort to have the river studies for possible inclusion in the Federal Wild and Scenic River Systems. Recently one of the major prototype development companies announced its intention to indefinitely postpone its oil shale development efforts giving, runaway inflation, construction costs and uncertain national energy policy as reasons for the decision. There is also currently being debated by federal officials, the amount of the net energy gain to be expected from oil shale development.

The prestigious Cornell Workshops[2] and the Western Interstate Nuclear Board concluded that greater dependence must be placed on the coal and nuclear resources of the West. The Western Interstate Nuclear Board's study observed that, despite the current rate of excalation in the rate of development of these energy resources, the West could not become fully self-sufficient until between 1980 and 1985. Only then would this occur if there are serious conservation efforts and load growth restraint.

Because 87% of the uranium mined in the U.S. comes from the West and only 17% of the uranium is consumed in the West, it was concluded that the West is already much more than self-sufficient in this energy resource, however, uranium was excluded from the self-sufficiency calculations in the WINB study.

The WINB report observed that of the 600 million tons of coal that is expected to be consumed nationally in 1985, only about 100 million tons would be used in steam-electric plants in the West. The Cornell Workshops observed that the transport of 500 million tons of coal would require seven to ten slurry pipelines of 36-inch diameter each. Much of the eastern coal is high in sulfur and will perhaps be used more in the future for coal gasification and other systems with sulfur scrubbers. Therefore, it is appropriate that western interests evaluate the role of the West in supplying a large part of the 1985 national coal demand. It would be unreasonable to expect that all of the coal used nationally should come from the West. An adjustment in the EPA sulfur limits could have a gross effect on how much low-sulfur western coal is needed in the East.

Both reports recognized the importance of coal gasification to meet the nation's dwindling supplies of natural gas. Although neither report predicted how many coal gasification plants will be installed in the U.S. between now and 1980 it is observed that some are already being constructed. Federal predictions are that 30-50 coal gasification plants will ultimately be built in the Rocky Mountain States.[3,4]

Meanwhile, natural gas users with interruptible contracts are seeking alternate energy sources. These alternate sources include conversion to electrical power. The WINB report predicted about 50% of the energy in the West would be used in form of electrical power by 1990. This is in variance with the national pattern as expressed by others[5] who predicted that nationaly, only 33% would be for electrical power by 1990. The West has traditionally used electricity to meet a higher percentage of its energy needs due to the absence of heavy industrial fuel requirements. In 1971, the West used 28% of its energy for generating electrical power. If the 50% is substantiated, a large amount of the growth between now and 1990 can be expected to be electrical.

This projected heavy dependence on electricity is a cause of concern to water managers since thermal-electric power generation has been singled out as the major user of cooling water.[6] In figure 1 it is shown that even now, nationally there is withdrawn more water for thermal-electric condensers than for irrigation. The great majority of these cooling water withdrawals are not consumed as they are involved in once through cooling processes and then returned to the streams. Caution should be taken, however, in view of this use with respect to future demands. The trend, in part guided by proposed EPA regulations is away from once through cooling to wet cooling evaporative towers, which do consume a large amount of water withdrawn. Figure 2 shows a decreasing rate of increased water use annually in an economy with an exponential electric growth rate. However, care should be taken in interpretation of figure 2. The water demand easing trend demonstrates that less water is used for the once through nonconsumptive cooling process and more is being used consumptively in cooling towers.

[3]Report on Water for Energy in the Upper Colorado River Basin, U.S. Department of the Interior, Water for Energy Management Team, July 1974.

[4]Water Work Group, Northern Great Plains Resource Program, Unpublished draft report presented June 3, 1974, Denver, Colorado.

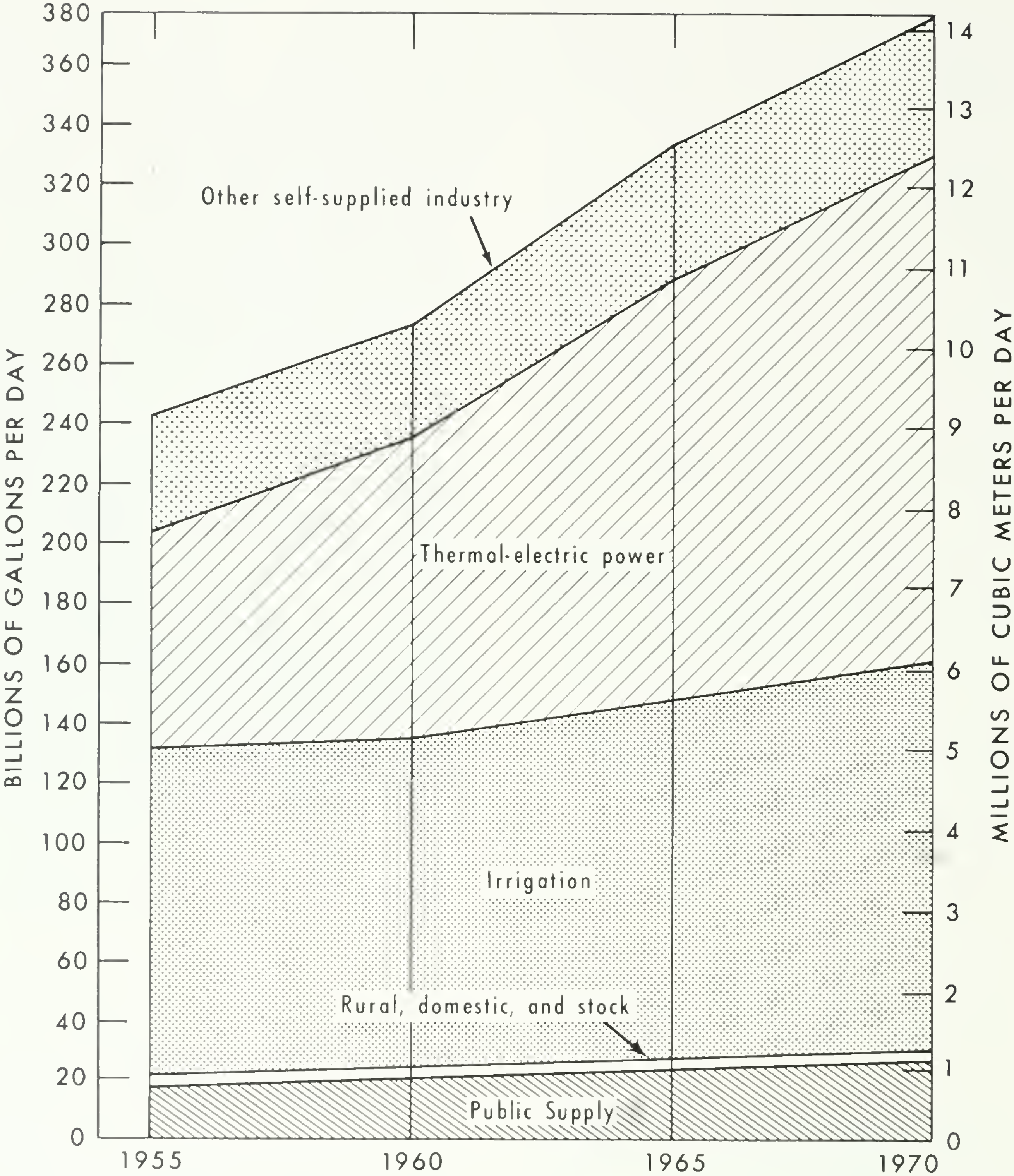
[5]Understanding the National Energy Dilemma, The Center for Strategic and International Studies, Georgetown University, 1973.

[6]"Water Demands for Expanding Energy Development," U.S.G.S. Circular 703, 1974, G. H. Davis and L. A. Wood.

Although consumptive use in some southeastern watersheds is of little consequence it can have gross consequences in some western watersheds. Tables 1 and 2 and figure 3 identify the location of planned new steam-electric plants. The coal-fired plants are, for the most part, planned to be located in the Rocky Mountain States and the nuclear plants are planned for Coastal State locations. Tables 1 and 2 only identify plants to be built into the early 1980's. These scheduled plants were for the most part identified in the WINB report and only a few changes and additions were made to update the tables. Sites, ratings and operational dates change as updated planning occurs and permits are applied for and construction is attempted. Therefore, there is no assurance that the plants will all be built when, where and to the size listed in the table. Siting and construction plans are preliminary and sketchy after that time. Since the heavy load centers are also in the Coastal States, as shown in figure 4, seawater cooling is a possibility for relieving some of the western water requirements described below. It should be noted, however, that only 6 of the 15 nuclear plants now planned for the West are situated on the Coast and safety and environmental restrictions may discourage or prevent additional coastal siting.

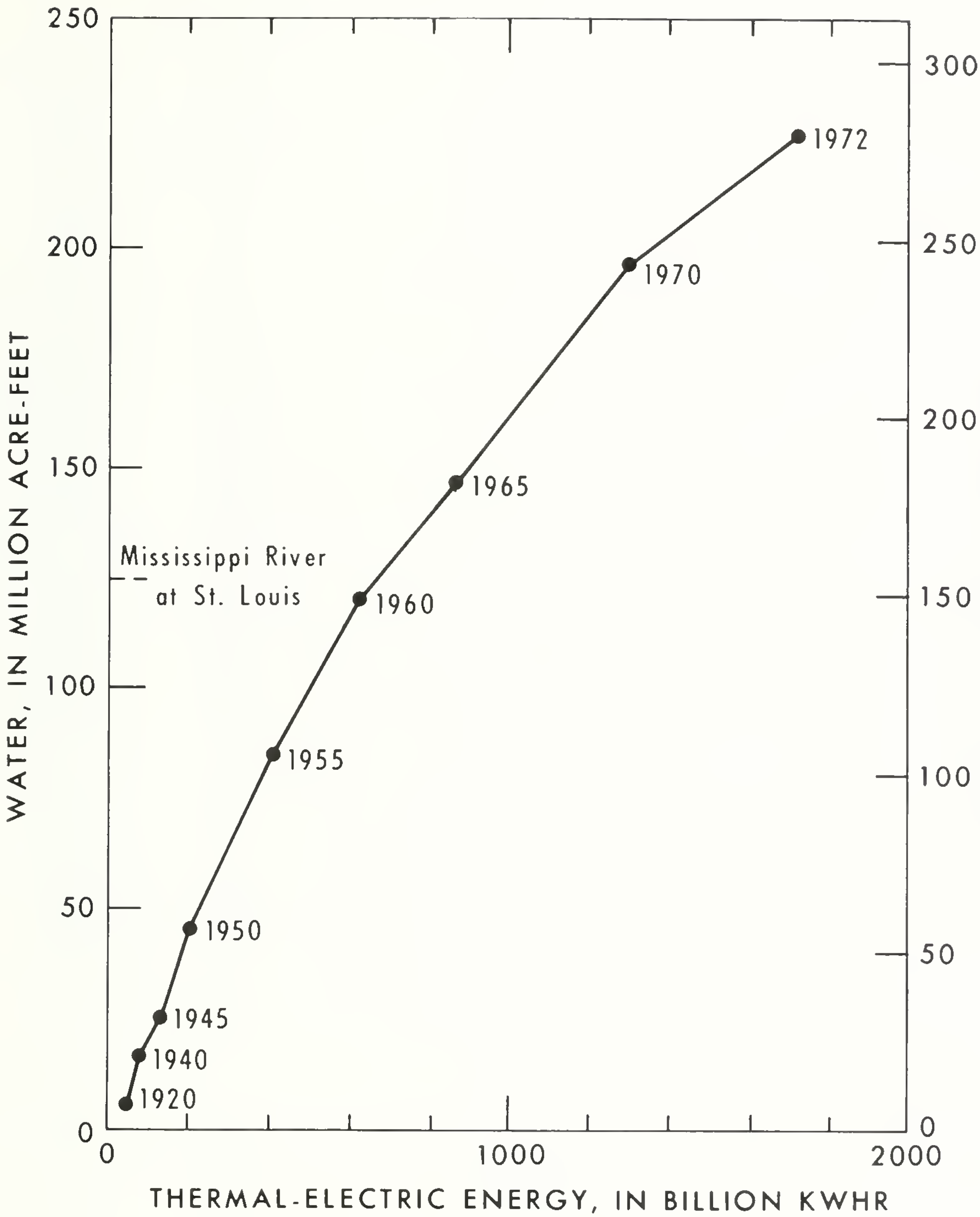
The total energy and the electrical energy requirements of the West are shown in figure 5 as predicted in the WINB study. This growth is 15.3% of the expected national growth. Although it can be shown that the West can eventually meet its own energy needs the question that remains is how much greater a burden can the West endure? The answer cannot be ventured without identifying the sources that can be developed, within the time frame of interest, and the water requirements for each.

Figure 1



Withdrawal of water for major uses
(Taken from U.S.G.S. Circular 703, 1974)

Figure 2



Annual withdrawals of water for thermal-elcetric power generation in the United States, 1920-72
(Taken from USGS Circular 703, 1974)

TABLE 1

COAL-FIRED POWER PLANTS SCHEDULED FOR WSWC MEMBER STATES

As Identified Summer 1974

Operational	Site	Name	Rating mw (Net electric)	Location
Dec. 1972		All existing to Dec. 31, 1972	9,110	West
Jan. 1973	1	Mohave No. 2	60 (rerate)	Nevada
Sept. 1973	2	San Juan No. 2**	330	New Mexico
Jan. 1974	1	Mohave No. 1	30 (rerate)	Nevada
Jan. 1974	1	Mohave No. 2	30 (rerate)	Nevada
Jan. 1974	3	Comanche No. 1	350	Colorado
May 1974	4	Navajo No. 1	750	Arizona
June 1974	5	Jim Bridger No. 1	550	Wyoming
June 1974	6	Huntington Canyon No. 2	430	Utah
May 1975	4	Navajo No. 2	750	Arizona
June 1975	7	R. Gardner No. 3	117	Nevada
July 1975	8	Colstrip No. 1	330	Montana
Sept. 1975	5	Jim Bridger No. 2	500	Wyoming
Jan. 1976	3	Comanche No. 2	350	Colorado
April 1976	9	Hayden No. 2	250	Colorado
May 1976	4	Navajo No. 3	750	Arizona
July 1976	8	Colstrip No. 2	330	Montana
Sept. 1976	5	Jim Bridger No. 3	500	Wyoming
Dec. 1976	2	San Juan No. 1**	340	New Mexico
May 1977	10	Wyodak**	330	Wyoming
June 1977	11	Cholla No. 2	250	Arizona
June 1977	6	Huntington Canyon No. 1	430	Utah
Oct. 1977	12	City of Colorado Springs	180	Colorado
April 1978	*	Public Service of Colorado	500	Colorado
April 1978	9	Craig No. 1	350	Colorado
May 1978	*	Arizona Station No. 1	350	Arizona
June 1978	10	Cholla No. 3	250	Arizona
June 1978	2	San Juan No. 3**	500	New Mexico
June 1978	13	Arrow Canyon No. 1	500	Nevada
Sept. 1978	14	Boardman Fossil	600	Oregona
April 1979	*	Public Service of Colorado	500	Colorado
April 1979	9	Craig No. 2	350	Colorado
May 1979	*	Arizona Station No. 2	350	Arizona
June 1979	*	Cholla No. 4	350	Arizona
June 1979	13	Arrow Canyon No. 2	500	Nevada
June 1979	15	Emery No. 1	530	Utah
July 1979	8	Colstrip No. 4	700	Montana
April 1980	16	Idaho Power Co.	500	Idaho
June 1980	17	Kaiparowits No. 1	1,000	Utah
June 1980	13	Arrow Canyon No. 3	500	Nevada
June 1980	2	San Juan No. 4**	500	New Mexico
July 1980	8	Colstrip No. 3	700	Montana
Oct. 1980	12	City of Colorado Springs	200	Colorado
April 1981	16	Idaho Power Co.	500	Idaho
April 1981	*	Public Service of Colorado	500	Colorado
June 1981	13	Arrow Canyon No. 4	500	Nevada
June 1981	17	Kaiparowits No. 2	1,000	Utah
May 1982	*	Arizona Station No. 3	350	Arizona
June 1982	17	Kaiparowits No. 3	1,000	Utah
		Total since Dec., 1972	21,517mw	
		Total	30,627mw	

*Unassigned

**It is anticipated that some dry cooling will be used at these sites.

TABLE 2

EXISTING & SCHEDULED NUCLEAR POWER PLANTS IN THE WSWC MEMBER STATES

As Identified Summer 1974

Existing	Name	Rating, mw (Net Electric)	State	Site
1963	Humboldt	68	California	A*
1966	Hanford No. 1	800	Washington	B
1967	San Onofre No. 1	430	California	C*
1973	Ft. St. Vrain	330	Colorado	D
1974	Rancho Seco No. 1	913	California	E
	Sub-total	2541		
Planned				
July 1975	Trojan	1130	Oregon	F
May 1976	Diablo Canyon No. 1	1084	California	G*
Sept. 1976	Diablo Canyon No. 2	1106	California	G*
Sept. 1977	Hanford No. 2	1100	Washington	B
Sept. 1980	San Onofre No. 2	1140	California	C*
Sept. 1980	Hanford No. 1	1250	Washington	B
May 1981	Palo Verde No. 1	1270	Arizona	H
July 1981	Pebble Spring No. 1	1260	Oregon	I
Sept. 1981	WPPSS No. 3	1240	Washington	J
Dec. 1981	San Onofre No. 3	1140	California	C*
June 1982	San Joaquin	1300	California	K
July 1982	Skagit	1200	Washington	L
Nov. 1982	Palo Verde No. 2	1270	Arizona	H
July 1983	Pebble Spring No. 2	1260	Oregon	I
May 1984	Palo Verde No. 3	1270	Arizona	H
June 1984	Vidal	1500	California	M
Sept. 1984	WPPSS No. 4	1300	Washington	B
	Sub-total	19,520mw		
	Total	22,061mw		

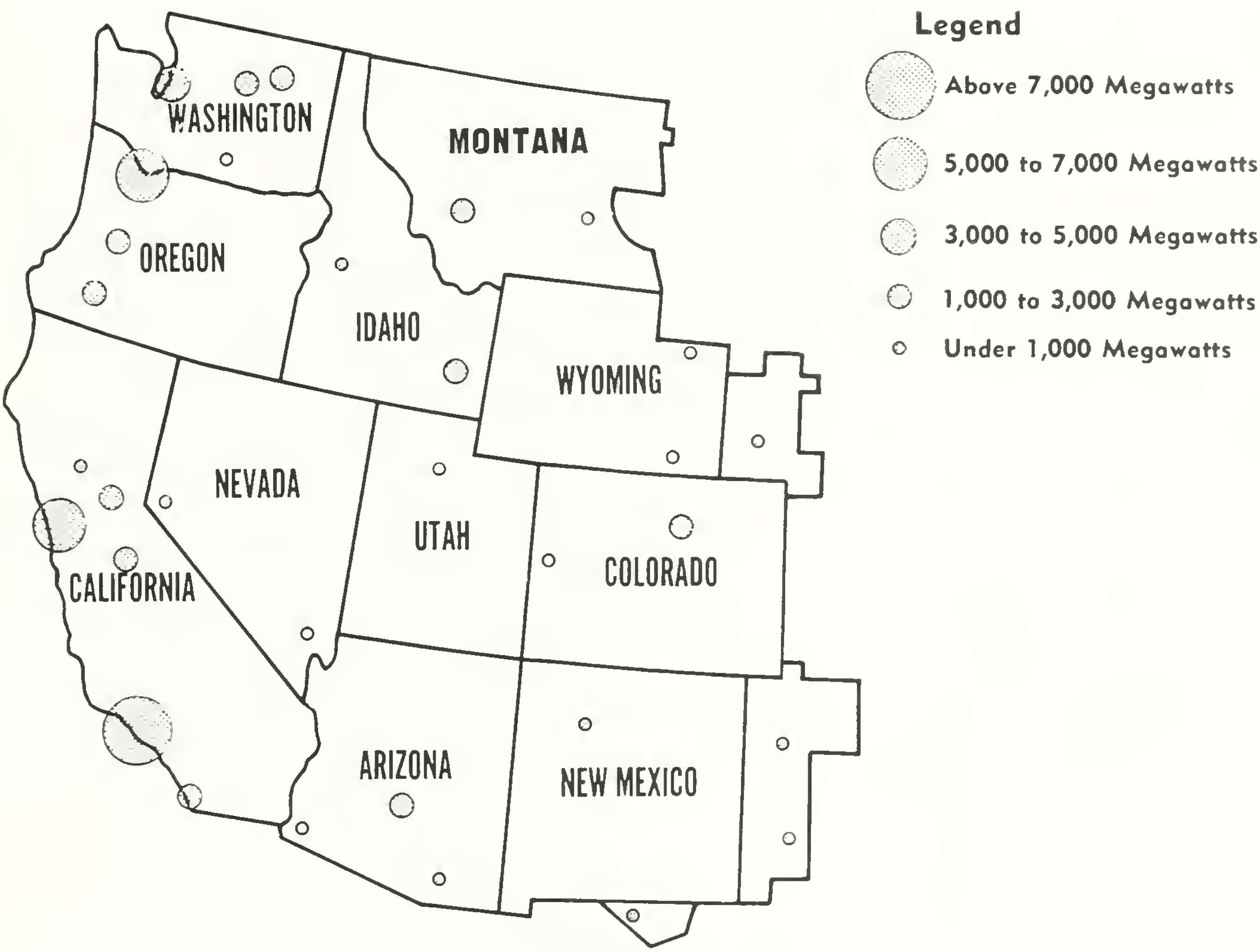
*Seawater cooling 4470mw

NOTE: Three additional plants at San Joaquin, California and three plants at Blythe, California, have been identified for construction after 1984. The total planned capacity of these 6 plants is 7,350mw. A ten year lead time is common for nuclear plants and it is anticipated that in the near future, planning efforts will identify additional nuclear plants.

Figure 3

Location of Scheduled New Coal and Nuclear Powered Electrical Generation Facilities

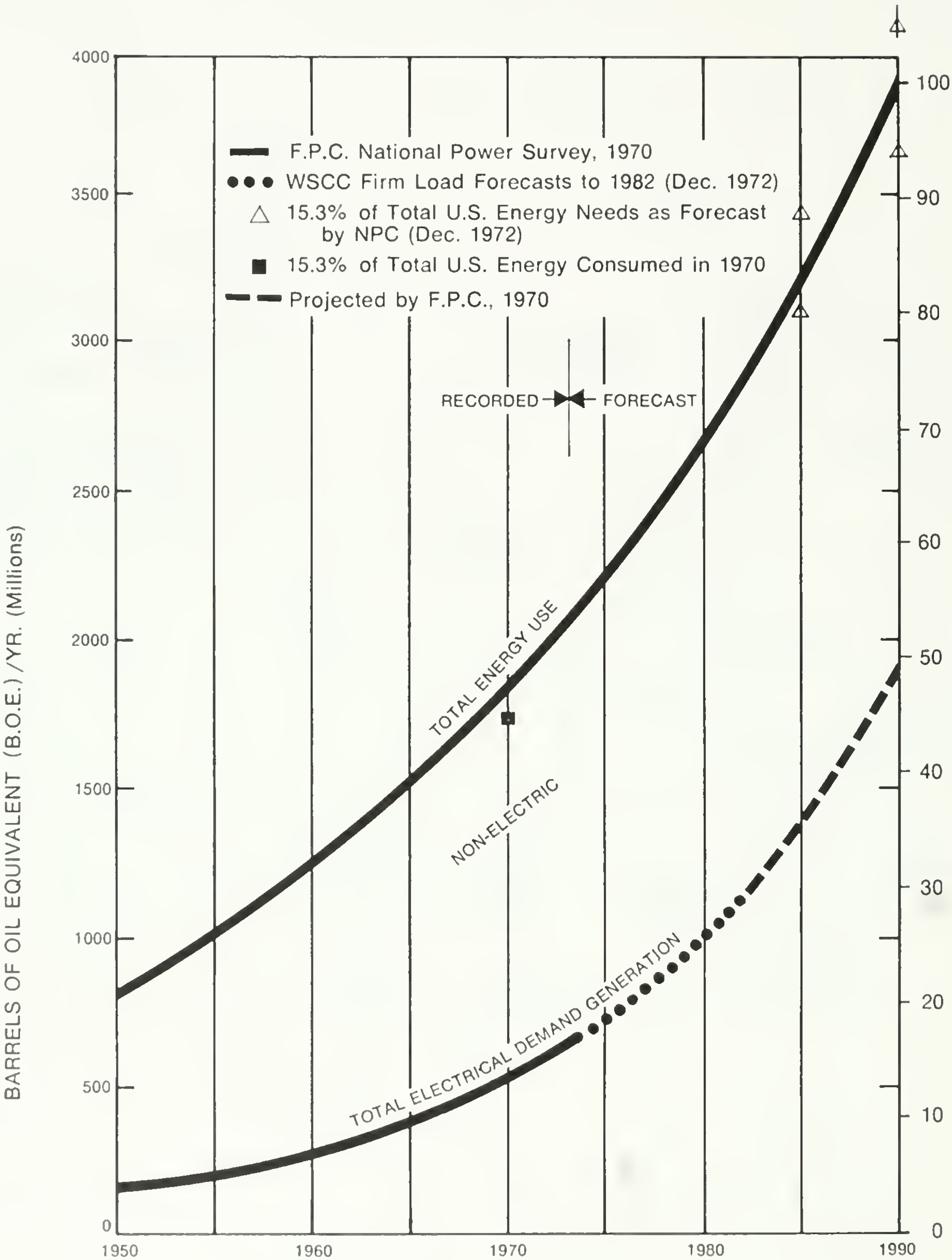
Figure 4



1970 Load Centers of the West Region

Note: To visualize these load centers by 1980, and 1990, multiply these values by 2x and 4x respectively.

Figure 5



Total Energy Use and Total Electrical Demand Projected for Western U.S.

ENERGY SOURCES BEING DEVELOPED IN THE WEST

There have been considerable discussion in recent months of exotic new energy systems that can meet our future energy requirements. The WINB report and the Cornell Workshops have basically concluded that in the time frame 1970-1990 we must rely on established basic energy forms and increased conservation. A treatment of some promising but undeveloped energy sources is not presented here since they are not expected to provide substantial energy to the West before 1990.

An energy mix diagram is shown in figure 6 and in figure 7. Each shows that the West depends upon five basic energy sources. Figure 6 covers the historic and future uses of energy for electrical generation, whereas, figure 7 includes all classes of energy demands for 1971. Figure 6 was based on predicted prices and future choices will be based, in part, on actual prices and assured availability. Figure 6 illustrates the thinking of officials in FPC in 1970 based on data generated before 1970. We now conclude that the use of uranium as a fuel in nuclear power plants is not occurring as rapidly as had been hoped because of widespread slippage in the construction of nuclear plants. Our current estimates are that although the same five fuels will be used in the West in 1990 as identified by the FPC, a significant amount of additional coal must be used to replace the lag in the use of uranium. It is now felt that the energy derived from coal in the West for the generation of electricity in 1990 will be about equal to the energy from uranium. Figure 6 is only a portion of the total energy needs showing only electrical generation demands based on 1970 data. An analysis of the expansion capabilities of the five basic energy forms in the West follows:

Hydro

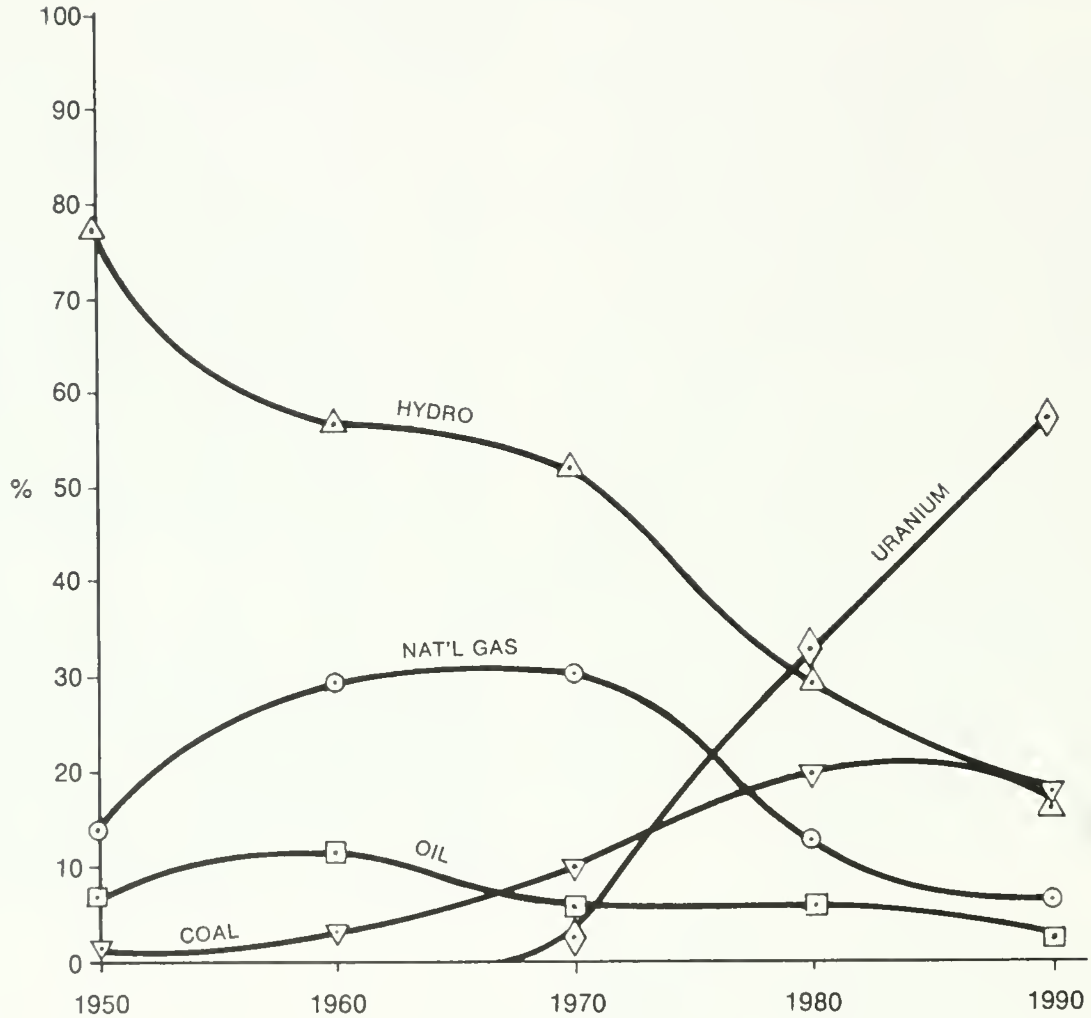
Hydroelectric plants have already been established at many of the best sites in the West. Not more than a few thousand additional megawatts were expected to be added from hydro sources before the U.S. became engulfed in an energy crisis. Now many hydro projects are being reconsidered. The certain higher costs of electrical energy make some "marginal" projects worth reinvestigating. Longer periods of industrial electrical power interruption have prompted some private industries to seek their own hydro sites, be it in Alaska or else-
Source: FPC 1970 National Power Survey Table 10
where. Increased prices in the petroleum economy have caused some to look to electrical energy for some forms of fertilizer production. Production of ammonia fertilizer by electrolysis now appears competitive to production of natural gas. In general, industries involved in shipborne commerce are seeking new hydroelectric sites at more remote locations where products can be produced and shipped readily to the consumer. The period of relaxation that appeared on hydroprojects before the energy crisis may have ended.

Some existing and new water storage projects without power facilities can also be developed into hydroelectric sites. It is too early to identify which hydro sites will be the earliest to develop. Early priorities have been identified in a United States Water Resource Council report now under review.[7] One excellent site in the Middle Snake has been delayed for a long period of time because of environmental concerns over instream uses of water and scenic values of the canyon. Such a project could develop 2,000mw with far less consumptive use of water than would be experienced from stream water cooled thermal electric plants with an equivalent output. However, consumptive use of water is only one of many factors that must be considered in the search for needed energy sources and in the building of hydro facilities. Recently objections have been raised on a national level to new construction in the Hells Canyon and the Senate with the support of Northwest Senators has passed a bill to make this portion of the Snake River a wild and scenic river.

The Western Governors and legislators have been urging timely development of the peaking capacity in existing federal dams on the Columbia River. However, this move is not likely to net any new base load energy—simply provide more peaking capacity. Despite the many possibilities for more hydroelectric projects, hydro is expected to continue its strong negative trend as a percent of total electrical energy, as shown in figure 6.

[7]Draft Water for Energy Self-Sufficiency Report, United States Water Resources Council, Summer 1974.

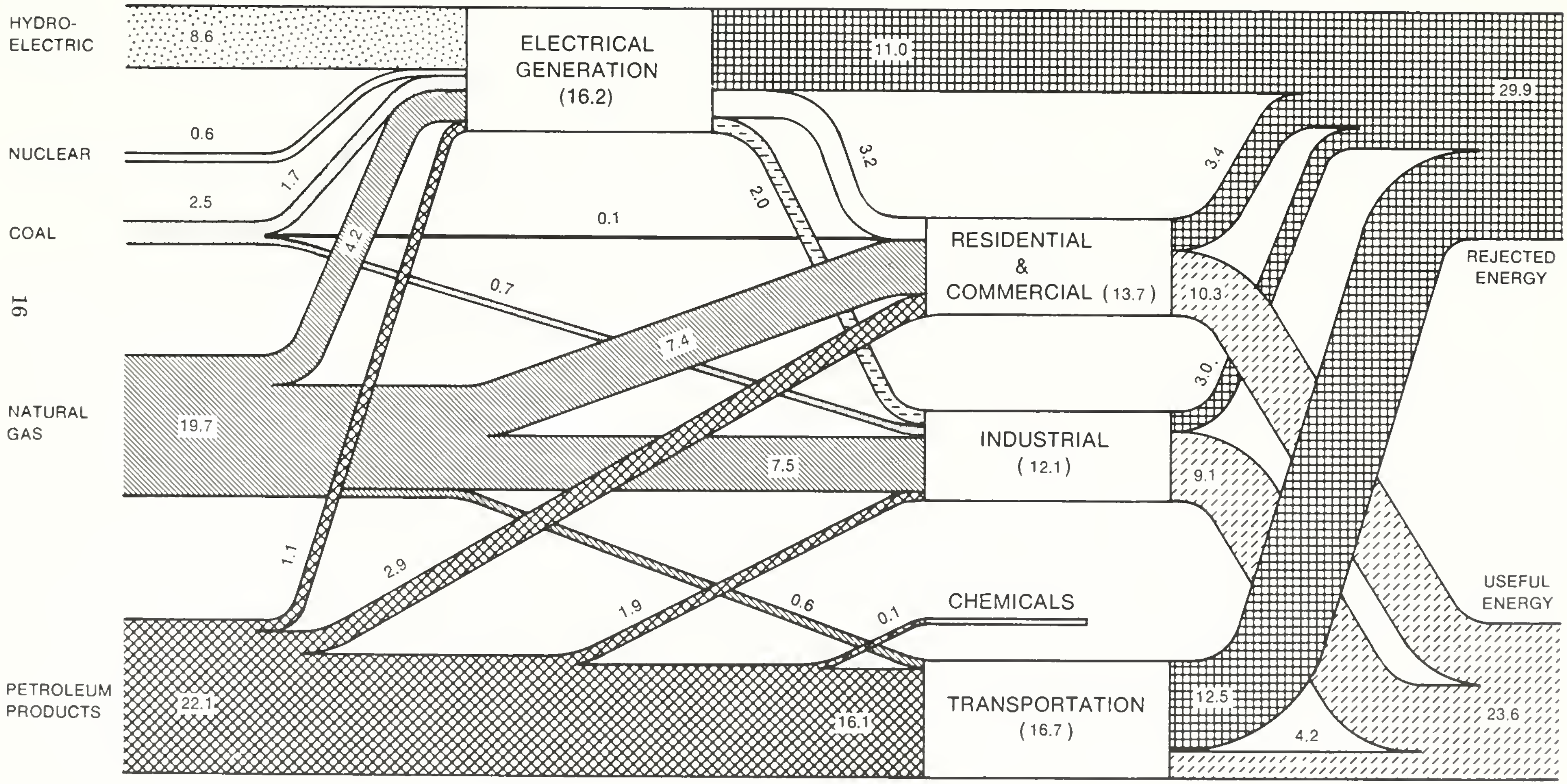
Figure 6



Historical & Projected Fuel Mix for Generating Electrical Power in the West

(Taken from FPC 1970 National Power Survey Table 10)

Figure 7
Energy Utilization in Western States—1971
(Barrels Oil Equivalent Per Person Annually)



Uranium

The uranium market has been overstocked for many years in the West. With the crude oil shortages and with accelerated international interest in nuclear power, the uranium industry is facing a challenge for the first time since the early fifties. Exploration efforts are being accelerated in the contiguous 48 states and in Alaska. There is little question that the West can continue to furnish at least 87% of the uranium that is needed in the nation to sometime after A.D. 2000. If a uranium shortage should develop, an accelerated schedule for imported uranium could be considered.

The nuclear industry could build nuclear power plants at a rate faster than they were called upon in mid-1973.[8] By 1990, the Atomic Industrial Forum concluded, the nuclear industry could install 700,000mw compared with the 460,000mw that they are now expected to produce. The construction place is currently limited by the federal licensing processes, other state and federal regulatory functions and the availability of major plant components.

Natural Gas

Natural gas continues to be a most popular fuel. The Federal Power Commission has permitted a 50% increase in price but it is still one of the least expensive fuels. Its future use is based on both price and availability. Exploratory drilling for natural gas and oil in the contiguous 48 states has been recently encouraged with higher prices for crude oil. Synthetic natural gas is not controlled by the same FPC price controls as is natural gas. The price will be controlled by production cost with coal as a feedstock. There has been strong effort to develop a synthetic natural gas industry in the U.S.

The synthetic natural gas industry will not be limited by the availability of coal from the West. It more likely will be limited by capital investment. To synthetically produce 30% of the 1971 consumption rate for natural gas, in the West, it will require a capital investment of nearly six billion. It is likely this amount might be invested in this way in the West by 1985.

Oil

Many have predicted that oil use will decrease as a percentage of the total energy mix. Energy supply predictions are indicated in figure 6. Recent events have led some, however, to make a reassessment and to conclude that oil use will probably increase rather than decrease as shown in figure 6. This conclusion is based in part on recent drops in availability of natural gas with oil being used as a stand-in fuel. As an example, figure 8 shows what happened in California when natural gas became less available after 1968. The new growth rate for oil consumption is very close to the sum of the previous growth rates for oil and natural gas when equated on an energy equivalence term of Barrels-of-Oil Equivalent (BOE). The higher growth rates for oil consumption along the West Coast appear to be such that the new oil sources in Alaska can be entirely consumed in the West Coast market. The Alaskan oil will have a strong influence on reducing the need for imported foreign oil which has been growing dramatically in California ports.

Reserves of oil locked in oil shale in the West are very large. The amount of oil to be derived from this source by 1990 is not known. It appears that any oil developed from shale must receive a high price to be profitable for those involved in this extraction.

Coal

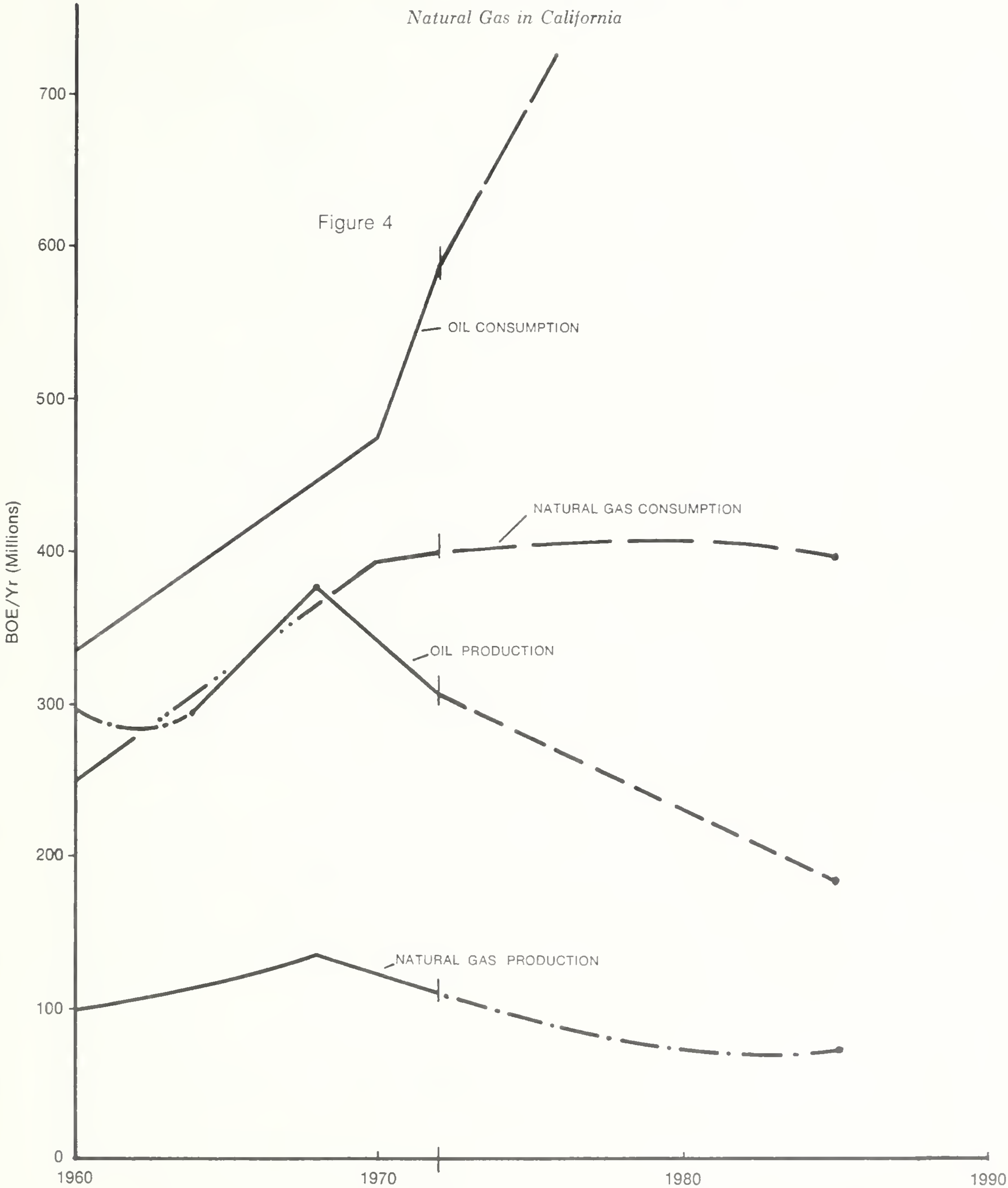
The growth rate of coal in the energy mix of figure 6 is much slower than it could be. The 36 million tons of coal produced in the West in 1971 is 50% greater than it was in 1946. However, some industry officials feel that resources technology, equipment and labor are available to the extent that production rates could conceivably increase by a factor of 3 to 10 if strip-mining companies were left free from leasing and environmental constraints. At present, in most areas, companies must assure state governments of their intentions to restore the strip mined areas and they may have to comply with federal legislation that is now before Congress. To the extent that environmental issues are resolved, an expanded production rate of coal will probably occur.

The documented coal fields in the West are shown in figure 9. Note that in the Northern Rockies much of the coal is on the eastern slopes. Few coal fields along the coast are sufficient to warrant electrical generation plants although several can contribute towards meeting industrial energy needs.

[8] Resource Needs for Nuclear Power Growth, Atomic Industrial Forum, New York– 1973.

Figure 8

Decreasing Ability to Satisfy Growing Demands for Oil and Natural Gas in California



(Taken from Energy in California Resources Agency, State of California, January 1973)

Figure 9

Coal Fields in WSWC Member States

Geothermal

Hot springs and fumaroles have been used for centuries by man for bathing and space heating. In 1904, the first conversion of geothermal energy to electricity occurred in Italy. However, it has only been in the last decade that geothermal resources in the United States have been converted to meaningful amounts of electrical energy. In fact, the only geothermal power plant in the United States is located at "The Geysers" development north of San Francisco. This facility is operated by Pacific Gas and Electric Company and projections are that within the next three years there will be produced more than 600 megawatts (about enough electricity to meet the demands of the City of San Francisco). Some predict the potential of this area to be 2,000 megawatts.

The geothermal resource at "The Geysers" area is identifed as a dry stream field. Many geothermal experts indicate that they believe that this type of geothermal deposit will be the exception rather than the rule. Geothermal energy has been found in other locations of the world in a form referred to as wet-steam. Wet-steam is more difficult to convert to electrical energy and its economics and its worth are not as apparent as the dry steam resources. Investigations are now occurring that would, if successful, allow for the economic conversion of geothermal energy into electrical energy by the use of secondary fluids in what is referred to as a binary system. If this conversion process becomes economically competitive, then a larger number of geothermal prospects will become potential electrical energy sources. Exploration is also underway in some areas where the natural hydrology does not provide the necessary fluids to bring the earth heat to the land surface. In these dry rock areas, the plan is to inject water and recover steam.

Other research efforts are looking at the potential use of hot water or steam from the earth for uses other than electrical energy. As for example, paper mills and potato processing firms in the West could use this type of energy to reduce their demand for other forms of energy. All that can be said is that the extent to which future geothermal resources can meet our demands is a matter of speculation.

One unpublished study prepared for the A.E.C. in Idaho concluded that geothermal projects converting low temperature fluids (below 350°F) with low salinity into electrical energy will be built in the near future with the construction of a 10 megawatt plant as early as 1977. The same analysis predicts that by 1980 there will be 29 megawatts produced, by 1985, 700 megawatts produced and by 1990 there will be 250 plants in the western United States producing a total of 30,000 megawatts.

The above sited example is the conclusion of one study analyzing one type of geothermal resource. It is given only as an example. In the infant industry of geothermal power there are many proposals and conclusions as to the ultimate potential of geothermal resources and their findings vary greatly. Much is yet to be accomplished in the fields of exploration for the basic geothermal resources, research into energy conversion processes, establishment of legal and institutional structures, and determination of environmental effects before the true worth of this resource is understood. However, it is believed that some additional use of geothermal energy at sites other than "The Geyers" will occur within the time frame of this study (before 1990).

WATER REQUIREMENTS FOR VARIOUS ENERGY PROCESSES

General

All energy processes that may be developed in the West will use some amount of water in in extraction, transportation, refining or conversion. Previously, location of energy development was based in part upon the availability of unappropriated water supplies. More recently, the search for energy resources has intensified and water resources development and change of place and nature of use are being considered in parts of the West where water supplies have long been appropriated for other beneficial purposes.

Often new energy resource development will seek to purchase and convert existing water rights. The availability of such rights and of unappropriated water, the costs of acquisition and/or the cost of development and the legal constraints that exist in state water laws or that may be established in the future, will effect decisions of developing companies as to the processes used in energy development. These future decisions will determine the real water requirements for various energy processes and the values given in this chapter can only estimate what these future water demands will be.

Thermal-electric

The largest water withdrawals in the U.S. today are for the once through cooling of condensers on the steam turbines of electric generating plants. Most of this water is returned to the rivers and reused for other purposes. There is currently a strong effort by the Environmental Protection Agency, and others, to require evaporative cooling systems at all new thermal-electric plants. Even direct cooling using seawater for plants along the Pacific Coast has met with some disfavor of the Environmental Protection Agency and other regulatory bodies.

Several alternate techniques exist and others can be developed. The most common alternate is a cooling pond which allows some of the heat to be dumped by conduction and convection. Much less common are plans for dry and wet-dry systems that consume a small fraction of the water needed for evaporative towers.

Figure 10 shows the expected growth in electrical supply from coal-fired and nuclear plants planned for the West for the next 5-10 years and projected growth beyond planned plants to 1990. Developments with planned dry cooling systems and those with ocean cooling have been included. The use of coal and nuclear sources is expected to be almost equal and the total need for 1990 will be about 120,500mw. Using the firmly planned plants it is shown by sites identified in table 1 that by 1980, a total of 26,777mw will be generated by coal-fired plants in the West. Table 2 identifies 5,523mw of nuclear-powered thermal plant capacity that will be using evaporative towers by 1980. Nuclear plants can be expected to consume 17,000 acre-feet of water/1,000 mw capacity and coal fired plants, 15,000 acre-feet of water/1,000mw capacity for a total need of almost 500,000 acre-feet of fresh water annually in 1980. If all unplanned plants were assumed to use evaporative cooling towers when amounts of water that may be needed were estimated and if these rates for thermal-electric plants are extrapolated to 1990 to meet the future electrical energy projection as shown in figure 10, over 1,700,000 acre-feet/year of fresh water will be needed if evaporative cooling is exclusively used as assumed.

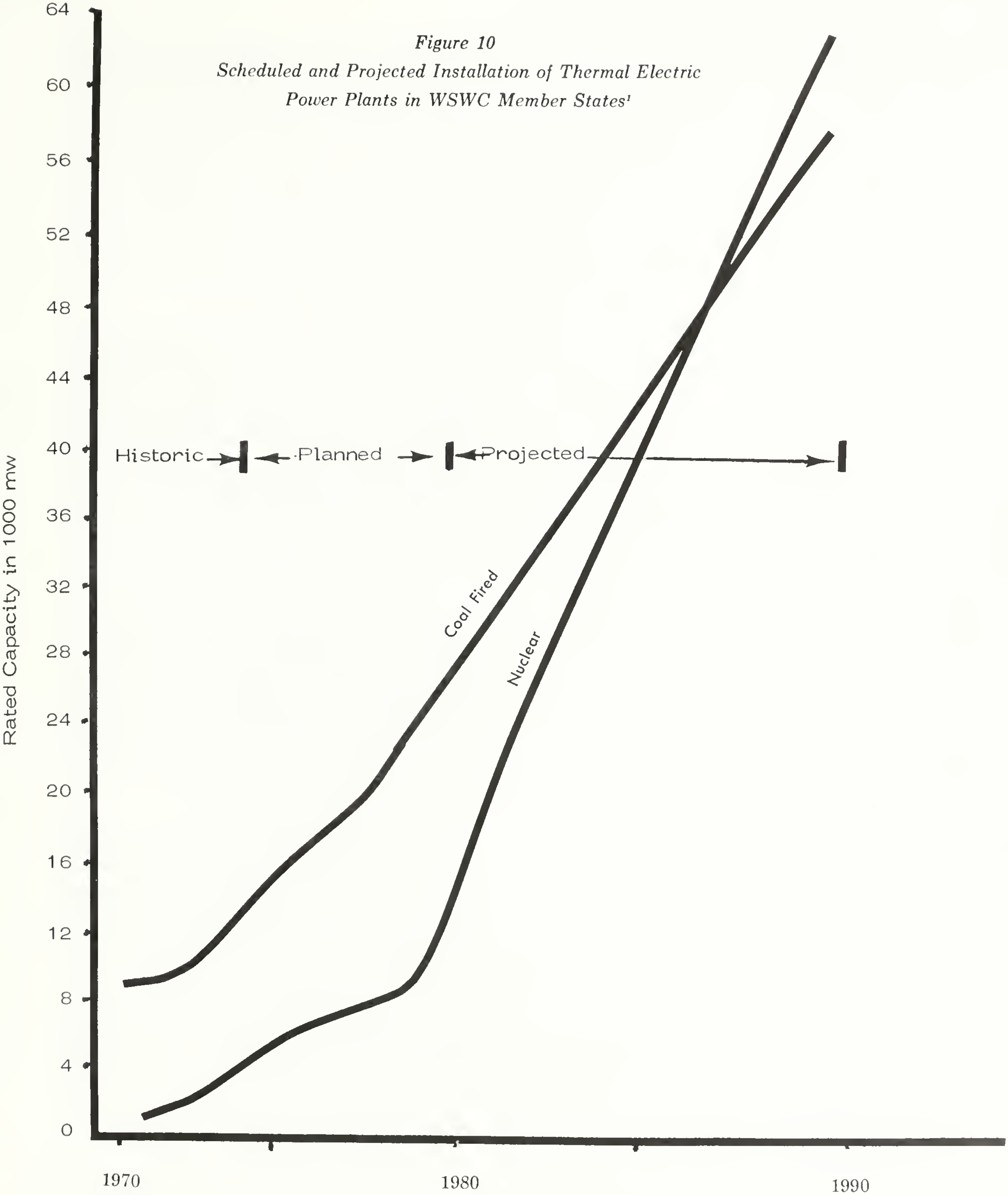
An extrapolation to the year A.D. 2020 would be difficult to quantify for lack of knowledge on energy demands. It is not difficult, however, to forecast that by 2020 in some areas all water resources will be committed and our society will demand that we do better than to evaporate our fresh water, as routine, in elecrical power production.

Coal Conversion

Coal is a suitable feedstock for producing a variety of burnable hydrocarbons. In combination with steam, coal can be used to produce a gas mixture of hydrogen, methane, ethane, carbon monoxide, and carbon dioxide. The temperature and pressure at which the reactions occur strongly influence the quality of the resultant gas. Federal efforts to develop commercially viable coal conversion systems in the next five years are expected to exceed $2 billion. Which process will prove most favorable and the water consumption rate of that process is uncertain at this time.

It is assumed that a coal gasification system known as the Lurgi process may typify the process needed to manufacture pipeline gas. The principal requirements for water are for process water, 4%; process steam, 1%; and condenser cooling, 95%. Due to the high temperature of the process much of the cooling could be accomplished with air cooling. Thus, in areas where water is unavailable, air cooling is presumed and, therefore the water requirements have been reduced by 75%. The range of water requirements normally associated with a commercial sized coal gasification plant are from 10,000 acre feet to 45,000 acre feet/250 million standard cubic feet per day produced.

Figure 10
Scheduled and Projected Installation of Thermal Electric Power Plants in WSWC Member States[1]



[1]includes plants with dry cooling systems or ocean cooling

Coal liquification is a similar process but the end product is a liquid hydro-carbon rather than a gas. Again the temperature and pressure of the process influence the quality of the product. The hydrogen need for the process comes from water, but this water is a small amount when compared to the amount of water that will be used for the condensing process. The range of water requirements normally associated with a commercial sized coal liquification plant are from 20,000 acre-feet to 130,000 acre-feet per year for a plant that will produce 100,000 barrels per day of liquid hydro-carbon. Even though the technology is still developmental, it may be safe to assume that the above water requirements could be reduced substantially if there was a compelling reason to do so.

Oil Shale

The recovery of oil from shale is first a gigantic mining operation, second a hydro-cracking process and third a large waste backfilling operation. A one million barrel per day effort would involve mining more than 150,000 tons/day of oil shale. The nature of the process requires that nearly the same volume that is shipped from the mines be returned to either the mines or a nearby canyon for disposal. With water the spent shale can be compacted and thereby stabilized. Nearly half of the water associated with oil shale processing is simply for the compaction process. This water need not be of any special quality and can, in fact, be saline or brackish water.

The crude oil from shale tends to be too viscous for transporting through an unheated pipeline. Therefore, in addition to the normal upgrading with an ore operation, there is a refinery process involved to upgrade the oil. The heating and condensing of the oil and associated gases would normally involve fresh surface or ground water but could involve distillation of saline water for the process needs.

The high quality water needed for revegetation, sanitary and associated urban use amount to 10% of the total water needs associated with oil shale recovery. The Department of Interior Environmental Impact Statement on Oil Shale Leasing estimated that 121,000 to 189,000 acre-feet/year would be diverted and consumptively used to produce one million barrels/day of oil. This amount includes associated domestic water requirements. All of the water diverted may not be consumptively used. However, it is anticipated that return flows or runoff from oil shale operations will be of such poor quality that returns will have to be collected and reused or disposed of because they will not be suitable for release into surface streams. Perhaps fortunately, the richest oil shale deposits in the West are in the Piceance Basin which covers a very large saline aquifer. If one million barrels/day is a reasonable scale of operation and the bulk of the operation is in the Piceance Basin, it is not clear that a serious water problem exists because the groundwater resources may prove to be an adequate source for most of the water needs. If several million barrels/day are sought from a variety of basins, the merit of using water for oil shale will need to be matched with the merits of using water for agriculture in some of those regions.

Extraction

Mining, whether it is coal, copper, iron or uranium, requires water as a working fluid. The water is used for flotation, fluidization, concentration washing, etc. In addition, around modern mining operations water is used for dust control. Such water needs are highly variable, but none are large by comparison with other water needs described above. The best parameter for measuring the water needs appears to be the number of acres involved in the extraction process. A unit consumption rate of 1 to 3 acre-feet/acre of surface area disturbed annually appears to be a generally acceptable range.

During the first two years after mining some restoration and revegetation directly over coal mining strips may require from .5 to 4 acre-feet/acre. If the land is then returned to a farmer he may choose to continue irrigation rather than to let the land revert to native rangeland. Water for this change in use of the land to perpetual irrigation is excluded from the analysis of water needs for energy.

Uranium tailings are normally returned to native vegetation and require only enough supplemental moisture to insure a good start. Perhaps 1 acre-foot/year would be applied to areas that are restored in the manner common to this industry rather than beneficiated by the revegetation process anticipated in coal strip mining operations.

The area disturbed in mining uranium ore is estimated to be 17acres/1000mw. The 460,000mw of nuclear capacity expected to be in operation by 1990 would therefore require about 8,000 acres per year if 90% of the ore was mined in the West. At 1 acre-foot per year per acre the total water needs for uranium mining in the West then would be 16,000 acre-feet/year.

For coal mining, the fraction that will be produced in the West is unknown and subject to the development of new technologies, federal leasing policies and environmental decisions. If one were to assume that coal production in the West were scaled up to 300 million tons/year by 1990, a total of 30,000 acres/year could be disturbed annually which would require prompt revegetation efforts. Restoration of this land to native species would be most likely. Water used in annual extraction of coal from 30,000 acres/year would be from 30,000 to 90,000 acre feet per year. If revegetation took two years, the land mined in the past two years (60,000 acres) would require 30,000 to 240,000 acre-feet per year. Taking the average of these estimates it can be calculated that by 1990 extraction of coal and the revegetation could require 195,000 acre-feet per year.

Even oil and natural gas extraction utilize water as a working fluid. During 1962, it is reported that across the nation the industry utilized 157,000 acre-feet nationally for secondary recovery operations. Drilling in the same year was reported to consume 37,000 acre-feet. The fraction of this industry in water-short parts of the West is small, however.

Refining

The use of water in refineries is standard practice and is unlikely to vary. Since most of the oil from the oil shale operation is planned for transport as crude oil, the water needs for refineries are not likely to impose large water demands in the Rocky Mountain states. A common unit that is used for refineries is 39 gallons of water/42 barrels of crude oil. The million gallons per day of crude from the oil shale operation will, therefore, require 930,000 gallons/day (1,000 acre feet/year).

Transport

The only use of water envisioned, at this time, for transporting energy sources is for coal slurry pipelines. Although an 18 inch pipeline in Arizona has met with mixed favor, there are considerations of several 36 inch lines that would go from the Rocky Mountain coal fields to midwestern states. One such project has already been initiated in the Powder River Basin of Wyoming.

The 18-inch coal slurry line from Arizona to Nevada uses 3,200 acre-feet/year and can supply 4 million tons of coal annually. Four 36 inch lines would then use 51,200 acre-feet/year to convey 64 million tons of coal/year.

Recently there has been a new interest in coal slurry pipelines. The Bechtel Corporation has just released a report for the Department of the Interior. This report identifies six proposed coal slurry pipelines. One is a 1,100 mile pipeline from Craig, Colorado to Houston, Texas; the second one is a 1,030 mile pipeline from Gillette, Wyoming, to White Bluff, Arkansas. A third pipeline is proposed to slurry coal 180 miles from Alton in Southern Utah to Arrow Canyon in Southern Nevada. Another 180 mile pipeline is contemplated to take slurry from Star Lake in Northwestern New Mexico to Snowflake in Eastern Arizona. A pipeline to take coal from Wyoming to Oregon has also been discussed. Long range planning has also considered using the trans-Alaskan oil pipeline as a coal slurry pipeline after oil reserves are depleted. Senator Henry M. Jackson from Washington has recently proposed legislation that would give pipeline carriers the right of eminent domain for the building of coal slurry pipelines. This effort, although opposed by some union and railroad forces, would greatly accelerate the implementation of pipeline construction if the legislation becomes law.

Alternatives to Evaporative Cooling

Future thermal-electric plants can exert heavy demands on western water supplies. The Western States Water Council has examined the impact on the water supplies of the West if the current trend continues of equiping thermal-electric plants with evaporative cooling systems. This summary is shown in the next section of this report.

Alternatives to evaporative cooling systems are many but none can be assured to have EPA approval. The alternatives include:

1. ocean cooling
2. cooling ponds
3. direct cooling by large rivers when the seasonal temperatures permit
4. multiple use of water allocated for sanitary and/or agricultural use
5. dry cooling radiators
6. wet-dry cooling radiators

Cooling ponds in most parts of the West require about two-thirds the consumptive use of the evaporative cooling towers. The other alternatives all use considerably less.

Several of the alternatives may be less expensive at given sites than evaporative cooling towers. This is both with regard to capital and operating cost. For those sites in which the alternatives may be more expensive, the evaporative cooling tower should perhaps be more carefully considered. Overall environmental cost may be greater at some stream locations if large amounts of water are evaporatively consumed. Any "guideline" that directly or indirectly requires all thermal-electric power plants in the West to use evaporative cooling towers is counter-productive towards saving valuable water. It is apparent that a blanket standard that would preclude other alternatives at any given site often would not provide an opportunity to conserve water or energy. In fact, such a common requirement may often consume water that is badly needed to enhance environmental instream values.

Consumptive Rates

A summary of the unit consumption rates for the energy resources described are shown below:

Energy System	Water Needs
Steam-Electric Nuclear	
Evaporative Cooling	17,000 acre-ft/yr/1000mw unit
Pond	12,000 acre-ft/yr/1000mw unit
River	4,000 acre-ft/yr/1000mw unit
Wet-Dry Radiator	2,000 acre-ft/yr/1000mw unit
Steam-Electric Coal	
Evaporative Cooling	15,000 acre-ft/yr/1000mw unit
Pond	10,000 acre-ft/yr/1000mw unit
River	3,600 acre-ft/yr/1000mw unit
Dry Radiator	2,000 acre-ft/yr/1000mw unit
Geothermal	48,000 acre-ft/yr/1000mw unit
Natural Gas	50,000 acre-ft/yr throughout the West
Crude Oil	50,000 acre-ft/yr throughout the West
Refineries	39 gal/Bbl/crude
Oil Shale	7,600 to 18,900 acre-ft/yr/100,000 BPD plant
Coal Gasification	10,000 to 45,000 acre-ft/yr/250 million SCF/day plant
Coal Liquification	20,000 to 130,000 acre-ft/yr/100,000 BPD plant
Coal Slurry Pipeline	20,000 acre-ft/25 million tons coal (1 cfs will transport about 1,000,000 tons per year)
Coal Mining	
Vegetation reestablishment	.5 to 4 acre-ft/acre/yr (some areas may require two years)

The many water and energy units used make it desirable to equate water uses based on a particular energy unit. Since one million BTU's is a common unit, the water requirements per million BTU's have been calculated and are shown below. (For reference purposes a typical barrel of crude oil contains six million BTU's.)

Energy Source	Consumptive Water Requirement
Steam-electric-nuclear	200 to 2,000 lbs. water/million BTU's
Steam-electric-coal	200 to 1,350 lbs. water/million BTU's
Coal Gasification	800 to 1,350 lbs. water/million BTU's
Oil Shale	100 to 240 lbs. water/million BTU's
Coal Slurry Pipeline	0 to 110 lbs. water/million BTU's

A wide range of numbers in the water requirement column reflect a variety of practices available. These practices were described previously and range from dry radiators to the more prevalent evaporative systems. The high rate of consumption in the electrical generating plants include the needs for the turbine condensers only. The product, electricity, can normally be further used without additional cooling water.

The water from a coal slurry pipeline could possibly be further used for cooling the turbine condensers on a coal-fired power plant or could be returned by pipeline for reuse in new slurry, thereby not consuming water. It is clear from figure 11 that the western water resources would be better conserved by shipping a coal slurry out of the region than by shipping out electrical power. Local economics, however, might not be best served by this export without conversion of energy resources.

Figure 11 can be interpreted to show the fraility of the agricultural economic structure, when most energy sources are worth about one dollar per million BTU's, and the water to the irrigation district is often worth less than $20/acre-ft. Figure 11 shows that for most of the energy developments contemplated for the West $20/acre-ft. is equivalent to less than one cent per million BTU's. From this exercise it is clear that consumptive use of water by industry is not likely to be discouraged by the price of water if there is agricultural water available for purchase.

Because of the lower temperatures, the conversion efficiency of geothermal energy to electrical energy is poor. "The Geysers" field in California now converts electricity at less than 16% efficiency. This means at "The Geysers" facility, as much as 2.33 times as much water is needed in the cooling process as might be required in a nuclear plant of equivalent size. As stated before, "The Geysers" field is considered an exception rather than the rule. Figure 12 illustrates that geothermal energy would consume more water per unit of energy than any other type of energy resource development. It should be noted, however, that in "The Geysers" development in California, the fluids produced from the ground provide more than enough water to operate the entire cooling system. Therefore, the geothermal development in California is actually producing rather than consuming water if you consider the ground water a new source of water.

A significant amount of addtional exploration and development must occur before prices or accurate figures can be developed concerning the total water demands of geothermal energy in the Western United States.

Figure 11

Cost of Water to Various Industrial Energy Developers

Example: 1c million BTU Equivalent to:

—6c/6 million BTU

—6c/Barrel Crude Oil

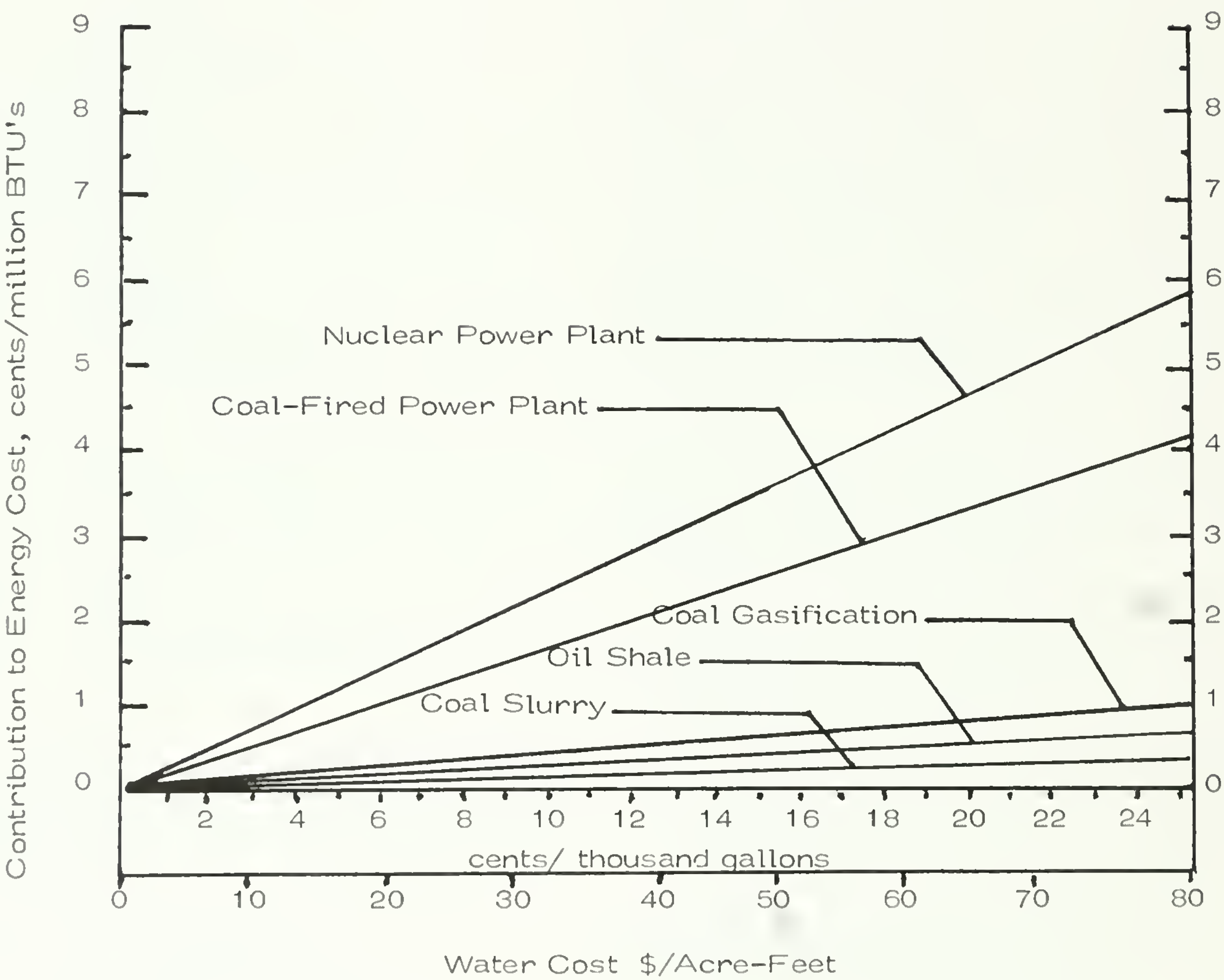
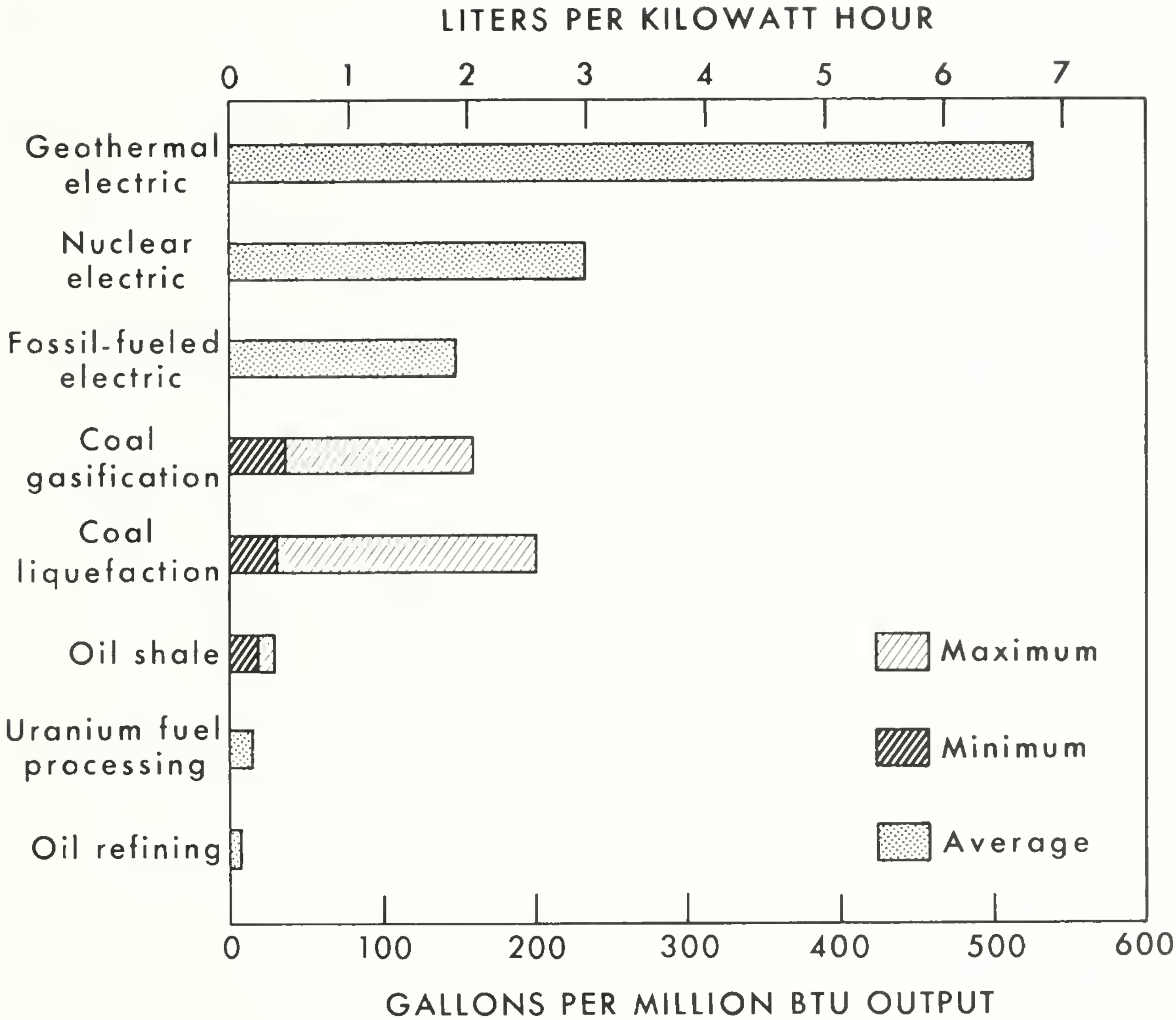


Figure 12



Water consumption in refining and conversion processes
(Taken from U.S.G.S. Circular No. 703, 1974)

SUMMARY WATER NEEDS

This section provides a summary of the expected energy developments and the associated water demands. No rationale is intended that would place the virtue of one energy source over another. Likewise, no inference is intended that the options that use the least amount of water are necessarily the best energy choice.

The electrical generation forecasts were shown previously. The plants installed by 1970 are, of course, history and those to be operational by 1980 very well determined. (table 1 and table 2) The thermal-electric capacity installed between 1980 and 1990 is assumed to be predominantly nuclear and coal and in the rated capacities shown in figure 10.

The evaporative water needs for planned thermal-electric generation is tabulated below for 1980. Some future nuclear plants will be seawater cooled. Not all of the generation predicted in figure 10 will be cooled by evaporation. Using the same percentage of evaporative systems as is expected in the West in 1980, the fresh water needs of coal-fired and nuclear plants expected by 1990 are listed below.

Coal-fired plants	Cumulative Capacity using evaporative cooling	Water need @ 15,000 acre-ft/yr 1,000mw
1972	9,110mw	136,650 acre-feet
1980	25,777mw	386,655 acre-feet
1990	55,750mw	836,250 acre-feet

Nuclear-powered plants	Cumulative Capacity using evaporative cooling	Water need @ 17,000 acre-ft/yr 1,000mw
1972	800mw	13,600 acre-feet
1980	5,523mw	93,891 acre-feet
1990	37,242mw	633,114 acre-feet

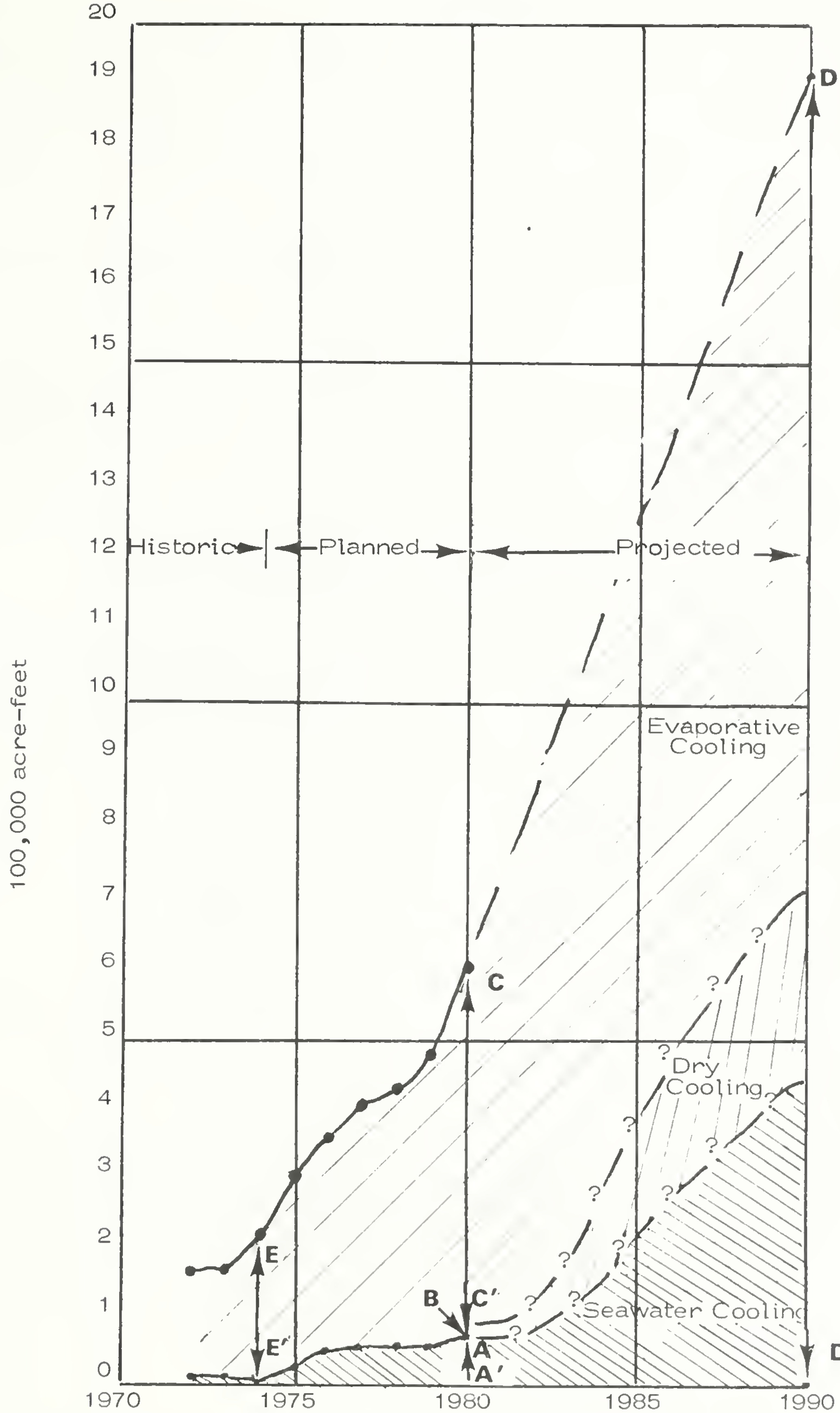
Together the thermal-electric power plants could be by 1990 using up to 1,469,364 acre-feet/year for evaporative cooling. With the view of conserving our limited western water resources in mind, the large evaporation of water may be undesirable and greater use of systems such as dry cooling and more seawater cooling should be examined.

Perhaps the future will show that more water conservation will occur than is indicated in these figures; on the other hand, however, policies that preclude the use of ocean water and other fresh water-saving cooling techniques may force more fresh water to be used than has been calculated above. To better illustrate the large volume of water that is at stake in only the electrical portion of western energy development, figure 13 was prepared.

Total electrical demands in the West have been projected in this report to 1990 as being 120,500mw with 58,000 coming from coal-fired plants and 62,500 from nuclear plants. If this entire electrical generation were cooled by evaporative cooling 1,924,000 acre-feet could be evaporated. Figure 13 graphically shows this potential demand. "D - D' " is the distance of the graph representing this large total potential. Generating facilities of 1980 are already well planned and some dry cooling and seawater cooling is planned that will substitute for some potential evaporative cooling needs. The distance "A - A' " represents the seawater cooling planned and the small distance between the two points marked by "B" is the amount of dry cooling planned. Even with seawater cooling and dry cooling providing some of the cooling needs, the evaporative cooling process will be used in 1980 to provide more than 80% of the cooling needs as is shown in figure 13 by the distance "C - C' ". Between 1974 ("E - E' ") and 1980, evaporation at steam- electric plants in the West will almost triple. The extension of any trends to seawater cooling and dry cooling is unclear and is clouded by unknown economics, untried technology and established and proposed environmental regulations and constraints. Even with optimistic projections as to the role that seawater cooling and dry cooling may place it can easily be estimated from figure 13 that the evaporative cooling needs by 1990 may increase by as much as six times over current uses.

The oil shale industry is just starting in the West even though it has been studied and heralded for many years. Projections in this report as to the near future production of oil from shale are certainly subject to significant change as efforts

Figure 13



Potential Evaporative Cooling Water needs for Scheduled and Projected Coal Fired and Nuclear Power Plants to 1990 to develop this resource mature. The first 50,000 barrel/day plant is expected to become operational between 1978 and 1980.[9] This plant will consume water at a rate of 8,000 acre-ft/yr. It has been predicted that by 1990 the oil shale industry could produce about two million barrels per day and would require between 150,000 and 378,000 acre-ft/yr. In certain areas there is the possibility that some of this water could be pumped from under-ground aquifers. The potential value of water for oil shale production is significant enough that expensive sources of water can be considered. Efforts to develop new and more expensive water sources could relieve or replace a potential demand on agricultural water.

Water needs for oil refineries in the West are small when compared to total water for energy needs. Mining and other extraction processes related to energy with the exception of coal, also require only small amounts of water. Therefore, these requirements have been combined in the tabulation below under the heading of "Other Related Energy Processes." Coal mining will by 1990 require perhaps 195,000 acre-feet per year in mining and revegetation operations.

Depending on proof of some refinements, it is reasonable to expect 18 coal gasification plants in the Western States Water Council states by 1990 (some federal estimates are higher). Using the range of water needs from previous chapters, 18 plants would require from 180,000 to 810,000 acre-feet annually. Eighteen plants of 250 million standard cubic feet per day capacity could produce about 1.5×10^{15} BTU's/yr. This is equivalent to 39% of the natural gas consumed in the West in 1971.

Coal could be exported from the Western States by slurry pipelines. To slurry 250 million tons of coal, four or five pipelines, 36 inches in diameter, would be required and 200,000 acre-feet of water annually would be needed. Although a bold undertaking is possible, it would require state support and legislative assistance. This section assumes that five pipelines will be operational by 1990.

There is an atmosphere of energy uncertainties. Nevertheless, water supplies need to be assured in 1980 for the oil shale, coal gasification and coal slurry pipelines if these developments are to occur by 1985. For the thermal-electric plants, the 1990 operation plans need to be assured of water in 1980. Therefore, the 1990 energy developments cited will call for all water resource planning to be complete by 1980 for 1990 energy.

A summary of the above water needs for Western States for 1990 in energy development as identified in this report and rounded to the nearest 1,000 acre feet are given below. The totals are in the order of 10 times the amount of water presently used in the West in the energy industry.

	Annual use acre-ft/yr.
Coal-Fired Power Plants	836,250
Nuclear Power Plants	633,114
Oil Shale	150,000 to 378,000
Coal Mining Operations	195,000
Coal Gasification—18 plants	180,000 to 810,000
Coal Slurry Pipelines	100,000 to 200,000
Geothermal Power Plants	22,000 to 44,000
Other Related Energy Processes	25,000
	2,141,364 to 3,121,364

It is obvious that a vast quantity of our valuable water resource is at stake. Water resource planners must become familiar with the potential demands, policies, economics and assumptions that lead to the potential needs for these large amounts of water. These water demand estimates were often determined by on-going practices. Water saving alternatives must be examined. The impact on various drainage basins will vary. The impact on existing compacts and well conceived water plans for alternate uses of water will also vary.

It is important to realize that 1990 is an arbitrary date and the energy projctions are not at a leveling off point nor do they reach a plateau at this point in time. It is anticipated that energy requirements can continue at an ever accelerating rate to increase into the twenty-first century. Associated impacts on water supplies in the twenty-first century can also be much greater than 1990 estimates found in this report.

[9]Personal communication with Colony Development Operation, 5/20/74.

WATER REQUIREMENTS BY STATES

In order for state administrators to assess the impact of meeting the projected energy requirements, it is necessary to identify the states most likely to receive various types and amounts of energy development. Estimates as to location by states of development have been made using the following guidelines:

1. Those thermal electric generating plants listed in tables 1 and 2 are assumed to be completed on the schedule indicated.
2. Additional thermal electric generating plants built between 1980 and 1990 are assumed to occur generally in the same states, and in somewhat the same proportions as 1974-1980 developments, except for known additional large plants that are now under study.
3. Coal fired thermal electric plants are assumed to continue to be located generally in the mountain states and nuclear plants are assumed to be located, for the most part, in the coastal states.

The 1990 water for energy production projection for each state is necessarily, to some degree, arbitrary as additional development must be assigned to probable locations even though advance site planning has not occurred. Tables 3 through 7 summarize by state, the projected growth in each type of energy production along with the related water requirements. Table 8 summarizes the total water required to meet the projected growth in energy production.

TABLE 3

Projected increase in coal fired power plants and evaporative cooling requirements in WSWC member states to 1980 and 1990

State	New planned capacity 1972-1980mw	Added capacity assumed by 1990 mw	1990 total mw	Increased water requirements by 1990 in nearest 1000 AF/yr*
Arizona	3800	1200	5000	75
California		5400	5400	81
Colorado	3030	3000	6030	90
Idaho	500	1500	2000	30
Montana	2060	6200	8260	124
Nevada	1737	1000	2737	41
New Mexico	1670	1000	2670	20**
Oregon	600	600	1200	18
Utah	2390	5600	7990	120
Wyoming	1880	6323	8203	118**
			Total	717

*Water requirements based on 15,000 acre feet per year for each 1000 mw

**New Mexico and Wyoming are planning now for dry cooling to be used to meet some of the cooling demands of the generation capacities listed

TABLE 4

Projected increase in nuclear power plants using vaporative cooling WSWC member states (1972-1990)

State	Planned Capacity mw	Under study or assumed by 1990 mw	Total mw	Water required for plants assumed to be using wet cooling to the nearest 1000 AF/yr*
Arizona	3810	50	4310	73
California	3713	12499	16212	276
Colorado	330	50	830	14
Idaho	0	500	500	9
Oregon	3650	3500	7150	122
Washington	4840	2600	8440	126
			Total	620

*Water requirements based on 17,000 acre feet per year for each 1000mw

TABLE 5

Projected increase in water required for oil shale development in WSWC member states (1972-1990)

State	Estimated production barrels/yr	Water required 1000 AF/yr
Colorado	1,625,000	260
Utah	250,000	40
Wyoming	125,000	20
	Total	320

TABLE 6

Projected increase in water requirements for coal mining developments in WSWC member states (1972-1990)

State	Water requirements in 1000 AF/yr
Arizona	10
Colorado	10
Montana	70
New Mexico	3
Utah	42
Wyoming	60
Total	195

TABLE 7

Projected increase in water required for coal gasification in WSWC member states (1972-1990)

State	Number of 250 million SCF/day plants	Water required 1000 AF/yr
Arizona	1	11
Colorado	1	11
Montana	4	44
New Mexico	7	72*
Utah	1	11
Wyoming	4	44
	Total	193

*some dry cooling assumed

TABLE 8

Projected increase in coal slurry lines to deliver coal outside WSWC member states (1972-1990)

State	Number of slurry lines	Water required 1000 AF/yr
Montana	1	40
Wyoming	4	160
	Total	200

TABLE 9

Projected increase in water requirements for geothermal development in WSWC member states (1972-1990)

State	Number of developments of various sizes	Water required 1000 AF/yr
California	1	22
Idaho	2	4
Nevada	1	2
New Mexico	1	2
Oregon	2	4
	Total	34

TABLE 10

Summary of estimated increased water required
to meet growth in energy needs of WSWC
member states in 1000 AF (1972-1990)

State	Coal fired power plant	Nuclear power plant	Oil shale	Coal min-ing	Coal gasification	Coal slurry	Geo-thermal	Other energy processes	Total
Arizona	75	73	0	10	11	0	0	2	171
California	81	276	0	0	0	0	22	13	392
Colorado	90	14	260	10	11	0	0	2	387
Idaho	30	9	0	0	0	0	4	0	43
Montana	124	0	0	70	44	40	0	1	279
Nevada	41	0	0	0	0	0	2	0	43
New Mexico	20	0	0	3	72	0	2	1	98
Oregon	18	122	0	0	0	0	4	0	144
Utah	120	0	40	42	11	0	0	3	216
Washington	0	126	0	0	0	0	0	0	126
Wyoming	118	0	20	60	44	160	0	3	405
								Total	2,304

General

The future extent and impact of water demands for energy is clouded by the lack of firm administration and direction. New federal agencies, bureaus, studies, and investigations are unveiled every day without the appearance of a master plan for implementing announced major national goals. State and regional administrations are eager to have input in a meaningful way, but often it is impossible to determine the force and importance or the objective of the multiplicity of inquiries or reports that are passed from federal to state hands which request comment and review.

This impediment to meaningful state involvement is unfortunate, because in order to facilitate sound resource planning, it is imperative that the states participate. Important considerations in the effort provide water for energy are the legal or water right ramifications. State water law is the basis for the allocation and use of water in the West. Any plans for large scale use of water for energy in the West must involve the state water right administration. The Western States also have administrative functions with respect to water quality and energy distribution and both water and energy planning authorities.

Notwithstanding these facts, to date states have felt little meaningful involvement in the new effort for "Project Independence" and often federal efforts appear to be uncorrelated and duplicative. Moreover, federal rules and regulations often appear to be counterproductive with respect to efficient new energy production, water conservation, and environmental enhancement. This section of the report is prepared to examine some specific examples of those problems that relate to the need for water for energy. They are 1) the leasing and rehabilitation of western coal lands 2) power plant siting regulations 3) proposed effluent limitations for steam-electric plants 4) multiplicity of water for energy studies 5) apparent uncertainties in the "Project Independence" effort. 6) associated community impacts.

Leasing and Rehabilitation of Western Coal Lands

It was noted earlier in this report that the present limiting factor on the rate of the development of western coal is not physical but administrative or legal. Federal leases to many western coal deposits are being withheld and issued leases are in some cases in question.

The Congress is currently attempting to enact legislation acceptable to both houses to regulate the surface strip mining of coal. The versions that appear to be most favored by the Congress are opposed by the Administration, the Secretary of Interior and the Federal Energy Administration. The Bureau of Mines has testified that proposed legislation would cut total coal production by up to one-third and would raise costs significantly. Neverthless, the House Interior Committee recommended enactment of the bill "so that industry can proceed to grow and develop in an orderly and environmentally acceptable fashion." It now appears that a bill requiring rehabilitation of coal lands will be passed together with federal enforcement standards to protect environmental values. The stringency of these laws and regulations may soon be determined by the Congress.

Although industrial water requirements for surface mining operations are small and do not present serious problems with regard to aquifer depletion or competition with existing uses, rehabilitation requirements in the more arid regions of the West would probably necessitate major and sustained inputs of water depending on the amount of acreage involved.[10] Estimates of water requirements are, however, difficult in light of the absence of long term, extensive, controlled experiments in the shaping and revegetating of western lands.

Power Plant Siting Regulations

The inadequacy of the existing power plant siting procedures has become increasingly apparent in recent years. The effect of this inadequacy on western water requirements has been twofold:

(1) The delays caused under present procedures have resulted in a failure to provide timely energy development with less consumptive water requirements than those now proposed; i.e., hydroelectric dams vs. coal-fired plants and oil shale development. (To the degree that construction of hydroelectric generating facilities has not kept pace with the growing needs, it seems fair to assume that reliance has been placed on other types of energy development with higher consumptive water requirements. The extent to which this reliance will continue will depend on whether, in fact, the construction schedule of hydroelectric generating facilities can be accelerated.)

(2) The delays inherrent in present procedures have resulted in some instances in a failure to develop energy facilities at locations

[10]Rehabilitation Potential of Western Coal Lands, National Academy of Sciences/National Academy of Engineering, Washington, D.C. (1973) (Draft).

where there are sufficiently adequate water supplies to avoid competing uses of water.

These problems were recognized in a resolution adopted by the Western Governors' Conference held September 26, 1973, which states as follows: "Pacific Northwest States rely almost exclusively on hydroelectric generating facilities for their electric power needs, and Southwest utilities benefit from this generation through interconnection of distribution systems. Needs have continued to grow, but installation of essential facilities have not kept pace. The Western Governors' Conference urges the Congress and the President to restore the national priority on the completion of hydro generation facilities, and, if possible, to accelerate the construction schedule to provide full generation of electricity from the water resources."

In order to avoid the kinds of delays in siting that have been caused by the present needs for multitudes of federal, state and local approvals, legislation has been sponsored by the Administration as well as members of Congress to streamline power plant siting procedures. The federal bills have noticeable differences, but they are similar in that each would require long-range plans for future sites, submission of alternative sites before any facility or site could be certified and full public disclosure during each step of the certification process.[11]

While federal bills have been proposed, some states have already passed siting laws requiring public and agency reviews of proposed plant sites. State approaches are varied due to differences in resources, geography, social, economic factors, industrial and agricultural activities, and population. However, regardless of how states have elected to regulate siting, every state law now in force would have to be amended to accommodate the Administration's bill as well as all other proposed federal bills. This will create additional delays in those states which have aleady enacted legislation.

Projects will also continue to be delayed by those who feel that the final decision on siting is against their interest. These cases will not be easy to try since the records will be massive and the interested parties numerous.[11] Controversial cases will continue to be litigated and once in the judicial system they will be subject to the same time-consuming process that presently exists.

In summary, significant gains in accelerating the construction of electric facilities, including the hydroelectric plants, do not seem likely at least for some time. The newness of proposed procedures, the continuation of litigation, and the pressures for delay cannot be avoided. Moreover, additional influences on siting procedures may develop by way of federal programs related to land use planning such as EPA's proposed new land use control.

EPA Proposed Effluent Limitations for Steam-Electric Plants

In justifying its proposed rules released March 4, 1974, the EPA stated that "it must be concluded that there is only one suitable technology available and demonstrated, evaporative external cooling to achieve essentially no discharge of heat, except for coldside blowdown, in a closed recirculating cooling system." As previously stated in this report, rigid requirements appear objectionable in that they fail to consider alternative systems under any circumstances.

The significantly greater water consumption required by evaporative cooling towers should be of serious concern. In its notice, the EPA answered a question concerning the advisability of requiring a technology that would significantly increase the national water consumption over present levels as follows: "While water consumption at individual sites might increase, it is not known that a significant national water debt would result since most of the evaporated water would precipitate through the natural water cycle."

Reaction to this EPA conclusion has not been favorable. The California State Water Resources Control Board in its comments on the EPA guidelines remarked as follows: "Comment (15) is an extremely shallow response to a serious concern and very much distracts from most of the text. We hope that this is not a demonstration of the level of consideration given to the potential problems we expressed previously relating to the impact of evaporating large quantities of scarce fresh water. No commentors are concerned over a national water deficit, but they are conerned with deficits existing over large areas, including Southern California. To rectify such deficits, large scale interbasin transfers would have to be developed."[12]

In its comment on the proposed rules, the Metropolitan Water District of Southern California states as follows: "In addition, the proposition that . . . 'the evaporated water would precipitate through the natural water cycle . . .' is not applicable in the Southwestern Region of the United States. In California, almost all precipitation is from Arctic storms which originate in the North Pacific area.

[11]"Power Plant Siting—An Overview of Legislation and Litigation." Environment Reporter, Monograph 15, 22, 1973.

[12]Comments on Effluent Limitations Guidelines for Steam Electric Power Plants as published in the Federal Register, Volume 39, #43, California State Water Resources Control Board, March 4, 1974 (preliminary draft).

In Arizona and New Mexico, almost all precipitation is from tropical storms which originate in the Carribean or mid-Pacific areas. Little, if any, of the water which evaporates in these states returns as precipitation in those states. Thus, any new use of water in these areas results in a net reduction in the water supply remaining available for other uses."[13]

As these comments indicate, not withstanding EPA's conclusion, the significantly greater consumptive use of water by evaporative cooling towers has been well documented. Between 15,000 and 22,000 acre feet of water per year is consumed annually by a 1,000mw generating plant operating at a full load using an evaporative cooling tower. The same plant with a cooling pond requires about 10,000 acre feet per year. A similar electric generating plant using a dry tower or wet-dry tower may require 2,000 acre feet per year, only 10% of the needs of wet tower cooling.[14]

The increase for the entire nation in total consumptive use resuling from the proposed EPA requirements would be over 2.2 million acre feet per year in 1983 while in the year 2000, the increase would exceed 10 million acre feet per year.[15]

The situation is aggravated in the coastal portion of California, for example, because of the regulatory actions of the State and Regional Coastal Zone Commissions which in some cases have placed restrictions on power plant siting along the coast. The utilities have reacted to this fact, to seismic safety rules of the Atomic Energy Commission and to other considerations and for the near future are planning to locate most of their thermal plants inland where they are placed in competition with agriculture for limited fresh water supplies.[16]

Multiplicity of Water for Energy Studies

In addition to proposed federal laws and regulations which seem to be ineffective or even counterproductive with respect to energy and water for energy problems, federal efforts to ascertain these problems and to develop systems to deal with them have been apparently uncorrelated and duplicative. There have been undertaken by a variety of federal agencies in recent months, many energy and water for energy studies. Ongoing efforts were, of course, to be expected from federal agencies that have long been in the energy research and development or regulation field, such as the Atomic Energy Commission and the Federal Power Commission. In addition to these efforts, the U.S. Geological Survey recently published a report entitled "Water Demands for Expanding Energy Development." The Secretary of Interior, separate and apart from this effort, created within the secretariat a task force to study the need for water for energy with particular emphasis on Interior's role in managing the resources for which it is responsible. This task force, on the Washington level, apparently has not prepared any external document for review. However, a field task force was created in Denver with the Bureau of Reclamation having the lead role with the assistance of staff from several federal agencies including the Bureau of Land Management. This field effort first focused on the Upper Colorado River and a report has been released entitled "Water for Energy in the Upper Colorado River Basins." This task force has now focused its efforts on the Missouri River Basin and a draft report is being prepared on the Yellowstone River.

Separate and apart from these efforts, the Secretary of Interior, acting as the Chairman of the Water Resources Council, instructed the Water Resources Council to create a task force to study water for energy self-sufficiency and report back to the Secretary of Interior. This task force, with the assistance of the staff of the Water Resources Council, has prepared a report that has been submitted to the Secretary.

The Federal Energy Office, and more recently, the Federal Energy Administration in connection with the "Project Independence" efforts has been involved in many studies to investigate the potential for energy resource development with respect to the various resources that are available. It was determined that all energy resources can only be developed with the use of some amount of water. Therefore, it was decided that a cross-cut study should be prepared analyzing the need for water in all areas of energy resource development. The Federal Energy Administration contracted with the consulting firm of Arthur D. Little of New York to prepare what appears will be the major framework for the cross-cut report. Arthur D. Little's very lengthy report is now being reviewed.

The FEA cross-cut report as well as the other "Project Independence" studies and the associated recommendations and conclusions are to be transmitted through the Federal Energy Administration to the Congress by early 1975. Apart from the "Project Independence" efforts, the Federal

[13] Letter from the Metropolitan Water District of Southern California to EPA Information Center, Environmental Protection Agency, dated June 4, 1974.

[14] Rehabilitation Potential of Western Coal Lands, National Academy of Sciences/National Academy of Engineering, Washington, D.C. (1973) (Draft).

[15] Consumptive Water Use Implications of the Proposed EPA Effluent Guidelines for Steam Electric Power Generation, Espey, Huston, and Associates, Inc., April 24, 1974 (Draft).

[16] Western Water News, Sacramento, California, May-June, 1974.

Energy Administration is looking at long range energy needs and preparing extensive water for energy studies in this regard.

The value and importance of the aforementioned reports and the necessity for states to take the significant amount of time and effort necessary to make comprehensive suggestions and evaluations of the proposals found within the documents is not clear at the present time.

Apparent Uncertainties in the "Project Independence" Effort

The Western States Water Council has long been aware of the growing need for the development of energy resources in the West and the obvious associated need for significant amounts of water resources in the West to be utilized in the support of the energy industry. This awareness predated the announced "Project Independence." When the President of the United States indicated that, in the interest to the nation, it was an administrative goal to be independent in an energy sense by 1980, it was felt that there would be a concentrated federal effort to formulate policy that would define the need for the development of energy resources in the West. The Western States Water Council deemed it important that it immediately initiate this study effort and report so that the Western States could better prepare to respond to federal requests to provide the much needed energy for the nation.

However, since its initial announcement, the concept of "Project Independence" seems to be significantly changing and the thrust and impact seems to be unclear and less meaningful. Federal administrators were first stating that "Project Independence" did not really mean that the United States would be independent by 1980, but rather that the United States would be to a degree self-sufficient in energy production. Self-sufficiency would be based upon the amount of energy resources that the nation could generate internally, so that from a political or strategic point of view, other nations could not use the sale or allocation of their energy resources in a way that would dictate U.S. foreign policy. Federal administrators were later found saying that 1980 was not a realistic date and perhaps 1985 was a more appropriate date for the goal of independence. More recently, in contacts with federal officials, it has been learned that the Federal Energy Administration is now talking of "Project Independence" becoming a reality in perhaps the late 1980's.

As it has been pointed out previously in this report, it is necessary for water planning to be completed by 1980 for water resources that are to be effectively utilized in energy resource and production by the year 1990. With the uncertainties outlined above, it is very difficult for the Western States to coordinate with the federal government the plans for the use of western waters.

Associated Community Impacts

Not only is water needed for the development of any energy resources, but water is also needed for communities which must be established in support of the growing energy industry. Existing communities will also need to expand their water supplies as they grow in response to the needs of the energy industry. These growths in community needs, with respect to water facilities and many other supporting facilities will be needed prior to any significant return in the form of tax revenues from increased evaluation as a result of the energy resource development. Schools will be needed for the incoming populace. Cities and counties will need to construct roads. Added sewage treatment facilities and additional electrical generation capacities must be planned for and provided if the growth of communities associated with the energy industry is to provide adequate housing and community support facilties. Advance planning and advance funding must occur, lest these communities take upon the appearance of the 'boom' towns of the mining industry a century ago.

On July 31, 1974, the Western Governors acknowledged these needs and resolved that if the Western States were to be called upon by the nation to provide the energy resources that are needed for energy independence, then the federal government should be prepared to provide advanced funding to accomplish the construction of facilities as they are needed.

The Western Governors indicated that funds in the form of federal assistance should be advanced to the states and could be the result of apportionment of the advance payment that the federal government has received for the sale of energy resource leases and royalties from the extraction of minerals in the West.

The Western Governors further acknowledged that grants, technical assistance and loan programs are needed. Among other purposes, the funds provided should appropriately be used for the planning of water supplies for these communiies and the building of the associated water storage facilities if required. To date there has been no clear delineation of federal policy with respect to federal assistance for these impacted areas.

SUMMARY AND CONCLUSIONS

Water demands to support the energy industry in the West will be large. This report estimates water requirements for energy within each of the Western States. While these estimates will be revised from time to time as plans for energy development become clearer, they provide one assessment for the states to use as they begin the process of decision making in regard to the way in which they wish their future water use and development to occur. The amount and location of these demands can now only be primarily estimated, because many decisions must be made, experimental processes tested, and laws and rules and regulations established before refined estimates can be made.

The amount of water needed can be varied by administrative decisions. Wise planning and prudent administrative choices could greatly reduce the demands for water for energy and soften the impacts on water short areas.

Most uses of water cannot compete economically with the energy industry in paying the cost of water. To allow the energy industry to acquire water rights at the market place, could result in the new allocation of limited waters to energy while reshaping established economies with perhaps locally the greatest impact being on irrigated agriculture.

Environmental laws and rules and regulations that do not allow for flexibility in choosing the best solution at given sites, could result in large wastes of water and could result in greater environmental damages.

States will administer water rights. States must be involved in advance planning and participate in administrative decisions. States should determine allocation of unappropriated water resources and determine the need for new water resource projects.

To date, there has not been noted, meaningful efforts toward the formulation of federal energy policies for "Project Independence." This must occur and states must be involved in a more effective way in key federal efforts if energy for the nation is to be efficiently developed and the limited western water resources are to be most judiciously used and conserved.

1

WESTERN STATES WATER REQUIREMENTS
FOR ENERGY DEVELOPMENT TO 1990

COVER CREDITS

1. The Huntington Plant of Utah Power and Light Company is located near Huntington, Utah, a community in central Utah. In the photograph the first of four planned units can be seen. Each unit has a nominal capacity of 430mw. The coal is taken from the mine by a conveyor belt that can be observed in the foreground of the photograph to the generating facilities. The plant is cooled by evaporative cooling. The evaporative cooling towers can be seen in the center of the photograph to the left of the plant. This photograph was provided by Utah Power and Light Company.

2. This scene depicts typical oil shale country. The photograph was taken near the Utah-Colorado border and the stream in the foreground is the White River which is a potential source of water for the oil shale industry. The photograph is courtesy of the White River Shale Project.

3. The Public Service Company of Colorado has built two reservoirs on Cabin Creek that allow for pump-back storage so that electricity can be generated during periods of peak demand and water can be pumped back during non-peaking periods for release later. The Cabin Creek pump-back facilities are located near Georgetown, Colorado, which is 35 miles west of Denver. The photograph was provided by the Public Service Company of Colorado.

4. The Four Corners coal-fired generating facilities are located near Farmington, New Mexico. The plant is operated by WESCO. One unit can be seen in this scene and three others are planned. The one unit has nominal generating capacity of 315 mw. The plant uses approximately 5000 acre-feet of water from the San Juan River each year with present installed capacities. Water is contracted from the Colorado River Storage Project and the photograph was provided by Region IV of the U.S. Bureau of Reclamation.

5. The Peabody Coal Company with headquarters in St. Louis, Missouri, mines coal on the Black Mesa in northeastern Arizona near the community of Kayenta and mixes the coal with water in the plant that can be seen in the photograph. The liquified mix is transported by an 18inch slurry pipe line southwesterly, a distance of 278 miles to the Mohave Power Plant located at Bullhead City on the Colorado River. The photograph was provided by courtesy of Peabody Coal Company.

6. The San Onofre Nuclear Power Plant is located approximately half way between the cities of Los Angeles and San Diego on the California coast. The 430mw plant in the photograph derives its cooling water from the Pacific Ocean. Two additional units are planned to be built, each with a capacity of 1140 mw. The photograph was provided by Southern California Edison Company, the owners of the facility.

7. Venting geothermal wells and steam from cooling towers in the winter make attractive and conspicuous plumes of water vapor over "The Geysers" located in northern California. This area, north of San Francisco, is the only area in the United States now providing geothermal energy for commercial generation on electrical power. The photograph was provided by the Pacific Gas and Electric Company which owns and operates the generating facilities.

8. The Grand Coulee Dam on the Columbia River is one of many hydro-electric dams in the northwest. Hydro electric power is a more important source of energy to the northwest region than any other region of the United States. The Dam and the third power house seen in the photograph are operated by the Bonneville Power Administration of the U.S. Department of Interior and BPA provided the photograph.

9. Near Colstrip, Montana, lands that have been strip mined for coal and revegetated. The photograph illustrates the third growing season of an area that has been seeded with perennial native and introduced domestic species of plants. The revegetation effort has been undertaken by the Western Energy Company, a wholly owned coal mining subsidy of Montana Power Company and WEC provided the cover photograph.