Water for Nevada

APPENDICES

9

FORECASTS FOR THE FUTURE—ELECTRIC ENERGY

W A T E R   F O R   N E V A D A

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FORECASTS FOR THE FUTURE --

ELECTRIC ENERGY

A P P E N D I C E S

ABSTRACT

Generation and use of electric energy require water and related land resources, the amount and distribution of which are related to the following certain factors, each of which is discussed in a separate appendix.

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TO THE CITIZENS OF THE STATE OF NEVADA

This report examines whether Nevada will import, export or be self sufficient with respect to electric energy, together with future water and related land resources questions. The report was edited and prepared by Victor R. Hill, of the Division's planning staff, along with Robert E. Walstrom, Natural Resources Consultant. Many other individuals and agencies provided extensive input for which there is space for only partial acknowledgment herein.

Nevada is currently a net importer of electric energy, and must also import the fuel required for generation within the State. Generation of electric energy in Nevada makes use of scarce water and related land resources. In this regard, generation requires considerable support. Accordingly, a preliminary listing of valleys which might efficiently support electric energy generation has been provided.

There are many things to consider related to Nevada's future electric energy course. Some of the more apparent include pressures building outside of Nevada affecting availability of sites and fuels. Transmission of electric energy is on a regional basis. Therefore, siting of generating facilities cannot escape regional import-export aspects. Inside of Nevada, this report examines methods of efficiently achieving reasonable economic and environmental balance, without a morass of regulations. However, recent and future federal actions may become controlling with respect to regulations.

It should be noted that there is great interest for future development of Nevada's geothermal resources. About 20% of the State is thought to have promise for future geothermal exploration. On a national scale, Nevada is estimated to be second only to California for potential geothermal development.

Additional emphasis in the report has been placed upon factors of efficiency in the use and generation of electric energy. In arid Nevada's future, conservation measures can help to prevent having to face in some areas the hard decision of whether to drink water or use it for coolant in electric energy generating stations.

Respectfully,

Roland D. Westergard
State Engineer

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INTRODUCTORY NOTE

Because this report has been written in sections, by persons from diverse backgrounds and interests, electric generating plants and other facilities are referred to differently. In some sections, the discussion will contain reference to "electric energy generating......" In other sections, the reference will be to "electric power generating.....". For the Division of Water Resources, the focus is mostly upon energy, because annual water use depends upon energy more than power. For utilities, the focus is mostly upon power, because installed electric generating capacity depends upon demand for power more than energy.

Energy and power are related because power is energy expended per unit of time. For a service area, on an annual basis, the total energy generated divided by the time in one year will give the average electric power generated for that year. Of course, power demand varies quite a bit above and below the average on a daily, weekly and seasonal basis -- both predictably and unpredictably.

In this report, we are attempting to focus mostly upon the long term electric energy use and generation, and associated interactions with water and related natural resources.

APPENDICES

FOCUS UPON EFFICIENCY

Generation and use of electric energy require significant support from Nevada's scarce water and related land resources. The following appendices are concerned with the applications of factors of efficiency as conservation measures for the generation and use of electric energy.

There is no question that the factors of efficiency are related among themselves, and some of this interrelation will show up in the appendices. The purpose of treating the factors of efficiency primarily separately, rather than in groupings, is to provide a wider future basis for examining options and their meanings for Nevada and the West. In this manner, it is intended to better provide for the future quality of life for individual citizens of Nevada.

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SITING

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SITING

Reasonable Balance

Recently, much planning attention has been directed toward examining the combined economic and environmental impacts of production and use of electric energy. The concept of attempting to reach a reasonable and efficient economic - environmental balance has resulted.

Economic conditions would include most importantly four factors, in an order of importance varying with time and place: water availability; fuel availability; proximity to load center; transportation. Environmental conditions would include the integrity of animal, plant and soil relationships. Economic and environmental conditions both include quality of life for people.

People, their economic activity and resource use are the instruments of man made pressures upon the environment. Siting of electric energy generation facilities is an element of these pressures, and has become a subject for regulations in many states.

Regulations

Discussion of siting regulations for energy generation facilities often revolves around the argument that no region or state should be able to lay its energy burden on others. This "laying on" as a matter regulation might be accomplished by court action, legislation or administrative action and would be described in statement form as:

REGULATIONS CONCERNING "LAYING ON"

No state or region should be able to lay its energy burden on others by:

1. Refusing to build generation facilities to produce the energy which is consumed in the area.

2. Importing energy which could be generated in the area.

At first glance, these statements seem reasonable. If all states and regions could be nearly self sufficient in meeting electric energy requirements, "laying on" would not exist as a reasonable subject for argument. However, many regions and states find that they do not have the resources or that it would be grossly inefficient to be self sufficient with respect to energy. Other states and regions barely could be self sufficient with respect to electric energy. A few states and regions easily could be self sufficient many times over.

From both an economic and environmental viewpoint, it seems inefficient to make laws which include or freeze out large blocks of a state or region for siting of electric energy generation facilities. Balanced, efficient siting within any large area is a stepwise process, consistent with many economic and environmental accommodations. Still, restrictive laws are sometimes a needed part of the mechanism when an area such as Nevada attempts to protect itself, should economic and environmental swings set in motion by a neighbor appear to be "laying on" the energy burden.

Siting-Rating System Development, Use and Limitations

In this report, analysis of past population and electric energy data has shown the tremendous forces and behavioral stability involved and provided insight into natural limits upon what planners and policy makers may reasonably expect to accomplish. From factual analysis of data, knowledge of planning limitations, and the concept of attempting to reach reasonable economic-environmental balance, criteria were developed for a preliminary "siting-rating" system.

Selecting preliminary criteria was accomplished by research, and particularly by asking for short contributions from experienced people. They were asked to provide opinions about major siting considerations for electric energy generating facilities.

The siting-rating system has been used to tentatively identify a sampling of typical valleys in Nevada.(1) These valleys appear to have the best potential for siting future conventional fossil fuel and nuclear electric energy generating facilities. In addition, potential geothermal areas and potential pumped storage sites have been identified. Figure 9 depicts stages of the process of siting prior to actual construction.

Analysis in this report shows that presently highly determined physical locations for population, economic activity and resource use will dictate the economics of siting for future electric energy generating facilities. Natural processes uncontrolled by planners have caused the physical location of resources needed for electric energy generation, such as water and fuel. Other resource uses, types of vehicle engines and transportation routes have influenced and been influenced by distribution patterns for economic activity and population -- largely uncontrolled by government planners.

Hence, government siting controls appear to be subject in normal situations to a high degree of predetermined natural and economic limits which define their efficiency. These same limits define the efficiency of industry when siting facilities. Constraints upon government and industry must overlap sufficiently

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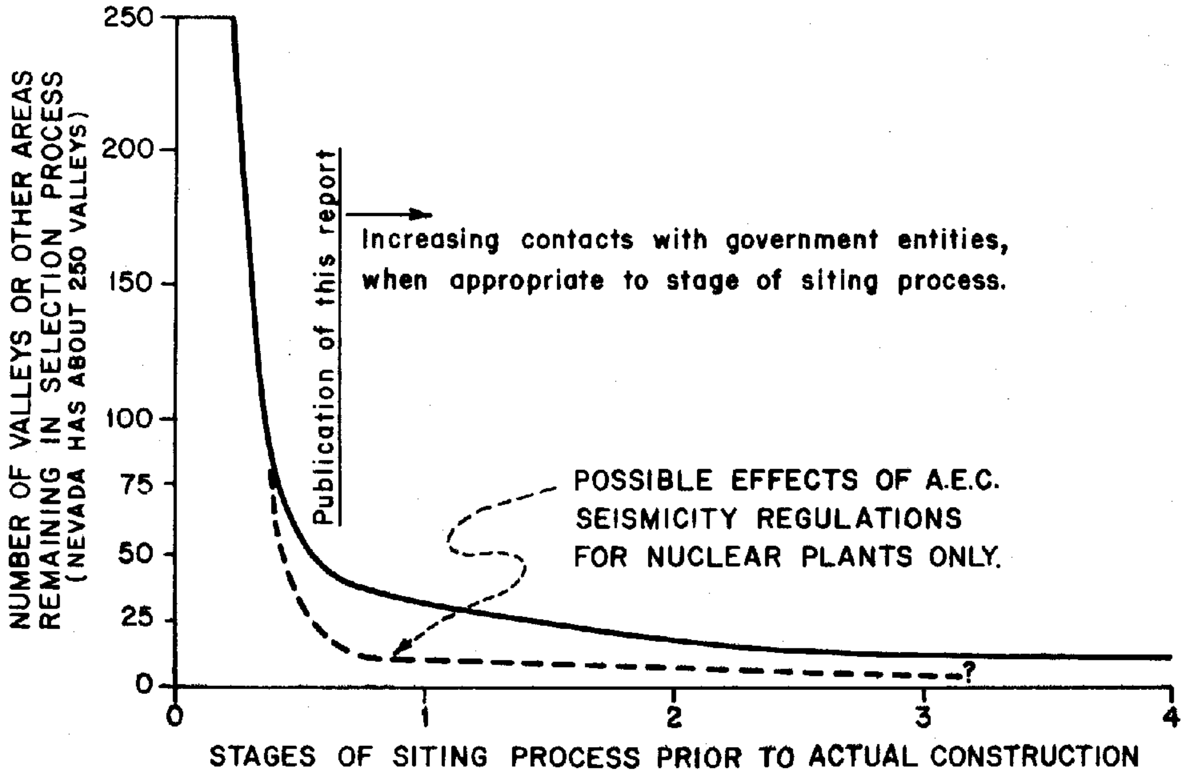
(1) See pages 42 and 46 for listing of criteria and valleys identified.

FIGURE 9

STAGES OF SITING PROCESS



DESCRIPTION OF SITING PROCESS STAGES	CONCEPTUAL ESTIMATES OF PERCENTAGE OF AREAS REMAINING UNDER CONSIDERATION
0. Projections have indicated time frame of need and management initiates selection	100 %
1. Broad siting selections completed	say 15 %
2. Advanced siting selections involving economic studies and some exploratory work within valleys	say 6 %
3. Finer site investigations involving environmental and detailed surveys within valleys	say 5 %
4. Single site surveys for final design	say 4 %
5. Construction at site or sites	up to ? %

to achieve agreement, otherwise there will be no investment for electric energy generation facilities in the area and time interval involved. Further, given uncertainty about agreement for a place and time, investment will be almost completely curtailed.

Listing of Criteria and Tentatively Selected Valleys

Criteria

Facilities must be sited to meet future needs for electric energy. Figure 10 shows how major criteria for use within the siting process may be classified as part of an economic-environmental balance mechanism. Where appropriate to cover throughout this report, page numbers in parentheses beside a criterion indicate where that criterion is most fully discussed.

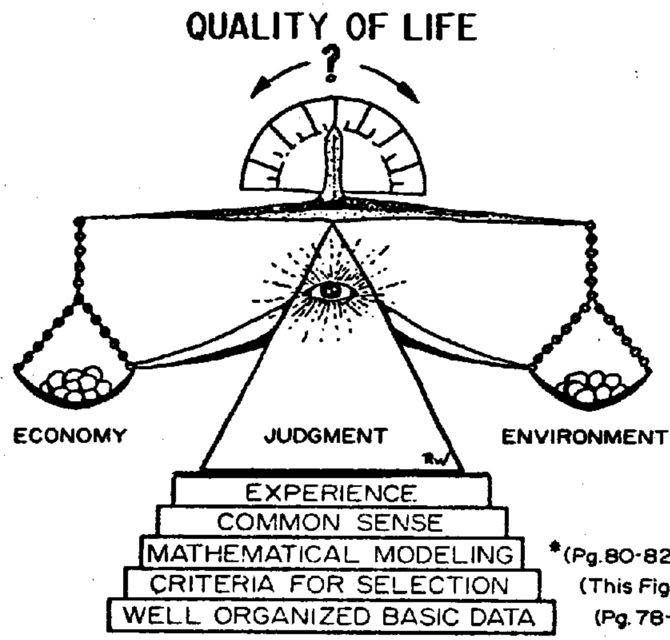
In carrying out the siting process, a balance sheet listing the criteria would be made up for each valley. Then the siting-rating system would be used to select the most efficient combinations of economic and environmental criteria believed to be possessed by only a few valleys out of 250 valleys in Nevada. Probably, a mathematical modeling technique called "linear programming" would be used to weigh criteria and complete tentative selections.

The linear programming technique is described in the last article of this appendix. It has been put there to show how what appears to be hopeless complexity, at first reading, may be tied together and coped with to reach a reasonable solution. Description of the newly developed aircraft and earth satellite remote sensing capabilities precedes description of linear programming. This was done to indicate that there is a well organized source of basic water, vegetation and related land data increasingly available for use in the near future.

Seismic constraints have been described first in this appendix because they may prove to be more important than water and related land resources in siting of nuclear electric energy generation facilities. Under the heading of safety, the Atomic Energy Commission (AEC) has adopted stringent limits upon how close a nuclear plant may be located to certain types of faults. Thus, available sites would become very scarce indeed.

It has been suggested that these limits may be overly stringent considering the present ability for taking the necessary offsetting design precautions. The degree of stringency could affect Nevada's import-export posture and consequently, its economic-environmental balance. This is because in the short term, there is no practical, efficient and large scale alternative to largely replacing the use of petroleum and coal by nuclear energy. Additionally, if these AEC seismic constraints prove to be overly stringent, they may be completely overthrown. This situation has so much weight for Nevada

FIGURE 10



*(Pg.80-82)
(This Figure)
(Pg.78-79,203)

*Basis of common system of measurements of weights

ECONOMIC-ENVIRONMENTAL BALANCE
MECHANISM FOR SITING-RATING SYSTEM

MANAGEMENT OF THE BALANCE MECHANISM (1)	
Essential Energy	(85-86, 150-154, 165-168)
Government Regulations	(39-42, 130, 141, 150, 153, 156, 164, 168-183)
Seismic Constraints	(48-54)
Other Hazard Constraints	(55)
Buffer Zone	(74-77)
Water Use	(44)
Private Operations	(39-42, See) (Govt. Reg.)

MAJOR NATURAL RESOURCES CRITERIA FOR SITING-RATING SYSTEM

WATER AND RELATED LAND RESOURCES		HUMAN RESOURCES		OTHER RESOURCES	
Surface		Archeological	(67-71)	Flora (Plants)	
Climate	(16,55)	Historical and Cultural	(72-73)	Rare and Endangered	(56)
Surface Water	(See Mgt.)	Present and Future		Critical Populations	(57-58)
Fragile Environments	(65-66)	Population and Activities		Fauna (Animals)	
Pumped Storage Sites	(109-127)	Associated	(24,25,160)	Rare and Endangered	(59-60)
		Economic	(167)	Critical Populations	(61-62)
Underground		Resource Use		Activities	
Ground Water, incl.	(See Mgt.)			Migratory Habitat and Breeding Grounds	(63-64)
Geothermal Steam	(88-107)				

(1) Achievement of reasonable economic-environmental balance may be connected with prudently paying an insurance premium. Cost of the premium can be weighed against quantities and associated qualities of life which could be lost without insurance. With this approach, final position of the balance mechanism is determined by individual payments, although the apparatus is "managed" by public and private entities. Focus of management upon efficiency will cut the size of premium required to achieve reasonable balance.

and the West that the future quality of life depicted by Figure 10 could be set to greatly swinging.

Surface water in Nevada has been substantially appropriated in the past. Ground water use has been administered under the concept of perennial yield, which provides reasonable balance statewide between net withdrawals and natural recharge. Mining of ground water on the scale which has been practiced in other Western States has been avoided in Nevada.

During more than 100 years of surface and ground water use in Nevada, a system of water rights has developed. Beneficial use has been defined by custom and statute as the basis, measure and limit of the right to use water.

One of the bedrocks upon which the siting-rating system must stand is continued recognition of established water rights. The manner of use, place of use and point of diversion of these established rights may be changed. Rights may be purchased with land or they may be specifically purchased separately from the land. Thus, through purchase, combinations of sources of water with uses of water may undergo change with conditions, within the historically determined system of established water rights.

Criteria described in this appendix are presented first to indicate how the energy related facilities to be constructed might be damaged by natural and man made conditions. Then, the impacts of the proposed energy related facilities upon natural and man made environments are examined. Finally, as previously mentioned, techniques for remote sensing and mathematical modeling are presented to show how the siting conditions might fit together for both facility and environment.

Criteria described are presented in the following order:

ORDER OF PRESENTATION
FOR CRITERIA
IN THIS
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Where appropriate, the individual, agency or organization making principal contribution to the write-up on a criterion has been acknowledged on the title page in this appendix for that criterion.

Valleys

In Table 8, valleys are referred to as hydrographic areas. Tentative selection was partly based upon adequate ground water to support 1,000 megawatts of electric generating capacity. In the neighborhood of 15,000 acre-feet of perennial yield would be required.[1] Valleys in developed urban and rural areas have been temporarily set aside from consideration, pending study beyond this report. Included in the set aside classification are the Las Vegas Valley, as well as other valleys in the Carson, Truckee, Humboldt and Walker River systems.

Electrical generating capacity close to larger electric load centers is economically efficient. Planners often say, "Keep the people and the facilities to serve them close together" -- so as to cut down on the total facilities required. However, there are limits to closeness where quality of life has been built and will continue to depend upon use of scarce water and related land resources.

If there is intense competition for existing water resources in an urbanized valley or area, it would probably be necessary to site generating facilities which would use additional water in a nearby but not water short location. The same would be true for agricultural areas, if generating facilities would infringe upon existing rights. Each situation should be judged on its own merits.

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(1) Refer to Appendix G for discussion of water consumption by electric energy generation and other energy processes.

TABLE 8: LISTING OF VALLEYS TENTATIVELY SELECTED

Hydrographic Area Name	Number	Hydrographic Area Name	Number
Dixie Valley	128	Pahranagat	209
Smoke Creek Desert	21	Snake	195
Kobeh Valley	139	Black Rock Desert	28
Frenchman Flat	160	Diamond Valley	153
King's River Valley	30	Amargosa	230
Newark Valley	154	White River Valley	207
Coyote Spring Valley	210	Muddy River Springs Area	219
Fish Lake Valley	117	Railroad Valley	173
Lower Reese River and Whirlwind Valleys	59, 60	Ruby Valley	176
Clayton Valley	143	Quinn River Valley	33
Clover Valley	177	Big Smoky Valley (North)	137b
Pahroc Valley	208	Steptoe Valley	179
		Spring Valley	184

Acknowledgement: Dr. Alan Ryall
Director
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SEISMIC CONSTRAINTS

During the historic period since about 1840, ten earthquakes with magnitude greater than about 6¼ have occurred in the western Nevada/eastern California region (Table 9). In 1872, the great Owens Valley earthquake destroyed the principal buildings in nearly every town in Inyo County. The 1872 earthquake was felt over a larger area than was the 1906 San Francisco earthquake, and probably had magnitude of at least 8.3. Five of the other ten events had magnitude of 7 or greater.

In comparing the current distribution of approximately 500 small earthquakes per year in the Nevada region, with that of larger shocks during the last century, we have come to the following conclusions: In areas where large historic earthquakes have occurred (Owens Valley, 1872; Pleasant Valley, 1915; Cedar Mountains, 1932; Fairview Peak, 1954), aftershock activity appears to decay exponentially, and to die out almost completely about 90 years after the main shock. In some areas, like Death Valley, California, and Granite Springs Valley in northwest Nevada, fresh fault scarps and very low seismicity suggest that large earthquakes probably occurred just prior to the historic period, and that these areas are seismically "dead" for the time being. In several areas that have been noted previously as gaps in the historic seismic zone(1), higher seismic potential is suggested by the combination of moderate seismicity and the lack of recent faulting. These include: (1) Owens Valley north of Big Pine, to Benton; (2) Fishlake Valley north to the Excelsior Mountains; and (3) a northwest trending zone from Carson City, Nevada, to Sierraville.

Maps of current earthquake activity (Figure 11) and of faulting over the last approximately 10,000 years (Figure 12) indicate that very much less activity has been occurring in northern and eastern Nevada. This may, however, be misleading, for the following reasons:

(1) There is a tendency for large earthquakes in Nevada not to recur in the same place for very long periods of time, probably on the order of several centuries or tens of centuries. Thus, the historic record may be helpful in determining where earthquakes will <u>not</u> occur in the near future, but probably not where they are most likely to occur.

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(1) See reference 3 at end of this section.

TABLE 9: LARGE HISTORIC EARTHQUAKES IN THE WESTERN BASIN AND RANGE PROVINCE, NEVADA AND CALIFORNIA

Year	Magnitude	Location	Remarks
1845?	7?	Near Stillwater	Reported by Indians. Knocked people down, changed the course of a river near Stillwater.
1860	6½?	Northwest Nevada?	Reported felt from Yreka, California, to Utah, over 200,000 sq. mi. "Very violent" at Carson City, suggesting epicenter may have been in that vicinity.
1872	8¼?	Owens Valley	Terrain disturbed for seventy miles, 27 killed at Lone Pine, principal buildings in nearly every town in Inyo County thrown down, felt over 640,000 sq. mi.
1915	7 3/4?	Pleasant Valley	Faulting for more than 20 miles with vertical offsets up to 15 feet, felt over 500,000 sq. mi.
1932	7¼	Cedar Mountains	Ground breakage in area 38 miles long and 4-9 miles wide.
1934	6.3	Excelsior Mountains	Damage in Mina, felt from California to Utah.
1954	6.8	Rainbow Mountain	Two shocks. Felt over 150,000 sq. mi., damage to canals and drainage system of the Newlands Project.
1954	7.2	Fairview Peak - Dixie Valley	Two shocks. Felt over 200,000 sq. mi., spectacular surface faulting in a zone 60 miles long, vertical offset up to 20 feet. Acceleration about 0.015g at Bishop, 210 km from the epicenter.

(2) In a number of other areas of the world, large earthquakes are preceded by an increase in seismicity several years or decades before the large shock. This is the basis for identifying several areas in the Nevada region which appear to have high potential for future earthquakes. However, the San Fernando earthquake on 9 February 1971 was not preceded by any buildup of activity, but occurred in an area of low-to-moderate seismicity, not unlike many other parts of southern California; and no buildup of activity was observed in the years prior to 1971. Thus, our picture of earthquake potential for Nevada is tentative at best, and the possibility of a large earthquake anywhere in the region cannot be ruled out.

(3) In general, earthquakes tend to occur along previous zones of weakness in the earth's crust. Historically, most of the largest shocks have occurred along well defined range-front faults (Owens Valley, Pleasant Valley, Fairview Peak), but the 1932 Cedar Mountains earthquake had a complicated zone of fracturing in an area of complex geology and low topographic relief. Thus, although the potential for large earthquakes is higher along well developed fault zones, they can also occur in areas where faulting is complicated or poorly defined.

(4) When detailed field mapping is carried out in this region, the picture that emerges is much more complicated than that shown on Figure 12. An example of this is shown on Figure 13, for the Reno and Carson City area. In a typical example, detailed mapping would produce hundreds or thousands of potentially active small faults within a radius of several tens of miles.

For nuclear power plants, the AEC siting criteria are very stringent in respect to the evaluation of "capable" faults. Faults a mile or more in length have to be considered within a radius of 20 miles from a reactor site, and within 50 miles all faults five miles or greater in length must be investigated. A "capable" fault is any fault which exhibits one or more of the following characteristics: (1) movement at or near the ground surface at least once within the past 35,000 years, or movement of a recurring nature within the past 500,000 years; (2) macro-seismicity instrumentally determined with records of sufficient precision to demonstrate a direct relationship with the fault; (3) a structural relationship to a capable fault according to characteristics (1) or (2) of this paragraph such that movement on one could be reasonably expected to be accompanied by movement on the other.

In a region like Nevada, with many thousands of faults, what these criteria boil down to in practice is a search for a site where faulting can be dated by one or another means, and where it can be shown that no "capable" faults exist within perhaps five miles of the site. Further studies then have to be carried out to determine the Safe Shutdown and Operating Basis Earthquakes for that site, based on the most severe earthquakes that could be associated with tectonic structures or tectonic provinces in the region surrounding the site.

The regional studies that have to be carried out before a site is tentatively selected are not trivial, and it is not currently possible for us to evaluate the seismic conditions for each of the more than two dozen hydrographic areas being considered at the "phase one" stage of the preliminary siting procedure. A mistake that has been made in the selection of power plant sites in the past is that of choosing a site because of availability of water or other, non-geologic considerations, and then trying to prove that the site meets the AEC's seismic and geologic siting criteria. In the western United States, sites that can be shown to meet these criteria are rare enough that geologic and seismic investigations should be viewed as a primary, rather than secondary, level of site selection.

For conventional power plants, seismic considerations would be the same as for any other large structure in an active seismic region. The plant would have to be designed to satisfy the minimum requirements of any applicable building codes. Additional studies of earthquake risk would be at the option of the owner, for the purpose of minimizing financial loss, hazards to plant facilities or power distribution systems, etc., during earthquakes.

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7. Slemmons, D. B. (1967). Pliocene and Quaternary crustal movement of the Basin and Range province, USA, J. Geoscience, Osaka City Univ., 10, 91-103.

FIGURE 11

EARTHQUAKES IN NEVADA FOR 1971

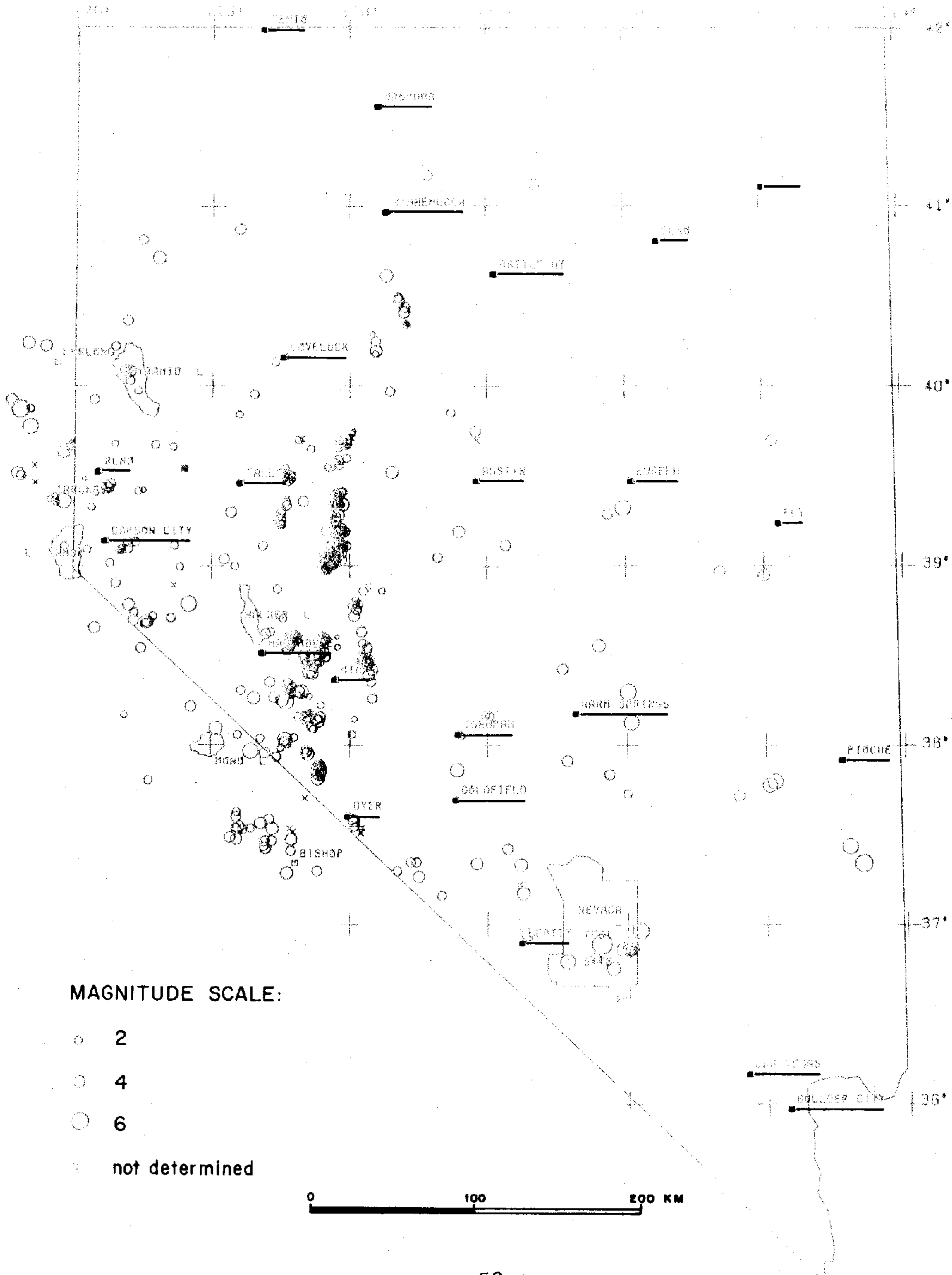
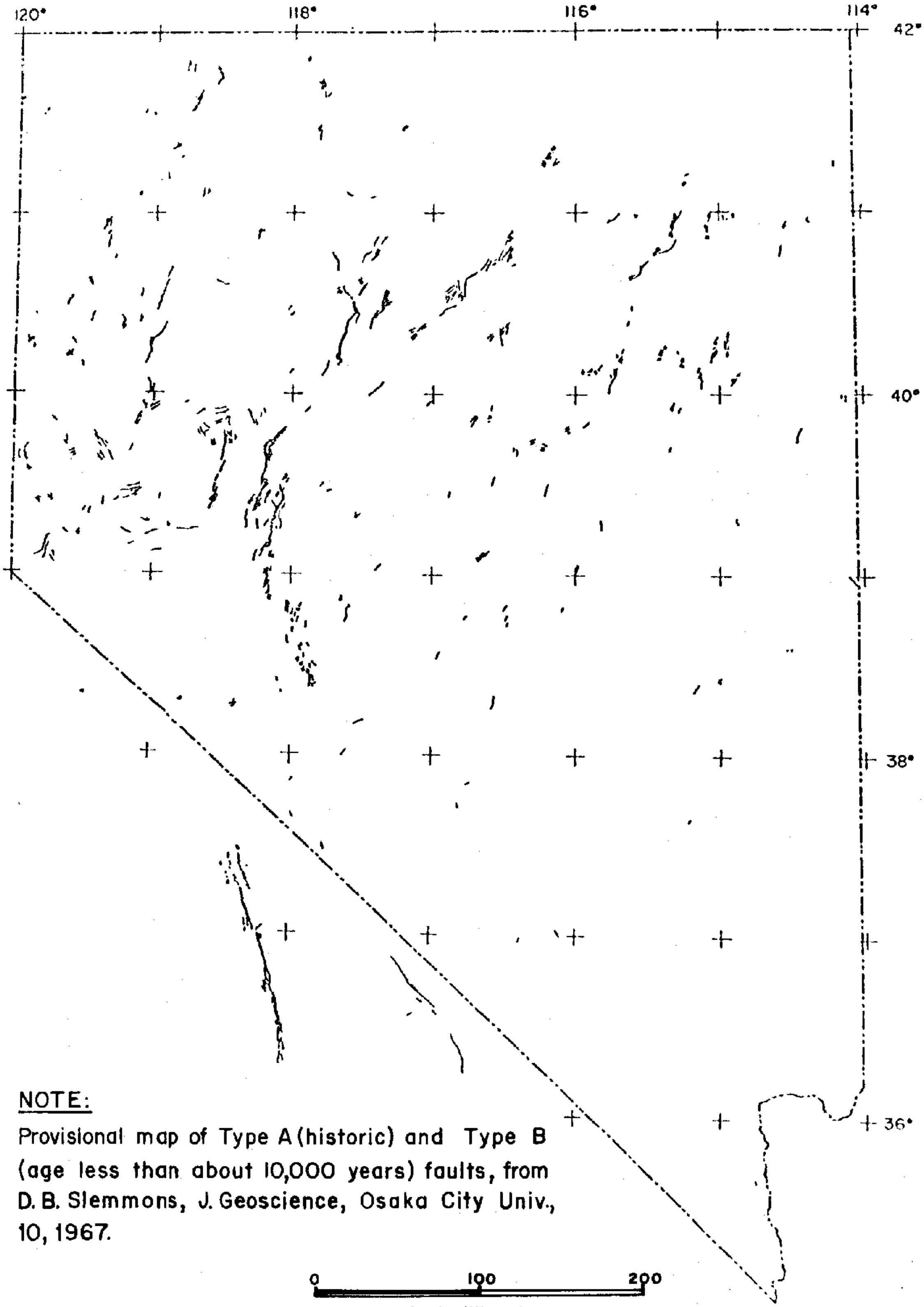


FIGURE 12

PROVISIONAL FAULT MAP OF NEVADA



NOTE:

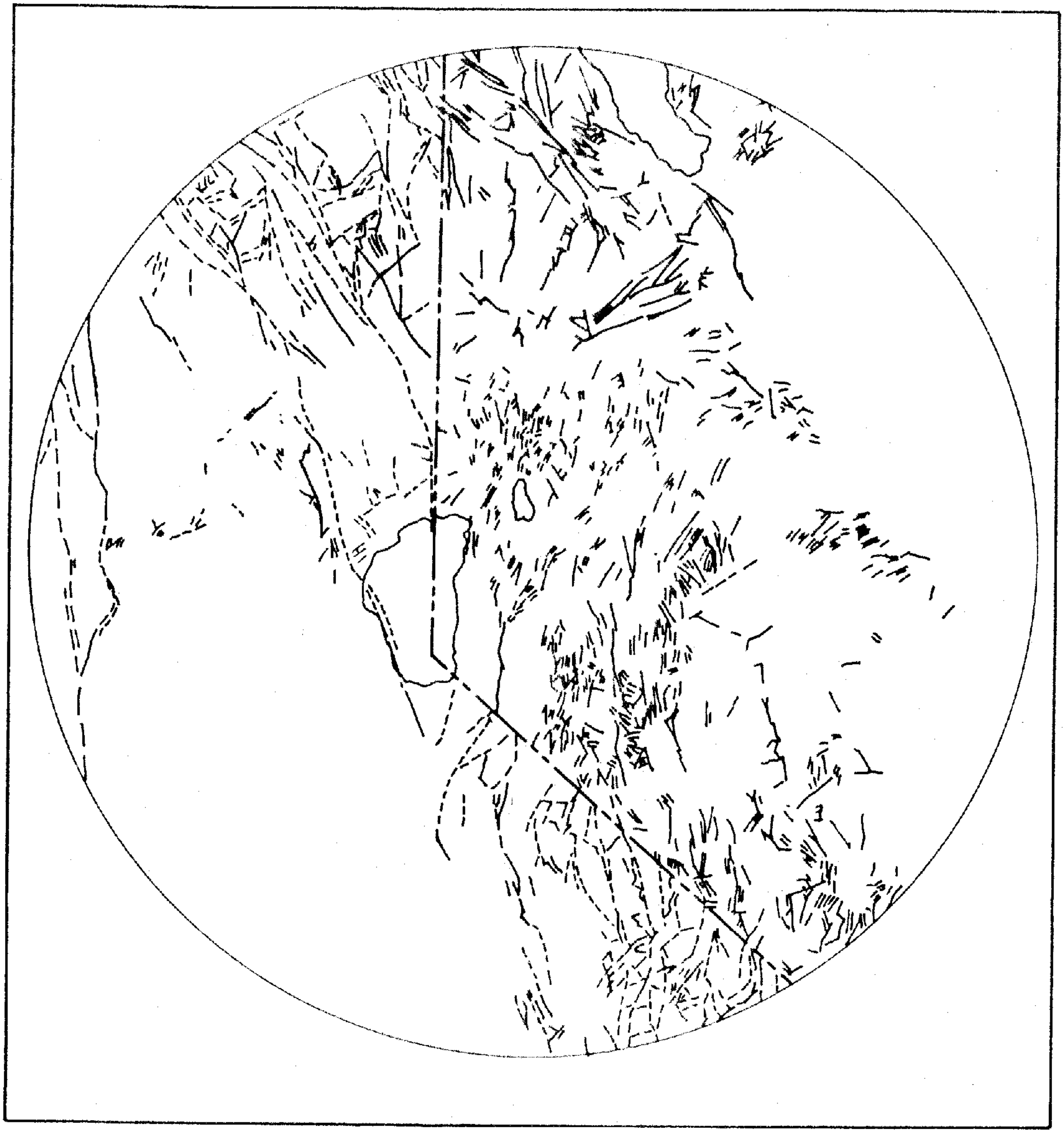
Provisional map of Type A (historic) and Type B (age less than about 10,000 years) faults, from D. B. Slemmons, J. Geoscience, Osaka City Univ., 10, 1967.

0 100 200

Scale, Kilometers

FIGURE 13

FAULTS IN THE RENO-TAHOE-CARSON CITY AREA



NOTE: Faults in the Reno-Tahoe-Carson City area, from California Resources Agency, *Earthquake Epicenter and Fault Map of California* (1964); Nevada Bureau of Mines, *Progress Geologic Map of Nevada* (1962); Nevada Bureau of Mines, *Bulletin 70* (1969), and *Bulletin 75* (1969). Radius of circle is 100 km, centered on Carson City.

OTHER HAZARD CONSTRAINTS

In studying possible hazardous areas, deteriorating situations brought about by natural evolutionary processes as well as by human activity should be taken into account. These factors should not only be taken in their present context, but also in light of possible future consequences as it might relate to electric generation facility site selections.

Certain areas containing natural and man made hazards involving possible water and earth movement should be well delineated and excluded as less desirable locations prior to the electric energy facility site selection.

These areas include flood plains and areas involving hazardous runoff due to excessive natural precipitation or man-caused conditions brought about by faulty construction or poor watershed management. Areas usually associated with higher slope ratios, where mass wasting is likely to occur, should be studied and also delineated. Mass wasting includes areas of possible soil creep, mudflows, earthflows, and various forms of landslides which become a threat through natural geologic processes and those which are initiated by man.

Areas of excessive wind and resultant adverse effects for power plants also need to be looked at in the context of potential damage to facilities. Windborn particles resulting in deflation of land surface, surface creep, sand storms, dust storms, and the formation of live dunes, pose possible threats in the form of inundation of construction and serious abrasion and eventual destruction of facilities. Serious chemical corrosion occurs when such metallic items as valves, lines and supporting trusses are inundated by fine wind blown particles, and then mixed with water, either from precipitation or from washing down the facility.

Additionally, areas should also be ruled less desirable where subsidence is likely to occur through underground activities, such as pumping of liquids and the removal of minerals. Areas in close proximity of recent vulcanism should be studied carefully to determine the possible threat of renewed eruption.

FLORA-RARE AND ENDANGERED

Vegetation, both terrestrial and aquatic, approaches the designation of rare or endangered when the entire community or population reaches a point where extinction seems possible or probable. Certain plant species require a larger numeric pool to ensure continued viability of the species and this factor may well place one species on the list while another would not qualify.

When considering a site for placement of thermal electric generation facilities, areas where rare or endangered flora exist must be considered less favorable than areas where they do not occur. To determine if an area contains any species under this designation, the appropriate State conservation agencies as well as State universities should be contacted. If rare or endangered species are found to live in the vicinity of a site, long-term, on-site studies may be required to assess potential displacement, habitat and behavioral impacts which may well be subject to controversy. In certain cases the exclusion zone associated with power plant sites could be adapted to serve as sanctuaries for rare and endangered floral species.

FLORA-CRITICAL POPULATIONS

Nevada contains a wide variety of vegetation cover types that are widely scattered over the State's basin and range topography. These cover types comprise eight general categories and are described in the following table:

TABLE 10: VEGETATION GENERAL CATEGORIES

SHOWING ESTIMATED AMOUNTS

Type of Cover	Millions of Acres	Percent of Acreage
Northern desert shrub	24.8	37
Salt desert shrub	22.3	33
Pinyon-juniper	9.2	14
Southern desert shrub	7.6	11
Mountain brush	1.2	2
Grass and forbs	1.6)	
Coniferous forest	0.5)	3
Alpine	0.1)	
	67.3	100

Source: Preliminary State-Federal Comprehensive Framework Studies, August, 1970.

Certain plant species may enjoy a wide distribution throughout the State while on a local level the population is restricted in number. This might possibly result in a localized critical population and would necessitate a careful evaluation of the species in respect to its place in the food chain, its relationship to soils and erosion, and recreational and aesthetic aspects, before siting powerplants or transmission lines.

Various kinds of vegetation, although common on a regional basis, might be necessary on a local level to perpetuate a rare and endangered animal species or control a critical erosion or fragile environment situation. Thus any plant species could qualify as critical under the particular circumstances of any given area depending on the requirements of the ecosystem involved.

Power plant construction in general can have deleterious effects on critical populations if situated in their midst. However, certain areas associated with these facilities could have a beneficial aspect by providing protection for critical populations of vegetation. This could be accomplished by withdrawal from public use within portions of an exclusion zone.

FAUNA - RARE AND ENDANGERED

There are 25 species of fauna (animals) in the category of rare and endangered within the borders of Nevada. (See State Water Plan Report No. 6, "Forecasts for the Future - Fish and Wildlife," for listing and distribution). These include 3 birds, 18 fish, one amphibian, 2 reptiles and one mammal.

Four species (peregrine and prairie falcons, greater sandhill crane and spotted bat) are aerial by nature and have a general distribution throughout Nevada. Examination of each hydrographic area or valley considered for siting power plants would be necessary to determine the extent of aerial and terrestrial habitat within each unit for these species. Specifically, nesting, feeding, breeding, resting and migration areas should be delineated and studied before siting.

Nineteen species are related directly to water: eighteen fish, one amphibian. The fish are native to the waters of Nevada and are located, for the most part, in springs and streams with restricted flow. However, several species are found in the reciprocal waters of the Colorado River of Arizona and Nevada. The single amphibian on the list, the Vegas Valley leopard frog, is associated with springs and riparian habitat only in the Las Vegas Valley of Clark County. Care must be exercised to protect the habitat conditions necessary for the survival of these species. Water levels and flows must be maintained and fluctuations kept to a minimum. Water quality and temperatures must be kept at a level to ensure proper breeding conditions as well as conditions to perpetuate prey species and cover types.

Two terrestrial species of reptile are found in southern Nevada. Associated with alluvial fans, valley floors and the lower rocky slopes of mountain ranges, these slow moving creatures are very susceptible to human collection and predation. As a result, access roads associated with power plant sites or transmission lines should be withdrawn from public use. Migration routes must be delineated. Methods for continued movement, such as underpasses, should be tested for feasibility before any construction is begun in areas where migration could be restricted.

In addition to water and other direct considerations, retention of all the elements in the local food chain must be considered. The elimination of just one element could very well have a severe detrimental effect on any of the 25 populations.

Associated with the construction of most thermal power generation facilities are pond systems of various sizes for cooling water purposes. Although each vary in water quality and temperature, there is the possibility that such ponds could be utilized for a variety of fishery habitat needs. These would include environment for rare and endangered fishes, brood stock facilities and sport fishery areas for the public.

Due to the fact that most of the native rare and endangered fish of Nevada thrive in a warm water environment, the cooling facilities associated with thermal power generating plants may very well be ideally suited to serve as additional artificial refuges for these species. At the present time, especially in southern Nevada, there exist conflicts between rare fish (list provided by Nevada Department of Fish and Game maintained open file) which live in natural springs, and agricultural and home developments. If these fish are transplanted into other existing natural springs, it may be only a matter of time before these too are rendered unusable. Therefore, refuges in conjunction with power facilities may prove to be the only option left open to some of these species.

The cooling ponds of thermal power generating plants could very well be adapted to the needs of a warm water fisheries brood stock, egg producing and rearing facility. Nevada has 16 warm water game fish species, yet owns no warm watery hatchery. Stocking at present is carried out by transplanting from other streams and lakes in Nevada, by importation from outside the State and by limited facilities developed in conjunction with existing trout rearing stations. Thus, these cooling ponds could be utilized to provide Nevada with a much needed self sustained warm water fisheries brood stock.

These ponds could also be used to provide additional recreational opportunity in the form of warm water sport fishing to Nevada. The existing thermal power generating facilities at Tracy on the Truckee River and Fort Churchill in Mason Valley provide sport fishery habitat which did not previously exist.

The potential problems of discharge of water of poor quality (temperature and salts) into existing waterways need to be carefully reviewed and regulated.

A program should be worked out for consultation between the Nevada Department of Fish and Game and the power companies prior to development of plans for a thermal plant. The objectives would be to generate information necessary to determine adaptability of the site for creation of fish and wildlife habitat, and to determine total impact upon fish and wildlife resources of the area.

FAUNA - CRITICAL POPULATIONS

There are approximately 100 game species of fauna in Nevada while nongame species account for many times that number. (See State Water Plan Report No. 6, "Forecasts for the Future - Fish and Wildlife", for listing and distribution). As with plant species, many of these animal species have populations which are considered critical to the viability of the species on a local, regional, or statewide basis. As previously outlined, individual species can have a general distribution throughout the State, while on a local level, the population is restricted in numbers. Again, this may result in a localized critical population, and careful evaluation of the species with respect to its place in the food chain, as well as recreational and aesthetic aspects must be considered in any plan to site a power plant or transmission line.

The entire local food chain as well as the available water and cover must be examined to determine the quantity and quality required to continue self sustained populations. Any construction might require recompense for habitat lost in the form of improvement of adjacent areas or creation of new habitat to accommodate translocated communities.

The identification of essential migratory routes, breeding and spawning areas, nesting areas and summer and winter feeding ranges for critical populations must be established in the vicinity of areas considered for siting. The consequences of disrupting these areas with power plants, transmission lines and associated construction must be known before destruction begins. The eradication or reduction of certain plant species or the presentation of barriers to natural movement could have overall detrimental effects on these animal populations.

Certain species require a definite minimum numeric pool of population to ensure the viability of the species. Reduction in population of any faunal community, if necessary for construction, should carry an assurance of a sufficient quantity in number to insure continual viability.

A critical population designation may be brought about as a result of several factors. One consideration would be the relative low numbers in local or regional populations. Another would be if the species under consideration were in relative abundance but is a prey species necessary for the survival of a predator species. Additionally, a critical population designation might be desired if the fauna form were required for local control of other flora and fauna to maintain a balance in certain ecosystems.

Although power plant construction generally has certain deleterious effects on critical populations if situated in their midst, creation of new water or habitat removed a distance from concentrated human activity can generate offsetting and very beneficial values for wildlife. A water source, or additional habitat at a distance of a mile or more from the facility, can provide a much needed element for all forms of wildlife.

Transmission lines usually present an overall negative effect on critical populations by providing perch sites for raptors (eagles, hawks, falcons and owls), providing unnecessary access, and destruction of habitat through construction of the line and associated roads. Thus, when planning for transmission line routes, consideration must be given critical populations of fauna to insure a minimum amount of disruption.

FAUNA - MIGRATORY HABITAT AND BREEDING GROUNDS

Many species of fish and wildlife utilize migratory routes on an annual or regular seasonal basis in Nevada. These routes must be determined not only on a regional, but also on a local basis before a site is to be considered for power plant construction.

Nevada is a part of the Pacific Flyway for migratory waterfowl. In excess of 30 species of migratory game birds utilize this route annually. Additionally, many other aerial species such as songbirds, raptors and bats use migratory routes throughout Nevada. With the proper design, cooling ponds associated with thermal power plants can provide nesting, resting and staging areas for these species.

There are many additional terrestrial fauna species which migrate as a part of their ecological life process. These include most of the larger cloven-hoofed herbivores, mountain lion, and to a lesser degree, various game birds and nongame species of wildlife.

The big game species in Nevada which migrate include mule deer, pronghorn antelope, desert bighorn sheep, elk and mountain lion. Some Nevada deer migrate from the upper reaches of mountain ranges in the summer to their winter range. Winter range must be located on the lower slopes, valleys or adjacent lower elevation ranges in the fall where food is available and which are relatively free from snow. However, many deer herds in Nevada exhibit migratory movements of from 15 to 70 miles, traveling across many mountain ranges and valleys. Antelope move seasonally from valley to valley depending on the availability of food, cover, and water. This species also utilizes kidding grounds where each year the females go to give birth. Desert bighorn sheep also migrate from summer to winter range but do not cover the long distances that deer travel. However, bighorn sheep do not utilize the valleys as winter ranges. The very limited populations of elk in Nevada move from their mountainous summer ranges to lower elevations and rarely to adjacent mountain ranges in the winter. Mountain lion movements can be associated directly to the larger cloven-hoofed herbivore herds which are their chief prey species. Deer in particular are the chief food source and lions can be found in relative proportion.

Certain small game species also migrate varying distances in their life cycle. Sage grouse is one of those that migrate. This species moves to well defined strutting and nesting grounds in the spring of the year. Further movements are associated with brood rearing areas in the summer, and wintering grounds in the December to February period.

Fish also migrate in the streams and lakes of Nevada for spawning purposes. Cutthroat and rainbow trout move in the spring and brown and brook trout and kokanee salmon migrate in the fall.

Caution must be exercised when siting a power plant to minimize the disruption of the natural movements of animal populations. Where these disruptions occur, adequate alternate methods must be devised to ensure the continued ecological balance for each population.

Transmission lines must be placed in areas of least detrimental effect on migratory routes. These lines provide perching sites for the birds of prey and therefore should not be placed in the vicinity of sage grouse strutting grounds, antelope kidding grounds, waterfowl habitat or key migratory routes. Additionally, transmission lines should be placed on the towers in such a manner as to avoid the electrocution of raptors.

It should be noted that the Nevada Department of Fish and Game provided important information relating to this criterion.

Acknowledgement: Lloyd Rooke, Soil Scientist
USDA Study Staff
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FRAGILE ENVIRONMENTS

Nevada has a wide variety of plant environments. However, for the most part, sage brush desert and pinyon-juniper forests predominate. Associated with this type of habitat, in most cases, is a very delicate balance between ecosystems and geological processes. Vegetation and the interaction with the rocks and soils of the earth are not discussed under this title. Brief additional discussion is provided under the heading, Remote Sensing. Soils, on the geologic side, hold one of the keys to the general stability and thus the fragility of an area under consideration for thermal electric generating plant site selection.

Soils are an important consideration involving any use of the non-aqueous surface of the earth. The kinds of soils are many and vary largely in accordance with relief. The basin and range topography of Nevada therefore makes for a complex pattern of soils. Soil maps provide an important tool for planners to evaluate alternative site selections having a minimum of detrimental effect on the environment.

A power plant occupies only a small part of the landscape. Its location is largely determined by proximity to supply needs. If an alternative exists for a construction site, the selection will be made usually on the basis of economics and the engineering characteristics of the soils. Problems relating to soils, such as drainage, are solved through engineering. This soil use normally creates no environmental problems. Important site selection considerations arise as a result of the network of supply, transmission, and maintenance corridors necessary for the operation of the power plant.

Power plant site selection involves large segments of the landscape. It involves construction of roads and other transportation corridors to import the facility supply needs, export its wastes, as well as deliver its product. The feasibility of construction and operating costs of such facilities relate to kinds of soil characteristics and properties. Environmental concerns such as erosion, sedimentation, and vegetation (controls wildlife occurrence and aesthetics) relate to kinds of soils in the overall landscape.

One widely accepted means of evaluating and implementing planning alternatives utilizes soil survey information. Field soil scientists study and map soils and soil related features such as slope, drainage, stoniness, rockiness, and vegetation. The accumulated data are catalogued in various types of reports that accompany the maps. From these data, interpretation criteria can be developed for many kinds of land use.

The usual planning procedure is to prepare overlay maps rating soils for specific uses. For example, a soil limitation rating of slight, moderate, and severe may be made for road use. Criteria usually include the following measurable items: soil drainage class, flooding, slope, depth to bedrock or hardpan, engineering subgrade class, shrink-swell potential,susceptibility to frost action, and stoniness or rockiness class. A range is set up for each rating and item. For this example, slopes of less than 8 percent may be considered slight; over 15 percent, severe; and moderate would be in-between for road use of the soil. If one item is severe and the others slight or moderate, the soil is rated severe.

Kinds of soil survey interpretations that may be useful for power plant site selection are: limitations for shallow excavations, road fill, local roads and streets, erosion potential, embankments, dikes and levees, pond reservoir areas, terraces or diversions, potential frost action, and area regeneration after denudation. Individual soil or soil related items are usually considered as criteria in the development of interpretations.

Separate criteria and maps may be prepared for each subject relating soils to power plant site selection. The geography of limitations for alternatives can readily be seen and routes selected for most economical and least detrimental effect on the environment. Composite overlay maps are normally used. The method may be converted to empirical procedure.

Soils are mapped in Nevada on various scales and detail. Any of these are suitable for broad regional planning purposes. A considerable part of Nevada has been mapped and much is in the process of being mapped. Soil interpreations for many uses are often available. The Soil Conservation Services (SCS) has information on the soils of Nevada that have been mapped and those where surveys are in progress. Advance material, before publication, for specific uses and areas can be made available on specific request. Additionally, the Division of Water Resources as part of the State Water Plan, entered into a cooperative program with the SCS and the Agricultural Experiment Station of the University of Nevada, Reno, to map soils in selected valleys. Soils data published and under development can be made available.

Acknowledgement: Robert Elston, Director
Nevada Archeological Survey
University of Nevada, Reno

Robert York, Archeologist
Nevada State Museum
Carson City, Nevada

ARCHEOLOGICAL RESOURCES

Water quantity and distribution has always dictated the range and movement of peoples because they had to depend upon known, reliable food and water supplies. Thus, wherever water is to be found in Nevada, archeological evidence of human habitation is almost always found in close association. This is a general rule that applies not only to "live" or existing waters but also to "extinct" water resources such as springs and lakes which existed in recent geologic time.

Nevada contains a wealth of archeological resources scattered over a wide area in relatively undisturbed condition. Due to the historically sparse human population of Nevada and the small amount of scientific investigation as yet carried out, there exists potential for a significant contribution to understanding the pre-history of man in the area, thus allowing better focus on the present. This potential can only be realized in Nevada if adequate steps are taken for investigation, excavation and preservation of the resource at some reasonable interval before present man made construction irreparably alters the resource.

Archeological sites are unique sources of data in that they often preserve at a single undisturbed place, pollen, plant fossils, and faunal remains in addition to the tools and manufacturing debris one usually associates with archeological studies. When these materials are found in stratified layers, their contexts yield additional information on rates and types of geological deposition and soil formation. Archeological sites frequently contain materials which can be dated by several specialized techniques, such as radiometry, obsidian hydration analysis, thermoluminescence, or diagnostic artifact styles. Modern archeology is, therefore, highly interdisciplinary. Data from archeological sites contribute to studies in quaternary geology, pedology, climatology, palynology and both botanical and faunal paleoecology.(1)

(1) Quaternary geology: study of geologic processes within the last 2.5 million years. Pedology: a science dealing with soils. Climatology: the science dealing with climates. Palynology: the science dealing with pollen and spores. Paleoecology: the study of organisms of the past and their environments.

Nevada has significant geothermal resources which are closely associated with hot springs scattered throughout the State. According to the Nevada State Museum, every hot or warm spring that has been examined by a professional archeologist has revealed significant prehistoric human habitation. This situation is due to the fact that these sites have been utilized by Nevada's native populations for thousands of years. This kind of extensive use of one place, over a great period of time, builds up a prodigious amount of stratified cultural material, a situation that is all too rare in the Great Basin. Archeologists are particularly interested in these sites due to the chances of finding preserved organic materials suited for radio-carbon dating and the opportunity to examine how various cultures over a long period of time have adapted to the resources in a particular area.

From a legal standpoint archeological values must be considered consistent with various official existing regulations. These include the Federal Antiquities Act of 1906, The Historic Sites Act of 1935, The Nevada Antiquities Act of 1959, The National Historic Preservation Act of 1966, The National Environmental Policy Act of 1969 and Executive Order 11593 - Protection and Enhancement of the Cultural Environment. It is apparent that a considerable body of law exists that requires a developer, governmental or private, to adequately and properly assess historic and prehistoric values before making any changes in the existing environmental situation.

When considering a site for thermal electric generation and transmission facilities, it is imperative that all areas subject to the direct and indirect impacts of the project be examined by professional archeologists. Both state and federal agencies responsible for enforcing the antiquities and environmental laws require professional interpretation and evaluation of archeological resources. The Anthropology Department of the Nevada State Museum, the Nevada Archeological Survey at the University of Nevada, Reno, and the Museum of Natural History at the University of Nevada at Las Vegas are sources of qualified professional archeologists.

A segment of the surface of Nevada has only been barely scratched in the way of exploration for archeological resources. The following tables and map provide brief perspective upon the number and type of known archeological sites, and indicate in a general way where they are. Under these conditions, anyone knowing of the location of an archeological site should notify a qualified archeologist at one of the previously mentioned institutions. In this manner, the resource may be listed, preserved and protected for future study.

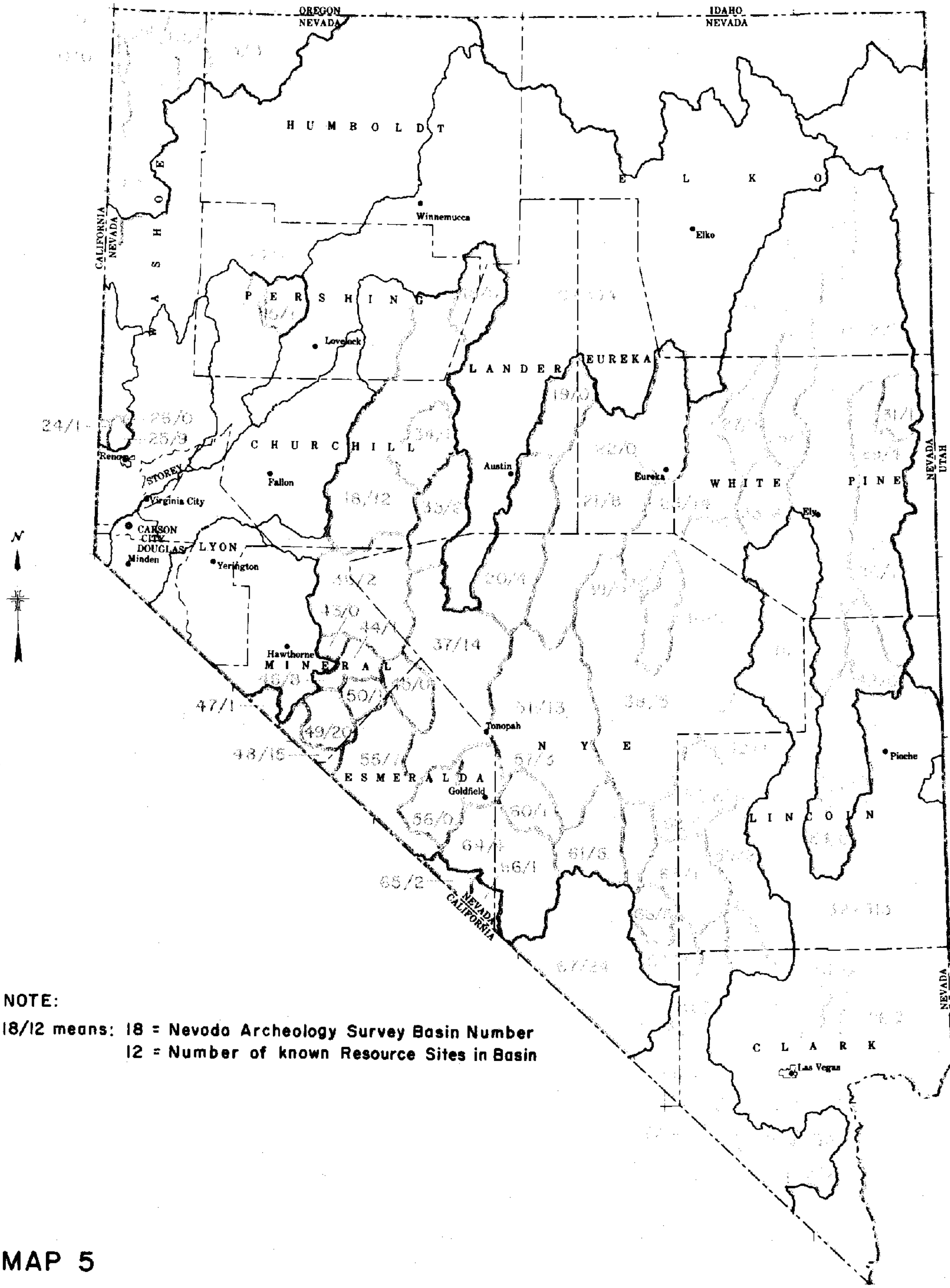
TABLE 11: KNOWN AND LISTED ARCHEOLOGICAL RESOURCES PER THE NEVADA ARCHEOLOGICAL SURVEY (NAS) 1974

	SITE TYPE							ROCK ART						
NAS BASIN	PERMANENT OCCUPATION	TEMPORARY OCCUPATION	HUNTING GATHERING	TRAIL	FOOD PREPARATION	QUARRY	WORKSHOP	HUNTING	ROCK ART	BURIAL	MISC	NO DATA	NO. OF SITES	%
0	0	0	0	0	0	0	0	0	0	0	0	0		
2	0	1	0	0	0	0	0	0	0	0	0	0	1	0.07
0	0	0	0	0	0	0	0	0	0	0	0	0		
4	0	4	0	0	0	0	0	1	3	0	0	0	8	0.52
5	0	1	0	0	0	0	0	0	0	0	0	2	3	0.20
6	5	202	20	0	2	25	33	4	32	7	38	226	594	38.67
7	0	16	2	0	0	0	16	0	1	0	2	3	40	2.60
8	0	0	0	0	0	0	0	0	0	0	0	6	6	0.39
9	1	25	0	0	1	1	6	0	2	2	7	7	52	3.39
0	0	0	0	0	0	0	0	0	0	0	0	0		
11	0	2	0	0	0	0	0	1	1	0	0	1	5	0.33
0	0	0	0	0	0	0	0	0	0	0	0	0		
13	0	6	0	0	0	1	0	0	1	0	0	19	27	1.76
14	0	1	0	0	0	0	0	0	0	0	0	0	1	0.07
15	0	1	0	0	0	0	0	0	0	0	0	0	1	0.07
0	0	0	0	0	0	0	0	0	0	0	0	0		
17	0	6	0	0	0	0	1	0	0	0	1	6	14	0.91
18	0	5	2	0	0	0	1	0	1	0	2	1	12	0.78
0	0	0	0	0	0	0	0	0	0	0	0	0		
20	0	1	0	0	0	0	0	1	0	0	0	2	4	0.26
21	0	0	1	0	1	0	0	0	3	0	1	2	8	0.52
0	0	0	0	0	0	0	0	0	0	0	0	0		
23	0	3	1	0	0	0	3	0	0	0	0	7	14	0.91
24	0	0	0	0	0	0	0	0	0	0	0	1	1	0.07
25	0	6	0	0	0	0	0	0	0	0	0	3	9	0.59
0	0	0	0	0	0	0	0	0	0	0	0	0		
27	0	0	0	0	0	0	0	0	0	0	0	1	1	0.07
28	0	0	0	0	0	0	0	0	0	0	0	3	3	0.20
29	0	1	0	0	0	0	0	0	2	0	0	1	4	0.26
30	0	0	0	0	0	0	0	0	0	0	0	1	1	0.07
31	0	0	0	0	0	0	0	0	1	0	0	0	1	0.07
32	62	207	0	0	26	7	21	3	49	5	59	74	513	33.40
33	0	0	0	0	0	0	0	0	0	0	0	6	6	0.39
34	0	0	0	0	0	0	0	0	1	0	0	0	1	0.07
35	0	0	1	0	0	0	0	0	0	0	0	1	2	0.13
36	0	1	0	0	0	0	0	1	0	0	0	0	2	0.13
37	0	10	1	0	0	0	1	0	0	0	0	2	14	0.91
38	0	3	0	0	0	0	0	0	1	0	1	0	5	0.33
0	0	0	0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	0	0	0		
44	0	1	0	0	0	0	0	0	0	0	0	0	1	0.07
0	0	0	0	0	0	0	0	0	0	0	0	0		
46	0	4	0	0	0	0	0	0	2	0	1	1	8	0.52
47	0	0	0	0	0	1	0	0	0	0	0	0	1	0.07
48	0	4	0	0	0	0	2	0	1	0	4	4	15	0.98
49	0	15	1	0	0	0	0	0	0	0	1	3	20	1.30
50	0	0	0	0	0	0	0	0	0	0	1	0	1	0.07
51	0	9	0	0	0	0	0	0	1	0	0	3	13	0.85
52	0	0	0	0	0	0	0	0	0	0	1	0	1	0.07
53	0	5	1	0	0	0	0	0	0	0	1	3	10	0.65
0	0	0	0	0	0	0	0	0	0	0	0	0		
55	0	1	0	0	0	0	0	0	2	0	2	2	7	0.46
0	0	0	0	0	0	0	0	0	0	0	0	0		
57	0	1	0	0	0	0	0	0	1	0	0	1	3	0.20
58	0	0	0	0	0	0	0	0	0	0	0	2	2	0.13
59	0	0	0	0	0	0	0	0	0	0	0	2	2	0.13
60	0	0	0	0	0	0	0	0	1	0	0	0	1	0.07
61	0	3	0	0	1	0	0	0	0	0	0	1	5	0.33
0	0	0	0	0	0	0	0	0	0	0	0	0		
63	0	1	0	0	0	0	0	0	0	0	0	0	1	0.07
64	0	3	0	0	0	0	0	0	0	0	1	0	4	0.26
65	0	1	0	0	0	0	0	0	0	0	1	0	2	0.13
66	0	0	0	0	0	0	0	0	1	0	0	0	1	0.07
67	1	11	0	0	0	0	0	0	0	0	5	7	24	1.56
68	0	3	0	0	0	0	1	0	0	0	1	0	5	0.33
69	0	4	0	0	0	0	2	0	0	1	1	0	8	0.52
0	0	0	0	0	0	0	0	0	0	0	0	0		
71	0	2	0	0	4	0	0	0	0	0	0	3	9	0.59
72	0	7	0	0	15	0	0	0	1	0	5	2	30	1.95
0	0	0	0	0	0	0	0	0	0	0	0	0		
74	0	2	0	0	0	0	0	0	0	0	0	0	2	0.13
75	0	0	0	0	0	1	0	0	0	0	2	0	3	0.20
0	0	0	0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	0	0	0		
78	0	1	0	0	0	0	0	0	2	0	1	0	4	0.26
No. of Sites	69	580	30	0	50	36	87	11	110	15	139	409	1536	
%	4.49	37.76	1.95	0	3.26	2.34	5.66	0.72	7.16	0.98	9.05	26.63		100%

Number of NAS Basins 78
Number with Resource 57
% with Resource 73

TABLE 12: NEVADA ARCHEOLOGICAL SURVEY BASINS CORRESPONDING TO DIVISION OF WATER RESOURCES HYDROGRAPHIC AREAS, 1974

NAS BASIN	DWR HYDROGRAPHIC AREA
1	13
2	11
3	10
4	6, 7
5	1, 2, 3, 4, 5, 27
6	19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30A, 30B, 31, 32, 32A, 33B, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 73A, 74, 75, 76, 77, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 94, 95, 96, 97, 98, 99, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110A, 110B, 110C, 123, 129
7	34, 35, 36, 37, 38, 39, 40, 41
8 & 10	14, 16, 17, 18
9	189A, 189B, 189C, 189D, 190, 191, 192, 193, 194, 195, 196
11	8, 9, 12, 15
12	177, 188
13	179, 186A, 186B, 187
14	79
15	78
16	131
17	176, 178A
18	124, 125, 126, 127, 128, 130, 132
19	138
20	137B
21	139, 140A, 140B, 151, 153
22	152
23	154, 155A
24	100
25	92A, 92B
26	93
27	175
28	178B
29-30	184
31	185
32	168, 197, 198, 199 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224
33	174
34	133
35	134
36	122
37	135, 137A
38	150, 156, 173A, 173B
39	155B
40	155C
41	180
42	183
43	121B
44	121A
45	136
46	120
47	111A, 111B, 112
48	113, 115, 116
49	114
50	119
51	141, 148, 149
52	171, 172
53	181
54	182
55	117, 118
56	143
57	142
58	170
59	169
60	145
61	147
62	157
63	158A, 158B
64	144, 146
65	232
66	231
67	225, 226, 227A, 227B, 228, 229, 230
68	159
69	160
70	161
71	162
72	163
73	217
74	216
75	164A, 164B
76	165
77	166
78	167



NOTE:
18/12 means: 18 = Nevada Archeology Survey Basin Number
12 = Number of known Resource Sites in Basin

MAP 5
NEVADA ARCHEOLOGICAL SURVEY BASINS & RESOURCES

Acknowledgement: Nevada State Park System
Carson City, Nevada

HISTORICAL AND CULTURAL RESOURCES

Nevada contains significant historical and cultural resources scattered throughout the state. These resources are sometimes not clearly evident. Nevertheless, all are important parts of our heritage.

Historical resources came about in essentially three phases. The first, or trapper and explorer phase, was initiated when Jedediah Strong Smith crossed the southern part of the state in 1826 on his way to California. Trapping was carried out in Nevada with only moderate success until the 1848 discovery of gold in neighboring California finalized the second or emigrant phase which had been underway on a small scale for several years. In the 1860's when the California gold rush was waning, the Comstock silver of Virginia City and a multitude of other mining camps brought a reverse tide of people to Nevada, and started the third or mining phase of historical events. Along with these three main events came the pony express, the transcontinental railroad and early agricultural and farming ventures.

The cultural resources of Nevada are many. Indian lands comprise nearly 1.6 percent of the total state area. These include 10 small colonies, 15 reservations, and scattered allotments. In addition, there are culturally significant Basque, Mormon and other cultural resources within the state.

In the preliminary site selection stage for thermal energy generation facilities, consideration must be given not only to the obvious structural and physical evidence of historical events but also to the not so evident trails and event sites such as battlefields and historic farms.

One agency suited for participation in planning for power plant sites from an historical and cultural standpoint is the Nevada State Park System. Here involvement could be completed early in the site study portion of the project. Focus would be primarily on analysis of potential, proposed and existing historical and cultural resource values in respect to areas presented for study as having potential power plant sites.

The site analyses should include the thermal electric generation plant itself plus access, transmission corridors and alignment, as well as any cultural-historical-energy relationships. Input at this early stage would be valuable for establishing the criteria for evaluating sites with cultural and historical park values. The criteria would be set up to identify values and rate their relative merits as compared to similar values elsewhere, as well as uniqueness of the feature. In this manner, the impact on existing and potential State park sites would be evaluated. It is believed that some high value lands having potential for historical or cultural aspects should be considered less favorable for power plant siting, since in Nevada these sites are few in number and widely dispersed.

These factors would be well defined prior to the initiation of the study and assessed by means of a value scale. The specific methodology for evaluation would be determined prior to initiation of the study. Briefly, possible methods of evaluation include matrix analysis, computer graphics (SYMAP), overlay mapping, cultural analysis, and site evaluation by experts in the field. Additional information about these specialized approaches can be pursued with the Nevada State Parks System.

The end product of this early phase would be none, one, or more suitable alternative sites within the area presented for study.

PROPOSED BUFFER ZONE

Creating new environments and habitat for existing and future communities of human, plant, fish and wildlife populations should be one goal in the planning of any place for power plant or transmission system construction. Landscaping and architectural treatment of surrounding areas, especially power plant sites, should include enhancement and the use of the land as a buffer zone.

The complete buffer zone for a proposed thermal electric generation facility could include four smaller zones, as shown by Figure 14. Zone one, which is an exclusion area, surrounds the reactor, turbine, cooling towers, and other facilities necessary for operation. Zone Two, a controlled and/or open access area, is designed for multiple-use activity. Here, a wide variety of scientific and recreational uses can be integrated dependent on the economic and physical conditions present at each individual site. Zone three, an open access area, is designed for uses by industry and would include land in all directions from the facility where it is economically feasible to utilize the products or by-products of the power plant without injuring existing rights to the use of the area's resources. Zone four, the corridor for transmission lines, would include any or all degrees of access and most activities which are delineated in Zones 1, 2 or 3. Additionally, this zone could be utilized for parking lots, green belts or other similar type uses.

Certain areas containing unique or valuable resources should be considered less favorable when siting power plants and using the buffer zone concept [(1)].

If the buffer zone is used in a cold climate for protection of delicate plant, fish and wildlife populations, a standby heat source will be required when the major electric energy generating facility is not operating. A 50 megawatt package boiler, which is a feature of some larger plants, would be sufficient. The fuel source would have to be guaranteed. Alternatively, geothermal energy could serve the purpose of protecting delicate flora and fauna.

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(1) Professor Peter L. Comanor at the Department of Biology, University of Nevada, Reno, suggests an effective environmental baseline study of the zones at a power plant site before the area is significantly disturbed. Subsequent monitoring of environmental effects should settle some of the controversy about these plants.

TABLE 13: PROPOSED BUFFER ZONE FOR PLANT SITING

	USE	ACTIVITIES	ACCESS
ZONE 1.	POWER PLANT FACILITY	(a) Electric Energy Production. Landscaped and architecturally designed to blend with natural surroundings.	Exclusion
ZONE 2A.	SCIENTIFIC	(a) Tree farm and nursery (b) Sport fishery brood stock (c) Greenhouse horticulture (d) Wildlife, fishery and plant life refugium (e) Wildlife management area (f) Preservation of landscape (g) Environmental and ecological study (h) Historic, geologic, cultural, and archeological preservation	Controlled
ZONE 2B.	RECREATION	(a) Sport Fishery and hunting (b) Boating (c) Picnicking, camping, etc. (d) Golf (e) Wildlife observation and nature study (f) Photography	Open
ZONE 3.	INDUSTRY	(a) Heating (b) Hydroponics (c) Commercial warm water fisheries production (d) Dehydration processes	Open
ZONE 4.	MULTIPLE USE	(a) Transmission lines (b) All or any uses & activities in Zone 1, 2 and 3. (c) Parking lots (d) Greenbelts	Exclusion, Controlled, Open
UTILITY CORRIDOR		Single access corridor for vehicular traffic, water, fuel, transmission lines and all other utilities to support facility	Any or all degrees of access.

FIGURE 14

PROPOSED BUFFER ZONE

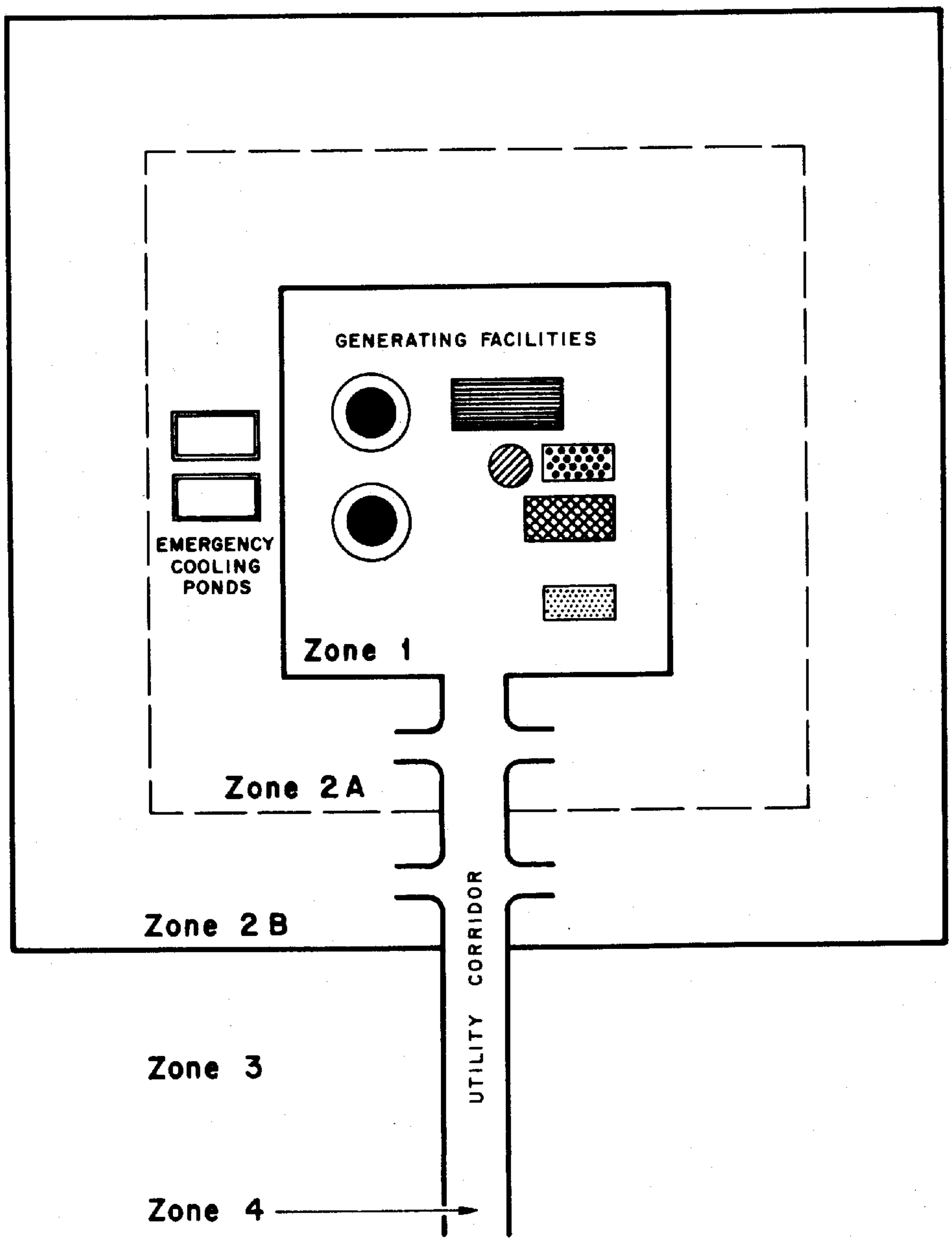

TABLE 14: LESS FAVORABLE AREAS FOR PLANT SITING

1. Relatively undisturbed examples of certain ecosystems.

2. Wilderness or primitive areas.

3. Agriculturally productive areas.

4. Endangered species - (Flora-Fuana).

5. Extensive mineral deposits.

6. Archaeological, historical and cultural resources.

*7. Human population centers.

8. Large scale recreation areas.

9. Wildlife Management Areas and Refuges.

*Note: There are no absolutes in this listing of areas. For instance, some communities may elect to use waste heat from electric energy generating stations to heat and cool residences and buildings.

Acknowledgement: Dr. Paul T. Tueller
Professor
University of Nevada, Reno

REMOTE SENSING

Applications for Siting-Rating System

Space and aircraft photographs of Nevada have in recent months become increasingly available from the Earth Resources Observation System (EROS) Data Center at Sioux Falls, South Dakota. These include images generated by the Earth Resources Technology Satellite (ERTS-1), Skylab and the National Aeronautics and Space Administration's High Flight programs (U-2 and RB57F aircraft). This photographic information coupled with that available from the U.S. Forest Service, Soil Conservation Service and other agencies provides an important information base for studying the State's natural resources.

The ERTS-1 imagery has much to offer because of its repetitive coverage. The major drawback is the poor resolution inherent in imagery obtained as line scans from 494 nautical miles in space. However, ERTS-1 imagery has already been used to map the principal vegetation types in Nevada -- southern desert shrub, salt desert shrub, northern desert shrub, pinyon-juniper woodland, mountain brush, aspen, agricultural, meadows, phreatophytes, and range seedings. An inventory is complete for standing water resources statewide derived from ERTS-1 imagery. Sequential imagery (every 18 days) allows any of these statewide inventories to be updated seasonally or annually. Water levels and water quality changes in reservoirs provide a natural application for this sequential imagery.

NASA high flight imagery with color infrared capability at intermediate scales (1:500,000 to 1:100,000) are valuable for depicting or measuring natural resource features where greater resolution is required. The non-repetitive nature of such imagery does not allow for the analysis of dynamic seasonally dependent events. Well timed missions, when available, provide considerable information on the location of wet, highly infrared (IR) reflective vegetation along streams, at springs, associated with marshlands, phreatophytes and crops. Often this imagery is used as part of a multistage sample. Multiband imagery is also helpful when a given feature is depicted on one band but not another. The best example is that the inventory of standing water resources is best evaluated on the near-infrared band width and less readily evaluated or not at all on other bands.

Much of the intermediate and large scale photography are available in stereo. Depending on the scale, this allows exact depictions of landform or topographic features related to ground water, surface water runoff, and elevation. A review of cultural features such as cities, towns, ranches, airports, etc. allows an analysis that can be updated with sequential imagery, and of demography and the growth and development of various kinds of land use. Land use capability classification is an important potential use for remote sensing technology.

In many of these examples, the use of remote sensing data should be considered cost effective. This basically means that the data can either be acquired only by remote sensing technology or remote sensing allows the acquisition of the information with less cost than required by conventional means.

Acknowledgement: Fred H. Dugger
Central Data Processing
State of Nevada

MATHEMATICAL MODELING

Linear Programming for the Siting-Rating System

Complexity involved in choosing the most appropriate valley or area for a major electric energy generation facility can begin to be appreciated after some careful reflection. Public and private economic and environmental considerations come to mind from the previous narrative.

Area dependent economic considerations would include costs of land acquisition, construction and maintenance. Accessibility to transportation routes for construction materials, maintenance supply sources and operating and construction personnel is important. Local housing accommodations for construction and operating crews should be available or must be somehow provided. Distances to power distribution systems and availability of a generous water supply are of paramount importance. All of these factors, and many more must be weighed against each other and compared for all potential sites to develop a most economically efficient selection of available sites.

We are all aware, however, that economic considerations no longer are as controlling a part of the decision making process as in the past. For nuclear power plants, as pointed out in the narrative on "Seismic Constraints", the single most limiting criterion is low seismicity, or low probability of a large earthquake. After satisfaction of that criterion, corporate climate, opinions of semi-public groups, and legislative edict all point to the need to weigh various environmental impacts. Now the relatively clear, though quite complex, balanced economic and resource use factors must be combined with the not as yet balanced environmental factors of general regional housekeeping and quality of life for people. By-product discharge into air and water and on land must be examined. Temperature and humidity changes to the immediate vicinity must be tolerable. The local wildlife habitat must be maintained or enhanced. Weather patterns must be considered with respect to provision of exhaustive safety precaution. In short, government and private guidelines with respect to environmental impact must be considered.

How is it possible to begin to cope with so many inter-related variables and hope to come up with any reasonable solution? Particularly, how is it possible to reach a solution which is in an overall sense the most advantageous? One approach is the use of linear programming and its related techniques.

Linear programming is the name of a technique designed to find an optimal or best solution where there are many variables. The optimal solution is picked from among one or many feasible solutions to problems which have defined constraints. Usually, the constraints are defined to serve some purpose or policy being pursued. Although it has been only twenty-odd years since George Dantzig formulated the linear programming problem and the simplex method for its solution, it has found widespread application in private industries such as manufacturing and transportation. An important use has been in optimally siting manufacturing plants and warehouses. This versatile technique has also been used in Nevada State government for such diverse problems as reapportioning the current Nevada Legislature, and providing optimal mating selection for Himalayan snow partridge.

The successful use of linear programming requires a prior knowledge of four specific areas of the problem which is to be optimized:

REQUIREMENTS

1) First, the measure of optimality or "goodness". Most frequently, this is a single measure such as dollars. Goodness could also be measured on a single judgmentally rated scale, composed of combinations of weighted variables.

2) Second, the amount of positive or negative contribution of each component or a proposed solution to the overall measure, such as, "How many dollars per mile for road construction?", where road construction is essential to the problem solution.

3) Third, the physical constraints which govern the application of resources to a problem. Obviously, if a proposed problem solution were to require water resources, that solution could not feasibly require more than 100% of available water.

4) Fourth, the total requirements of the problem. These are often considered to be merely additional constraints.

It is easier to visualize linear programming (often referred to simply as LP) through practical example situations. Frequently, a situation occurs when a manufacturer wishes to site a warehouse so that he can achieve a most economic (optimal) distribution network to his shipping points. He must consider frequencies, quantities and costs of shipping to each point. He must use existing road, rail and air systems. He can then determine <u>the</u> site (there will most likely be one most preferable) which <u>will</u> be most economic. This is the basic simplistic approach using only one set of restrictions. Undoubtedly, to be reasonably sure, he must impose and test additional seemingly major, minor or occasional restrictions. These might include minimum point-to-point ship times for critical items, mandatory utilization of preferred (or owned) carriers, or availability of alternate transportation systems in event of strike. All of these can be included in the original problem formulation as additional constraints to the final solution.

There are many side benefits which accrue to the use of LP techniques. The first is the potential establishment of an infeasible solution. Where there are stipulated constraints so restrictive as to pose an impossible problem, the LP technique will say so. It will further say which specific constraints were the ones which pushed the solution out of bounds. Certainly, this is a tremendous aid in moving to a feasible problem formulation. Once a feasible solution is reached, the LP technique will say which constraints are the most restrictive, and thus provides the basis for a "sensitivity analysis".

Perhaps the greatest difficulty in using LP techniques for the siting of an energy generation source involves the first requirement mentioned above, the use of a single measure of goodness. For all economic constraints there is no problem, for these can be measured in terms of dollars. Environmental constraints are far different. The many types of environmental constraints involved constitute a gigantic "fruit salad" for which there is no common denominator. A common measure must be established; therefore, many seemingly arbitrary evaluations must be made. Is one trout pond worth a .02% increase in a "safety" factor? Is the potential, though highly improbable, chance of substantive water pollution worth $10,000? or $10,000,000? What about limiting access to a now undeveloped, rather unimportant archeological or historical site?

Obviously, the types of environmental constraints selected depend heavily upon the inclinations and purposes of the people responsible for the LP formulation. This entire previous class of environmental evaluations is a problem which must be faced squarely, and approached in a fair, logical, systematic fashion, although somewhat arbitrarily. Failure to so approach the problem would result in an unusually arbitrary establishment of relative values which might be highly inappropriate.

For purposes of this report the measure of goodness or optimality can be defined as a measure of the most efficient combinations of economic and environmental criteria believed to be possessed by only a few valleys out of about 250 valleys in Nevada. This definition of optimality should be adopted to follow the report's concept of reasonable economic-environmental balance at a high level of efficiency.

Logical formulation of a complex raw problem into an LP problem will be an exercise which in itself will provide valuable insight into the exact inner relationships of the problem variables. The subsequent LP analysis can provide one of the most orderly, although somewhat arbitrary, problem solutions available.

The LP analysis can provide a method of presentation to regulatory bodies and to the public. Where either does not agree on relative weights, the analysis can be reevaluated with new relative weights to demonstrate sensitivity.

APPENDIX B

ALTERNATIVE PROCESSES

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Part 1: GENERAL

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Part 1: GENERAL

ESSENTIAL ENERGY

Electricity and Solar Radiation

Electricity is the essential refined energy for use by industrialized societies. It is presently obtained indirectly in major part from combustion of fossil fuels, and in lesser part from falling water and nuclear reactions. Except for nuclear energy, the other indirect sources have been originally supplied by conversion of solar radiation.

In the short term, direct conversion of solar energy into electricity appears too expensive, except for experimental purposes. However, solar operated, non-electrical heating and cooling systems for homes are coming into limited use, thus relieving some of the demand for scarce electricity. In the long term, on a large scale, direct conversion of solar radiation into electricity holds promise for largely eliminating environmental impacts caused by present indirect methods.

Many Energy Sources and Processes

It is true that many energy sources are available for use if only we had knowledge of necessary extractive processes. There is no use speculating in this report upon when some of the presently unproved processes might be available for large scale application in the production of electricity. Based upon what is known and foreseeable from past experience, a successful process would take a human generation to gain full application. This means that the year 2000 is the probable horizon for large scale application of presently new energy extractive processes.

Economic and technical barriers must be overcome before electric energy can be extracted competitively on a large scale from sources such as geothermal, nuclear fusion, tides, and trash combustion. In the Western States and in Canada, coal, oil shale and tar sands hold great potential for future development. In Nevada, sites for geothermal and pumped storage are presently thought to have great potential for future development. It is expected that in special situations, at special locations, limited applications will gradually increase for electric energy sources and successful new processes.

Presently, fossil fuels are produced in remote regions where they are available at low cost. The same applies to hydro-electricity. Transportation for bulk fuel and for refined electric energy to points of consumption must be accomplished. Nevada is no stranger to the facts of life with respect to requiring transportation of bulk fuel by train or truck or pipeline and of refined energy over a power line. On a world scale, the volume of fossil fuel which is transported from points of production to points of consumption probably exceeds ocean shipment of all of the rest of world trade combined. Under these present and foreseeable circumstances, costs of total energy per capita must include transportation as well as production.

For obtaining lowest cost electric energy, siting is very important. Any process for production of electric energy must have a location with proper support features, such as adequate coolant water, land, fuel and transportation. The location determines transportation facilities, which include ships, railroads, trucks and pipelines for fuel, and high voltage transmission lines for electricity. Therefore, per capita costs for electrical energy, similar to total energy, are determined by combination of costs for production and transportation.

Production costs go up with distance from fossil fuel source and transmission costs go up with distance from load center. Minimum cost for electric energy would most often occur with a location for production or generation somewhere between the fuel source and the load center. This is because over 90% of electric energy is generated through combustion, and almost all combustion processes for generating electric energy depend upon fuel sources remote to the load center, while very few combustion processes depend upon fuel sources nearby to the load center. Additionally, hydroelectricity can be generated only at well defined locations, while processes for converting solar energy and nuclear energy are apparently going to be highly regulated with respect to siting. However, production costs relative to fuel sources for these three last processes are highly insensitive to transportation.

Siting is an illustration of the operation of efficiency. More efficient sites produce cheap electric energy, which can then be sold to areas not possessing the necessary resources to locally generate cheap energy. If siting efficiency is constrained, both economy and environment will suffer. For instance, the number of dams, reservoirs and transmission lines will increase as the siting related cost of steam-electric energy increases in comparison to hydro-electric energy. This will increase water related environmental impacts at a higher level of energy demand. Hence, it is more difficult to achieve better economic-environmental balance at lesser economic efficiency. Generally, it is more difficult to bring promising new processes into general use at higher siting costs.

Conclusion

Per Capita costs for alternative processes for generating electric energy are highly sensitive to location. Efficient siting is therefore a major factor in choosing processes as well as number and size of plants for generating electric energy.

Part 2: GEOTHERMAL

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Note: A portion of the narrative on geothermal resources has been adapted from the State Water Plan report No. 4, entitled, "Forecasts for the Future - Mining".

GEOTHERMAL RESOURCES

Background

The term "geothermal resources" means, literally, resources of earth's heat. In the common usage of today, geothermal resources means earth heat that can be used to drive generators to produce electrical energy. Although this use is just getting underway, it will undoubtedly become a major source of electricity in the future, because it substitutes an apparently inexhaustible energy source for the distinctly exhaustible supplies of petroleum, natural gas and coal that are presently used to generate most electricity. Moreover, it is without the pollution effects associated with conventional and nuclear fuels. It will probably also become a minor source of metals, for they are present in small quantities in some hot spring waters and eventually will be recovered as byproducts.

Many kinds of geological and geophysical studies have demonstrated that the interior of the earth is extremely hot. At depths of a few miles below the surface it is estimated that temperatures of about 900° Fahrenheit are usual, while the deep interior of our planet reaches temperatures estimated to be as high as 9000° Fahrenheit. These high interior temperatures are very effectively insulated by the outermost few miles of crustal rocks.

At one time the crust was as hot as the interior, but it gradually cooled during eons of geologic time by radiating away heat into outer space and it now serves as an excellent insulating blanket between the hot interior and the cool surface. Heat is still escaping from the interior, but at a very slow rate.

The most spectacular kind of escape occurs where volcanoes produce lava that reaches the surface while still molten and glowing. This heat is quickly dissipated into the atmosphere as the lava congeals. Much less spectacular but probably more important in the long run is the slow conduction of heat through the rocks of the crust. This process is similar to the slow heating of a thick mug when it is filled with hot coffee: the outside doesn't get as hot as the coffee inside, because the heat is radiated away from the surface.

Measurements in deep mines and drill holes indicate that the temperature of the rock increases at a rate of between 15 - 80° Fahrenheit per mile as one proceeds downward from the surface. At least this is true in the six or so miles of crust that holes have penetrated. A similar kind of temperature increase would be found (but on a much smaller scale, of course) by drilling a hole into the outside of the coffee mug.

At most places on the earth it is presently not feasible to drill holes deep enough to reach regions of high temperature. However, there are some spots where temperatures as high as several hundred degrees Fahrenheit can be reached by drilling holes only a thousand feet or less. These hot spots, or "geothermal areas," which may be from a mile to many miles in diameter, are the places where geothermal resources may be developed because here the heat of the earth can be tapped.

The origin of hot spots is not definitely known, but it seems likely that they are places where magma or molten rock that was melted deeper in the earth has been squeezed upward until it is perhaps only a few miles from the surface. Some geothermal areas are though to be the roots of old volcanoes, which are heated by the magma that remains underground after the explosions and lava flows that formed the volcano have ended. The volcanoes themselves may have been active several million years ago and have been long since eroded away, their earlier existence being recognizable only by careful geological mapping; however, much of the heat of the magma is still contained by the insulating cover of rock above and around it.

The heat in the rocks themselves cannot be recovered directly, but water that seeps through them is heated and can be brought to the surface through drill holes, vaporized to steam and then used to drive electrical generators. Alternatively, special fluids can be pumped into a well where they are heated by the hot rock before being returned to the surface. Many geothermal areas are recognizable by the presence of hot or warm springs, the heated water having leaked up to the surface from below. The origin of the hot water is not always well understood. As magma cools and solidifies, it releases some water, but certain evidence indicates that in most geothermal areas this source accounts for only a very small percentage of the water that is present. At most places, much of the water apparently has slowly circulated from the surface through very deep channelways that lead it through the hot rocks and then back to the surface.

The first development of a geothermal area to produce electrical energy was at Lardarello, Italy in the 1930's, and another area, Wairakei, New Zealand, was developed in the 1950's. Additional areas have been developed to produce energy in several countries, but the only one in the United States is at The Geysers, in California, where electrical energy generation from geothermal sources started in 1960 on a modest scale.

Through the 1960's interest in energy generation using geothermal resources increased greatly in the United States, but to a rather large extent developmental activities were frustrated by the fact that many geothermal areas are on public domain lands, and the Federal government had no legal mechanism whereby title to this resource could be obtained. Since it was not technically a mineral, it could not be acquired by locating mining claims, nor could it be leased under the terms of laws that pertain to certain specified minerals, such as common salt and petroleum. In 1971 legislation was finally passed establishing procedures for leasing rights to geothermal areas, and it is to be expected that there will be more rapid development in this field in the next few years.

The interest in geothermal generation of electrical energy is stimulated by three considerations. First, estimates indicate that the demand for electrical energy will continue to increase tremendously in the future, and geothermal resources are a vast reservoir of energy that can be converted into electricity. Some authorities estimate that if all known geothermal areas were developed they could supply virtually all the world's present needs for electrical energy. Second, geothermal generating plants do not cause the smoke and gaseous pollutants that coal, oil, or gas fired generators produce. Third, once a geothermal area is developed to generate electricity, there is no continuing cost for fuel: the heat is theoretically free. Strictly speaking, only the first of these advantages is nearly without offsetting disadvantages: geothermal resources can help to supply the future demand for electricity, and can do it without consuming resources of either conventional or nuclear fuels.

Geothermally-produced energy does not generate the atmospheric pollutants that fuel-fired plants produce, but possibilities of limited pollution do exist. In particular, many geothermal waters contain dissolved elements that are definitely pollutants if released into streams or into the normal underground water reservoir that serves for irrigation and domestic use. Probably most plants of the future will return the water to the hot underground area through recharge wells drilled for the purpose, after its heat has been used in the generators. This will not only dispose of it without polluting other waters, but will also maintain the water supply in the heating system. However, there remain possibilities for short-term pollution of surface waters by occasional spillages, and also for long-term pollution of groundwater by leakage from the underground plumbing system into the local groundwater supply.

Considering the notion of "cost-free" heat, it is true that the earth's heat is simply there, available for the taking. But to view it as free is a distinct over-simplification. Those geothermal areas that are on public domain will have continuing costs in the form of royalty payments to the Federal government that are comparable to the usual payments for fuel. Privately owned ground with geothermal resources might be purchased and thus be free of continuing payments, but in effect this constitutes simply one large purchase of fuel. More importantly, the cost of testing a geothermal area to find out if it is suitable for development into an energy generating site can be very large - the problem is exactly the same as finding an ore body of any mineral commodity that is large enough and rich enough to be worth mining. This cost of exploration, too, must be considered as a large initial purchase of fuel for the generating plant, but with an added element of financial risk. The result of the testing may be a determination that the area is not suitable for development and the work has then to be repeated in other areas. Finally, maintenance costs are high in geothermal energy plants because of corrosion of pipework and formation of scale within the pipelines.

The principal considerations that are important in determining the suitability of a geothermal area - once the existence of a market for the energy has been established - are: (1) the temperature of the steam or water, (2) the volume of water available, and (3) the kind and quantity of minerals dissolved in the water. All three of these vary widely in different geothermal areas. A minimum temperature can be obtained from one well, but in order to estimate the average temperature, as well as the volume of water, at least several wells must be drilled and their flow measured over a period of several months. Dissolved materials are important because some of them are corrosive while others deposit a scale in the pipework that greatly reduces the efficiency of the process. In general, water that has a temperature of 400° Fahrenheit or more is preferable because at this high temperature the water will "flash", or be converted to steam, when it is brought to the surface where the pressure is lower than in the hot reservoir underground. Some techniques, however, do not require steam, so water with lower temperatures can be used.

Nevada's Geothermal Potential

In Nevada, water has always been an important resource even if hot and mineralized. During pioneering times, hot springs in mining areas and along the California trail were well known, many being used for resorts. In the Stillwater area in western Nevada, steam and hot water were encountered while water wells were being drilled, and this source of energy has been used to heat dwellings in this largely agricultural area. In addition, a number of homes in the general Reno area are heated using energy from hot water occurring in the Steamboat-Moana fault.

Nevada's interest in effective utilization of geothermal energy resources is far more than academic. Electric energy consumption in Nevada is expected to reach over 12 million megawatt hours annually by 1980, nearly double present consumption. The relatively high cost for producing electric energy in Nevada by conventional means inspires serious consideration of geothermal energy resources.

Serious studies and exploration efforts are again being made in Nevada, after having been stifled since 1965 largely due to problems of geothermal leasing on federal land. Previous attempts were made between 1959 and 1965 to develop geothermal resources as a source of energy.

About 87 percent of the land area of Nevada is owned by the federal government. There are essentially no state lands for geothermal development. The potential for leasing of public lands for geothermal energy development has been considerably advanced as a result of the Federal Geothermal Steam Act of 1970. Leasing regulations have now been developed, and lease applications are being processed by the Bureau of Land Management. (See Map 6).

As part of the development of Federal procedures for utilizing geothermal resources, the U.S. Geological Survey investigated geothermal areas in the western United States, and has located and identified certain of these as "Known Geothermal Resource Areas" (KGRA). There are 14 such areas in California, 13 in Nevada, seven in Oregon, and no more than two in each of the other western states. Additionally, the Geological Survey designated a great many areas as prospectively valuable for geothermal resources. The total of 13.5 million acres in such areas in Nevada constitutes nearly 20 percent of the State.

At least 250 hot springs (springs with temperature at least somewhat higher than normal groundwater temperature) are scattered over the entire State except for the area in southern Nye and Lincoln Counties, which also is barren of most metal deposits. The west-central and north-central parts of the State have higher hot springs temperatures and greater than normal heat flow through the rocks, and consequently, are considered to have special potential for electric energy generation. Exploration will probably be concentrated in these areas during the next few years.

Nevada's future utilization of geothermal resources will become more apparent as the sequence of development unfolds. The following outline provides information on the present status of exploration of potential geothermal resources.

EXPLORATION OF POTENTIAL

GEOTHERMAL RESOURCES

Item	Title and Major Information
Table 15	"Known Geothermal Resource Areas (KGRA) in Nevada." Lists the 13 KGRA in Nevada, and provides description and total acreage associated with each.
Table 16	"Exploratory Geothermal Drilling in Nevada Through 1973." Lists pertinent characteristics derived from exploratory drilling at KGRA.
Map 6	"Known Geothermal Resources Areas (KGRA) and Lease Application Activity in Nevada." Shows general areas described in Table 15, with a spring 1974 generalized overlay of lease applications for development of the resource on federal lands.
Map 7	"Hot Springs and Geothermal Wells in Nevada." Shows hot spring areas, some from Table 16 where significant exploratory drilling has occurred, as well as "Battle Mountain High," which has conspicuously higher heat flow than surrounding areas.

TABLE 15: KNOWN GEOTHERMAL RESOURCE AREAS (KGRA) IN NEVADA *
(343,996 acres)

Source: Report 21, Nevada Bureau of Mines and Geology, University of Nevada, Reno

1. Beowawe (12,712 acres)
   Secs. 13, 24, T.31N., R.47E.
   Secs. 1-5, 7-12, 15-20, T.31N., R.48E.
   Sec. 6, T.31N., R.49E.
2. Brady Hot Springs (19,020 acres)
   Secs. 1-4, 9-16, 21-27, T.22N., R.26E.
   Secs. 34-36, T.23N., R.26E.
   Secs. 6-8, 17-19, 30, T.22N., R.27E.
   Sec. 31, T.23N., R.27E.
3. Darrough Hot Springs (8,398 acres)
   Secs. 1, 12, 13, T.11N., R.42E.
   Secs. 5-9, 16-20, T.11N., R.43E.
4. Double Hot Springs (10,816 acres)
   Secs. 3-5, 8-10, 15, 16, 21-23, 26, 27, 34, T.36N., R.26E.
   Secs. 32, 33, T.37N., R.26E.
5. Elko Hot Springs (8,960 acres)
   Secs. 14-17, 20-23, 26-29, 33, 34, T.34N., R.55E.
6. Fly Ranch (5,125 acres)
   Secs. 1, 2, 11-14, 23, 24, T.34N., R.23E.
7. Gerlach (8,972 acres)
   Secs. 3, 4, 8-11, 14-17, 20-23, T.32N., R.23E.
8. Leach Hot Springs (8,926 acres)
   Secs. 1, 2, 12, T.31N., R.38E.
   Secs. 25, 26, 35, 36, T.32N., R.38E.
   Secs. 5-7, T.31N., R.39E.
   Secs. 29-32, T.32N., R.39E.
9. Moana Springs (5,120 acres)
   Secs. 13, 22-26, 35, 36, T.19N., R.19E.
10. Monte Neva (10,302 acres)
    Secs. 13-15, 22-27, 34-36, T.21N., R.63E.
    Secs. 18, 19, 30, 31, T.21N., R.64E.
11. Steamboat Springs (8,914 acres)
    Secs. 4-6, T.17N., R.20E.
    Secs. 20, 21, 27-29, 31-34, T.18N., R.20E.
    Sec. 1, T.17N., R.19E.
    Sec. 36, T.18N., R.19E.
12. Stillwater-Soda Lake (225,211 acres)
    Secs. 1-3, 10-15, 22-27, T.19N., R.27E.
    Secs. 24-26, 34-36, T.20N., R.27E.
    Secs. 1-30, 32-36, T.19N., R.28E.
    Secs. 1-5, 7-36, T.20N., R.28E.
    Secs. 13, 14, 22-28, 33-36, T.21N. R.28E.

Secs. 1-36, T.19N., R.29E.
Secs. 1-36, T.20N., R.29E.
Secs. 13-36, T.21N., R.29E.
Secs. 1-36, T.19N., R.30E.
Secs. 1-36, T.20N., R.30E.
Secs. 13-36, T.21N., R.30E.
Secs. 3-10, 15-21, 29, 30, T.19N., R.31E.
Secs. 3-10, 15-22, 27-34, T.20N., R.31E.
Secs. 16-22, 27-34, T.21N., R.31E.

13. Wabuska (11,520 acres)
Secs. 9-17, 20-24, 26-29, T.15N., R.25E.

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* As determined pursuant to Sec. 21 (2), Geothermal Steam Act of 1970 (84 Stat. 1566), and published in the Federal Register v. 36, no. 58, Thurs., Mar. 25, 1971.

TABLE 16: EXPLORATORY GEOTHERMAL DRILLING IN NEVADA THROUGH 1973 (1)

Source: Report 21, Nevada Bureau of Mines and Geology, University of Nevada, Reno

Operator	Name	API No.[2]	Location	Depth	Maximum Spring Temp. (°F)	Maximum Well Temp. (°F)	Completion Date	Remarks
1. Steamboat Hot Springs					203	369		
Nevada Thermal Power Co.	Steamboat No. 1[3]	27-031-90000	NW/4,NE/4,S28,T18N,R20E	1830			1954	Hot water present with 5-10% steam flashover. Eight core holes drilled by the U. S. Geological Survey (1950), for a total footage of 3316 feet. Also several wells for hot water baths, etc. Numerous homes are heated from warm water wells in the Renc area. For more information see White (1968).
Nevada Thermal Power Co.	Steamboat No. 2[3]	27-031-90001	SE/4,SW/4,S28,T18N,R20E	964			1959	
Nevada Thermal Power Co.	Steamboat No. 3[3]	27-031-90002	NW/4,NE/4,S32,T18N,R20E	1263			1960?	
Nevada Thermal Power Co.	Steamboat No. 4[3]	27-031-90003	NE/4,NW/4,S32,T18N,R20E	520?			1960	
Nevada Thermal Power Co.	Steamboat No. 5[3]	27-031-90004	NW/4,NW/4,S32,T18N,R20E	826			1961	
Nevada Thermal Power Co.	Steamboat No. 6[3]	27-031-90005	NW/4,NW/4,S32,T18N,R20E	716			1961	
2. The Needles (Pyramid Lake)					208	240		
Western Geothermal Inc.	Needles No. 1	27-031-90006	NW/4,SW/4,SW/4,S6,T26N,R21E	5888			1965	Large flow of hot water.
Western Geothermal Inc.	Needles No. 2(?)[3]	27-031-90007	C,W/2,NE/4,S12,T26N,R21E	~4000?			1964	
Western Geothermal Inc.	Needles No. 3(?)[3]	27-031-90008	NW/4,SW/4,SW/4,S6,T26N,R21E	?			1964	
3. Wards Hot Springs (Fly Ranch)					203	>220		
Western Geothermal Inc.	Fly Ranch No. 1(?)[3]	27-031-90009	SW/4,S2,T34N,R23E	1000+			1964	Largest hot springs in northwestern Nevada.
Western Geothermal Inc.	Granite Creek Ranch No. 1(?)[3]	27-031-90010	S35(?),T34N,R23E	800			1965?	
4. Monte Neva Hot Springs					193	190		
Magma Power Co.	Monte Neva No. 1(?)[3]	27-033-90000	S24(?),T21N,R63E	402			1965	Melvin (Goodrich) Hot Springs
5. Beowawe Geysers					205	414		
Magma Power Co.	Beowawe No. 1	27-011-90000	NE/4,SE/4,NW/4,S17,T32N,R48E	1918			1959?	Hot water with 5-10% steam flashover. Problems of scaling and cold water inflow.
Magma Power Co.	Beowawe No. 2	27-011-90001	SE/4,SW/4,NW/4,S17,T32N,R48E	715			1959?	
Vulcan Thermal Power Co.	Vulcan No. 1	27-011-90002	NW/4,SW/4,NW/4,S17,T32N,R48E	715?			1961	
Vulcan Thermal Power Co.	Vulcan No. 2	27-011-90003	C,SE/4,NW/4,S17,T32N,R48E	655?			1961	
Vulcan Thermal Power Co.	Vulcan No. 3	27-011-90004	NE/4,SW/4,NW/4,S17,T32N,R48E	795 or 715			1961	
Vulcan Thermal Power Co.	Vulcan No. 4	27-011-90005	S17?,T32N,R48E	767			1961	
Vulcan Thermal Power Co.	Vulcan No. 5	27-011-90006	S17?,T32N,R48E	237			1963?	
Vulcan Thermal Power Co.	Vulcan No. 6	27-011-90007	NW/4,SW/4,NE/4,S17,T32N,R48E	478			1963	
Sierra Pacific Power Co.(?)[3]	Sierra No. 1	27-011-90008	S17?,T32N,R48E	927			1964?	
Sierra Pacific Power Co.(?)[3]	Sierra No. 2	27-011-90009	S17?,T32N,R48E	397			1964?	
Sierra Pacific Power Co.(?)[3]	Sierra No. 3	27-011-90010	NW/4,SE/4,NW/4,S17,T32N,R48E	2052			1964?	
Sierra Pacific Power Co.(?)[3]	Sierra No. 4	27-011-90011	NW/4,NE/4,NW/4,S17,T32N,R48E	1005			1964?	
Chervon-American Thermal Res.	Ginn No. 1-13	27-015-90000	C,SE/4,SE/4,S13,T31N,R47E	–			–	
6. Hot Springs Point (Crescent Valley)					122	166		
Magma Power Co.	Hot Springs Point No. 1(?)[3]	27-011-90012	S1,2, or 11,T29N,R48E	410			1965	Hot water.

TABLE 16 (Continued)

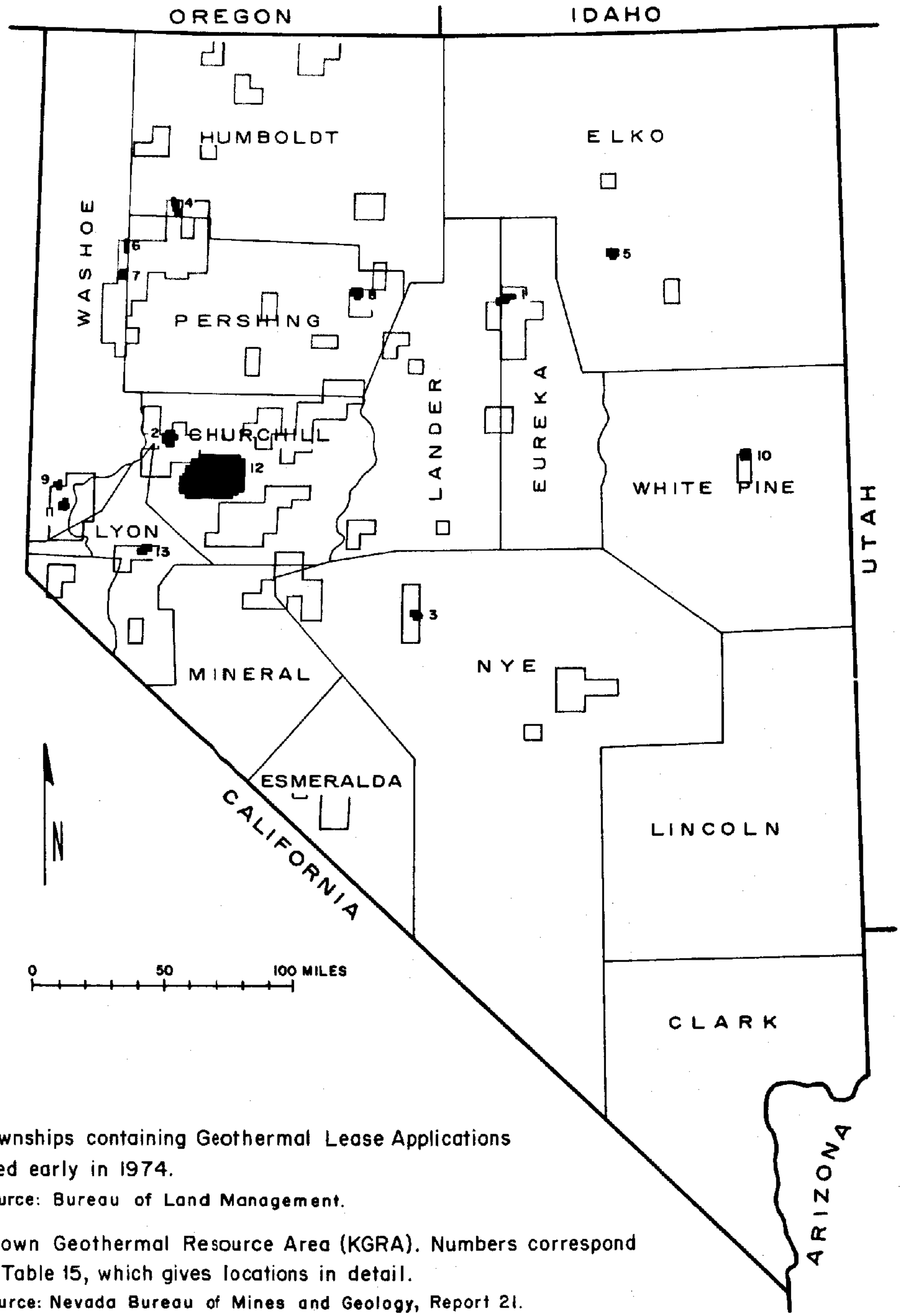
Exploratory geothermal drilling in Nevada through 1973[1]

Operator	Name	API No.[2]	Location	Depth	Maximum Spring Temp. (°F)	Maximum Well Temp. (°F)	Completion Date	Remarks
7. Wabuska Hot Springs					162	222		
Magma Power Co.	Wabuska No. 1	27-019-90000	S16?,T15N,R25E	488			1959	Hot water used for green-house heating.
Magma Power Co.	Wabuska No. 2	27-019-90001	SE/4,NE/4,SW/4,S16,T15N,R25E	532?			1959	
Magma Power Co.	Wabuska No. 3	27-019-90002	NE/4,SE/4,SE/4,S16,T15N,R25E	2223			1959	
8. Fernley (Hazen)					?	270		
Magma Power Co.	Hazen No. 1(?)[3]	27-019-90003	SW/4,S18?,T20N,R26E	750			1962	Patua Hot Springs.
Magma Power Co.	Hazen No. 2(?)[3]	27-019-90004	S18?,T20N,R26E	~300?			1962	
Magma Power Co.	Hazen No. 3(?)[3]	27-019-90005	S18?,T20N,R26E	~300?			1962	
9. Hind's Hot Springs					144	?		
U. S. Steel Corp.	Hind's No. 1(?)[3]	27-019-90006	SW/4,SE/4,S16,T12N,R23E	?			1962?	Hot water in wells cooler than springs at surface.
U. S. Steel Corp.	Hind's No. 2(?)[3]	27-019-90007	SW/4,SE/4,S16,T12N,R23E	?			1962?	
U. S. Steel Corp.	Hind's No. 3(?)[3]	27-019-90008	SW/4,SE/4,S16,T12N,R23E	?			1962?	
10. Darrough Hot Springs					207?	265		
Magma Power Co.	Darrough No. 1(?)[3]	27-023-90000	S17?,T11N,R43E	812			1962	Very large flow of hot water, little steam.
11. Brady's Hot Springs					194	418		
Magma Power Co.	Brady No. 1	27-001-90000	NE/4,NE/4,SW/4,S12,T22N,R26E	700?			1959?	Hot water with 5% steam flashover. Problem of scaling.
Magma Power Co.	Brady No. 2	27-001-90001	NE/4,NE/4,SW/4,S12,T22N,R26E	241			1959?	
Magma Power Co.	Brady No. 3	27-001-90002	SE/4,SE/4,NW/4,S12,T22N,R26E	610			1961?	
Magma Power Co.	Brady No. 4	27-001-90003	SE/4,SE/4,NW/4,S12,T22N,R26E	723			1961?	
Magma Power Co.	Brady No. 5	27-001-90004	NW/4,SW/4,NE/4,S12,T22N,R26E	593			1961?	
Magma Power Co.	Brady No. 6	27-001-90005	NW/4,SW/4,NE/4,S12,T22N,R26E	770			?	
Magma Power Co.	Brady No. 7	27-001-90006	NW/4,SW/4,NE/4,S12,T22N,R26E	250			?	
Earth Energy Inc.	R. Brady EE No. 1	27-001-90007	S12?,T22N,R26E	5062?			1964	
Earth Energy Inc.	Brady Pros. No. 1	27-001-90008	S12?,T22N,R26E	1758?			1965?	
12. Stillwater					–	240		
O'Neill Geothermal, Inc.	Joseph I. O'Neill, Jr. Reynolds No. 1	27-001-90009	NE/4,SW/4,SW/4,S6,T19N,R31E	~4200?			1964	Some water wells drilled in this area encountered hot water and steam which have been used for space heating. No springs or other surface features.
13. Wally's Hot Springs					160	181		
U. S. Steel Corp.	Wally's No. 1	27-005-90000	SE/4,NW/4,NW/4,S22,T13N,R19E	1268			1962	Twenty-six shallow holes were also drilled to measure the temperature gradient.
U. S. Steel Corp.	Wally's No. 2	27-005-90001	SW/4,SW/4,NW/4,S22,T13N,R19E	499			1962	

[1] Listing does not include thermal water wells or wells drilled to exploit thermal waters for spas, swimming pools, space heating, etc.

[2] The American Petroleum Institute Unique well number system has been applied to geothermal wells as well as oil and gas wells, and is recommended for the unique identification of wells by all agencies of industry and government.

[3] Name assigned by Nevada Bureau of Mines and Geology; original name unknown.

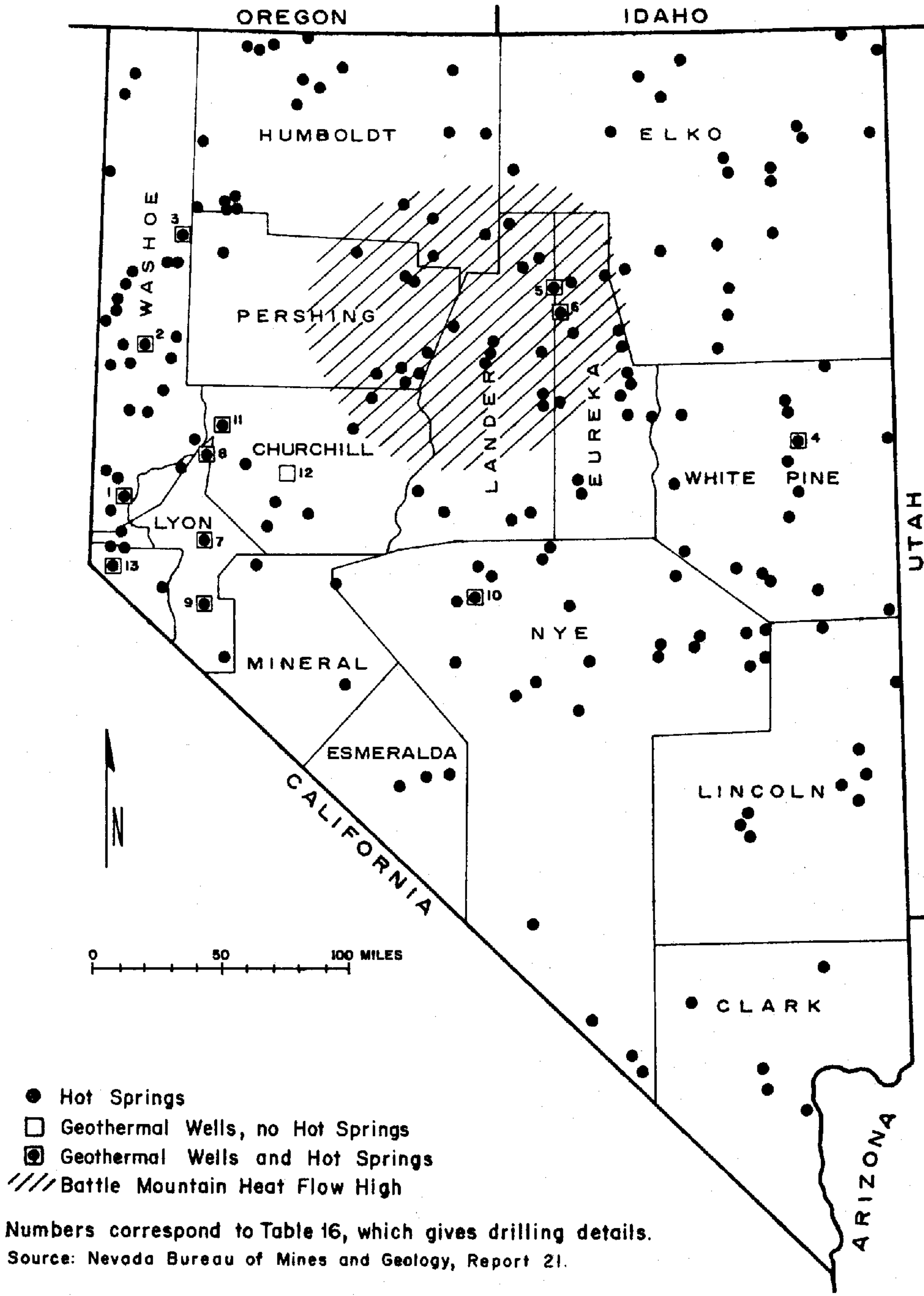


Townships containing Geothermal Lease Applications filed early in 1974.
Source: Bureau of Land Management.

Known Geothermal Resource Area (KGRA). Numbers correspond to Table 15, which gives locations in detail.
Source: Nevada Bureau of Mines and Geology, Report 21.

MAP 6

KNOWN GEOTHERMAL RESOURCE AREAS (KGRA) AND LEASE APPLICATIONS ACTIVITY IN NEVADA



Numbers correspond to Table 16, which gives drilling details.
Source: Nevada Bureau of Mines and Geology, Report 21.

MAP 7
HOT SPRINGS AND GEOTHERMAL WELLS IN NEVADA

Projections of Nevada's Use, 1980 - 2020

Virtually all projections indicate that the demand for electric energy will grow at a very rapid rate during the next few decades, partly because of increasing population, but also because almost every aspect of the rising standard of living requires energy. Demand will probably increase at an even greater rate during the next ten years in Nevada because of the extension of transmission lines into remote areas where the population presently uses little electricity because it simply is not available. The relatively high cost of producing electricity in Nevada by other methods makes geothermal energy here especially attractive.

In spite of the demand for energy, it is anticipated that development of geothermal resources will proceed slowly at first.

Although about two dozen geothermal power plants are now in operation throughout the world, the technique must still be considered to be in its infancy. Each new geothermal area that is considered for development presents new kinds of engineering problems that must be solved with newly-designed techniques or equipment. Additionally, geothermal energy production is like all other mining operations in that the exploration phase is a very time-consuming one. The size and grade of the ore body must be established, components of the ore that might interfere with recovery of the valuable components must be identified and techniques worked out to nullify them, and both markets and potential competing ore bodies must be investigated. As tables 17 and 18 indicate, it is expected that there will be two geothermal power plants in Nevada by 1980, but that several more of larger capacity will be in operation by the year 2000, and that even greater utilization of this resource will occur by 2020. Many plants will probably use an essentially closed system, returning the water to the geothermal reservoir through recharge wells. Some facilities may be operated in conjunction with desalination plants, thus combining power generation with the production of fresh waters and valuable minerals. Still other plants will not remove water from the ground at all, but will circulate other fluids through the hot rocks. Although the latter system has advantages, particularly in that it greatly reduces the possibility of pollution, we anticipate that in the period of our concern circulation of geothermal water itself or power generation followed by desalination will be preferred. The first process will allow recovery of valuable elements from the reservoir as byproducts of power generation; and the second, recovery of fresh water as well as recovery of valuable minerals. There was no attempt to estimate what quantity or quality of water, or quantities or kinds of mineral byproducts may be recovered. For simplicity, it was assumed that the smallest feasible geothermal energy plant will generate 80,000 megawatt-hours of electricity annually, and that larger plants will generate multiples of this minimum. Further, it was assumed that the smallest plants will employ 15 men each, and larger plants of any size will employ 30 men. A price of $5.00 per megawatt-hour has been used.

Estimates show that each 80,000 megawatt-hour unit of power generation capability will have new water requirement of 34 million gallons and water consumption of 29 million gallons, per year. This water probably will not come from the geothermal reservoir, but will have to be drawn from ordinary surface or ground water supplies, and does not include domestic and municipal water for people associated with power generation. However, the water usage shown in table 17 and 18 includes that needed for the condensing systems of generation plants, and for domestic purposes.

TABLE 17: ESTIMATED FUTURE GEOTHERMAL ENERGY STATISTICS BY COUNTY

Source: Division of Water Resources

County	Generating Plants	Megawatt-Hours of Electricity	New Water Requirement Millions of Gallons	Water Consumed Millions of Gallons	Number of Persons Employed	Value at 1970 Prices Thousands of Dollars
1970						
NO GEOTHERMAL ELECTRIC ENERGY PRODUCTION IN 1970						
1980						
Churchill	1	80,000	52	38	15	400
Lander	1	80,000	52	38	15	400
State Total	2	160,000	104	76	30	800
2000						
Churchill	2	480,000	258	201	45	2,400
Elko	1	160,000	104	76	30	800
Lander	1	400,000	206	163	80	2,000
Nye	1	80,000	52	38	15	400
Washoe	2	160,000	104	76	30	800
State Total	7	1,280,000	724	554	150	6,400
2020						
Churchill	2	640,000	344	268	60	3,200
Elko	2	320,000	208	152	60	1,600
Eureka	1	160,000	104	76	30	800
Lander	1	560,000	274	221	30	2,800
Nye	1	160,000	104	76	30	800
Washoe	2	400,000	242	181	60	2,000
White Pine	2	160,000	104	76	30	800
State Total	11	2,400,000	1,380	1,050	300	12,000

TABLE 18: ESTIMATED FUTURE GEOTHERMAL ENERGY STATISTICS BY HYDROGRAPHIC REGION

Source: Division of Water Resources

Hydrographic Region	Generating Plants	Megawatt-Hours of Electricity	Water Consumed Millions of Gallons	New Water Requirement Millions of Gallons	Number of Persons Employed	Value at 1970 Prices Thousands of Dollars
1970						
NO GEOTHERMAL ELECTRIC ENERGY PRODUCTION IN 1970						
1980						
4	1	80,000	52	38	15	400
5	1	80,000	52	38	15	400
State Total	2	160,000	104	76	30	800
2000						
2	1	80,000	52	38	15	400
4	2	560,000	310	239	60	2,800
5	1	400,000	206	163	30	2,000
6	1	80,000	52	38	15	400
8	1	80,000	52	38	15	400
10	1	80,000	52	38	15	400
State Total	7	1,280,000	724	554	150	6,400
2020						
2	1	240,000	138	105	30	1,200
4	4	1,040,000	586	449	120	5,200
5	1	480,000	240	192	30	2,400
6	1	160,000	104	76	30	800
8	1	160,000	104	76	30	800
10	1	160,000	104	76	30	800
12	2	160,000	104	76	30	800
State Total	11	2,400,000	1,380	1,050	300	12,000

Initial Small Scale Use

As previously mentioned, initial utilization of the geothermal resource will be on a small scale. Practical small scale applications in Nevada could include providing a water supply for a municipality or agriculture where otherwise there might be none. Mining and industry could also be served.

Generation of electric energy from geothermal sources on a semi-experimental small scale would be very valuable to some locations in Nevada which are not likely to be served otherwise. Later, as geothermal technology advances, large scale generation of electric energy could become a reality. As a by-product, recovery of salts and metals would be achieved.

The Division of Water Resources, as part of the State Water Plan, has investigated the small scale production and use of geothermal resources at Brady's Hot Springs. Brady's is located about 55 miles east and somewhat north of Reno, on U.S. Highway 40. The potential small scale plant at Brady's would provide desalted water and electric energy. For those wishing to delve further into the details, reference is made to the State Water Plan report entitled, "The Future Role of Desalting in Nevada." This report is available from the Division of Water Resources.

Leasing on Federal Lands

Geothermal resource development on federal lands requires that a lease must be obtained through the Bureau of Land Management. Summary of federal geothermal resources leasing regulations is provided in the following table.

TABLE 19: GEOTHERMAL RESOURCE DEVELOPMENT ON FEDERAL LANDS

<u>Authority:</u>	Geothermal Steam Act of 1970 and Regulations 43 CFR 3200 published December 21, 1973 and effective January 1, 1974.
<u>Exploration:</u>	In addition to exploration operations authorized by a geothermal lease, permits may be issued for exploration not connected with a lease. A "Notice of Intent" describing the proposed exploration and a $5,000 compliance bond are filed with the District Manager, who has 30 days to either approve or disapprove the permit. Upon completion of the exploration, a "Notice of Completion of Exploration Operations" is filed and the District Manager has 90 days to notify the party as to whether or not the conditions of the permit have been met.

Leasing:

Size - Geothermal leases cover from 640 acres (one section) to 2,560 acres (four sections). A maximum of 20,480 acres (32 sections) per state may be held by one lessee. Applications are filed at the State Office.

Term - Leases are issued for 10 years and so long thereafter as steam is produced in commercial quantities up to 40 additional years. If still producing, a second 40 year term may be allowed.

Diligence - Each lease will contain provisions for diligent exploration.

Rental - The annual rental is not less than $1 per acre per year for the first 5 years. Thereafter, it escalates at the rate of $1 per acre per year until commercial production is reached.

Royalty - Upon production, a royalty of 10 to 15% of the value of the steam is assessed. Royalties of up to 5% are assessed for byproducts, including commercially demineralized water.

Environmental Considerations: Before any lease is issued an environmental analysis (or Environmental Impact Statement, if warranted) is made to determine whether or not a lease should be issued. Special protective stipulations may be included in the lease. Additionally, the lessee must comply with general regulatory requirements to minimize environmental damage.

Bonding: Two bonds are required before a lease is issued: A $10,000 bond to insure lease compliance and a $5,000 bond to indemnify any damages to persons or property. A $150,000 nationwide bond or $50,000 statewide bond may be substituted.

Types of Leases: Non-competitive leases are issued for lands outside of any Known Geothermal Resource Area (KGRA). Within KGRAs leases are issued only by competitive bidding. KGRAs are areas recognized as having good enough prospects for commercial development to warrant expenditure for that purpose. They are established either by designation by the Geologic Survey based on physical data or by displaying competitive interest (where one half or more of a lease application is covered by another lease application filed during the same filing period).

Non-competitive Leases - For lands outside of any KGRA non-competitive lease applications are filed. They are accompanied by a non-refundable $50 filing fee and the first year's rental. Each calendar month is a separate filing period and all applications are filed in sealed envelopes which are opened the first of the following month.

For the first filing period (Jan. 1-31, 1974) all applications will be considered simultaneously filed and priority will be determined at a public drawing.

For all subsequent filing periods, priority will be based on date of filing (overlapping applications filed on the same day will be decided by public drawing).

New KGRAs that are created by overlapping applications will be leased by competitive bidding.

In addition to the bonds, a proposed plan of operation must be filed before the lease is issued and must be approved before any surface disturbing operations may be commenced.

Previously Leased Land - Cancelled, relinquished, or terminated leases will be reoffered by a simultaneous filing period, with a public drawing to determine priorities (similar to oil and gas simultaneous filings).

In addition to the bonds, a proposed plan of operation must be filed before the lease is issued and approved before any surface disturbing operations may be commenced.

Tracts not applied for in the simultaneous filing are again available for over-the-counter applications.

Competitive Leases - All lands within any KGRA are available only by competitive bidding. Tracts may be put up for bid by Bureau motion or upon nomination.

Competitive leasing notices will be published in the newspaper, sealed bids will be received and the lease tracts awarded to the highest qualified bidder.

In addition to the bonds, a proposed plan of operation must be filed before the lease is issued and must be approved before any surface disturbing operations may be commenced.

geothermal resources require consumptive use of ground waters, which may be significant in quantity and would, in some areas, influence adjacent water rights on public or private lands.

In Nevada, 14 areas have been declared critical ground water basins by the State Engineer. This has been done to protect existing water rights as legally permitted drafts on the local system reach or exceed the natural recharge to the basin. Of the 13 known geothermal resource areas which have been designated in Nevada, two (Leach Hot Springs and Fly Ranch) fall in areas previously declared critical by the State Engineer's Office. In all, 11 of the 14 critical ground water basins contain published geothermal resources in the form of thermal springs.

Additionally, geothermal exploratory drilling should be performed by Nevada licensed well drillers, according to State rules and regulations.

Part 3: PUMPED STORAGE

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INVESTIGATION OF PUMPED STORAGE

Scope

The arguments for further investigating Nevada's pumped storage potential as a regional as well as a local alternative energy development are provided in the following narrative. Necessary background on what would be involved physically and in the way of pumped storage investment costs in dollars per kilowatt is also provided. A tentative listing of typical reservoir sites follows the narrative.

Fossil fuel and nuclear electric energy generation plants supply relatively low cost energy to carry base loads. However, they are an expensive supply for carrying peak loads. Pumped storage appears to be a possible economic alternative for supplying peak loads where the peaks are sufficiently large. Figure 15 shows important features of pumped storage plant operation.

Basic Description

Basically, pumped storage is a method of accumulating water instead of electric energy. Electric energy cannot under present technology be stored in sufficient amounts to smooth out the peak demands on a seasonal, weekly, daily, or even hourly basis. Therefore, without some other form of storage, installed electric generating capacity must be capable of handling long term average loads and short term peaks on the same instantaneous demand basis. This is an inefficient use of resources.

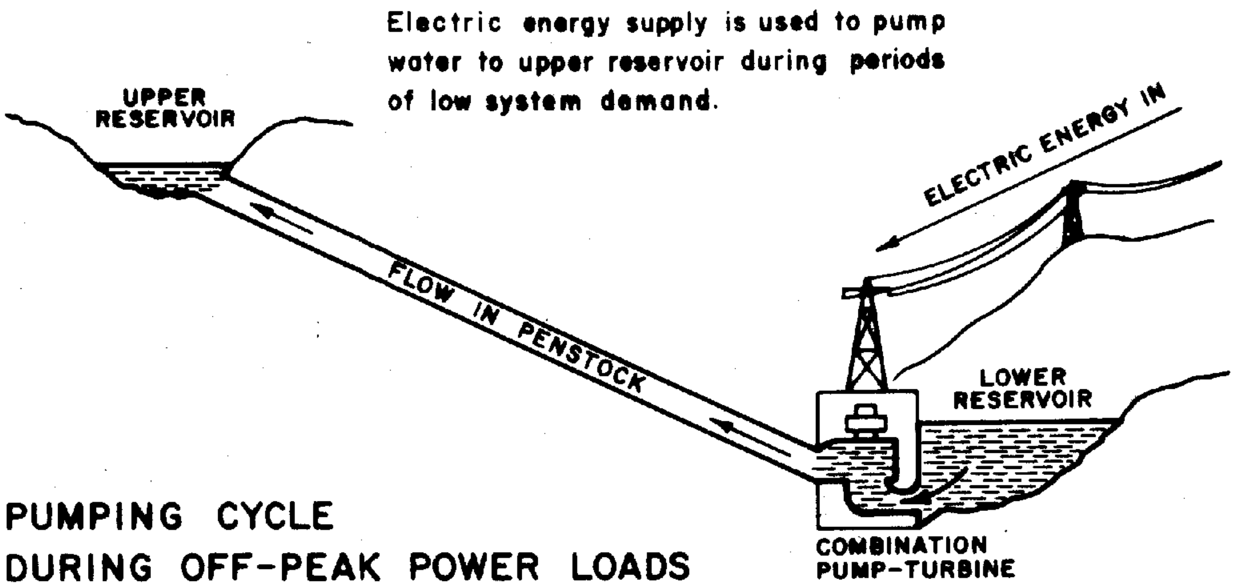
Pumped storage functions as an energy accumulator when generating plants would not otherwise be operating anywhere near installed capacity. When demands begin to approach installed capacity, accumulated energy is released. A rough rule of thumb is that two units of energy can be recovered later for every three units of energy expended to obtain storage. The process is about 67% efficient. At this level of efficiency, it has often been economical to make use of pumped storage, because the stored energy can be used when it is more valuable.

Regional and Local Alternative

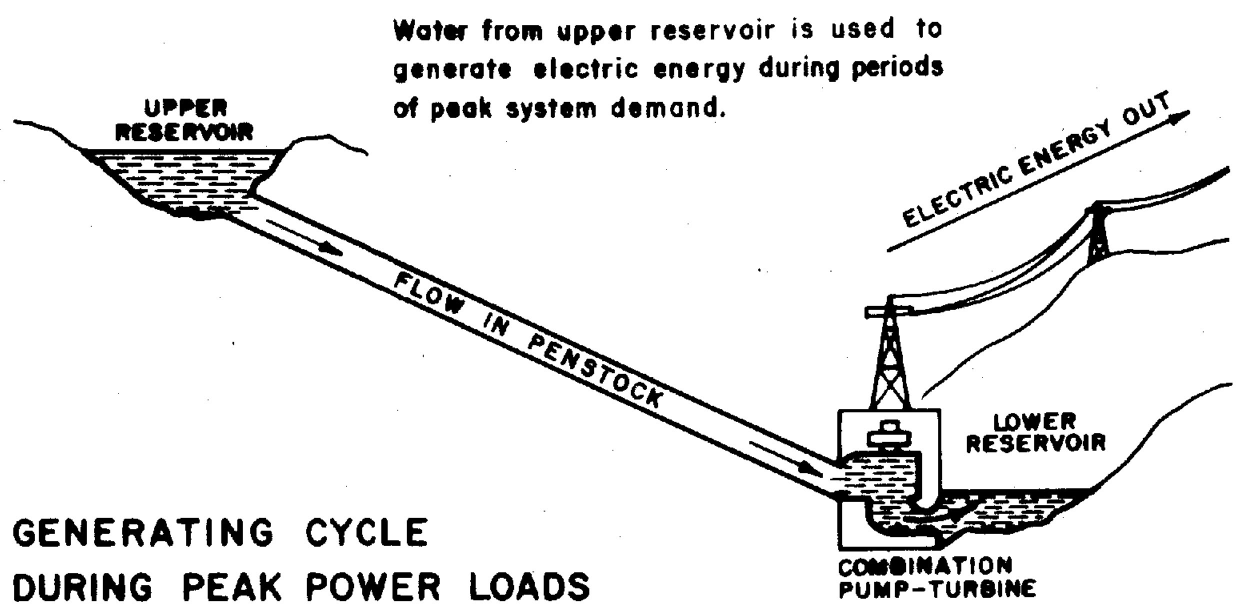
The 11 western states as a region will require additional pumped storage capacity. With improvement in transmission technology, transmission losses will be cut. This would allow pumped storage plants to economically serve larger areas for longer periods, making larger installations more attractive. It should be noted that although most of the narrative involves large installations of 1,000 megawatts (MW) capacity, or larger, a quick appraisal of smaller plants is offered. Using smaller plants, pumping energy is important on a strictly local basis, and must be considered at the outset.

FIGURE 15

PUMPED STORAGE PLANT OPERATION



PUMPING CYCLE
DURING OFF-PEAK POWER LOADS



GENERATING CYCLE
DURING PEAK POWER LOADS

Highly urbanized areas in Nevada, such as Las Vegas Valley and the Sierra Front near Reno, might provide enough future demand to justify pumped storage installations.

Before discussing the 1,000 MW and larger facilities and then briefly discussing the smaller facilities, it is important to understand historical development of electric energy generation using hydro-electric and steam electric plants.

Water powered electric energy generation plants were initially favored over steam-electric generating plants because steam plants had a high installation cost and fuel consumption was also high. As lower cost and higher efficiency steam plants became possible and siting for water powered plants became less economical, the number of steam-electric plants outstripped the number of hydro-electric plants. An important factor in this sequence was the increased availability of fuel oil, coal and natural gas. Subsequently, the construction of some very large hydro-electric plants was undertaken by the government, in conjunction with navigation, flood control and irrigation projects.

With fuel oil and coal costs on the rise, and the use of natural gas curtailed in steam-electric plants, and the general condition of present energy uncertainty, the prospective hydro-electric to steam-electric relationship should be closely examined. Under these conditions, Nevada should look to pumped storage as a potential regional and local alternative energy development.

Cooperative Effort

As a result of the State Water Plan and cooperation between the Federal Power Commission (FPC) and the Nevada State Study Team (1), a sampling of potential pumped storage sites has been provided in Table 20. Map 8 locates these sites, and Table 21 summarizes criteria for their selection. The FPC is planning to publish a reconnaissance report in the near future showing a number of additional potential pumped storage sites. Preliminary studies indicate sufficient sites for over 40,000 megawatts (MW) of potential installed capacity. This amount considerably exceeds the projected peak load of 6,000 MW for Nevada in the year 2000.

Sites shown in Table 20 were initially identified visually from contours on U. S. Geological Survey 15 minute quadrangle maps (1 inch to the mile), which are available for most of Nevada. Areas in Nevada not covered by the USGS 15 minute maps were not evaluated for pumped storage potential. Therefore, the sites

---

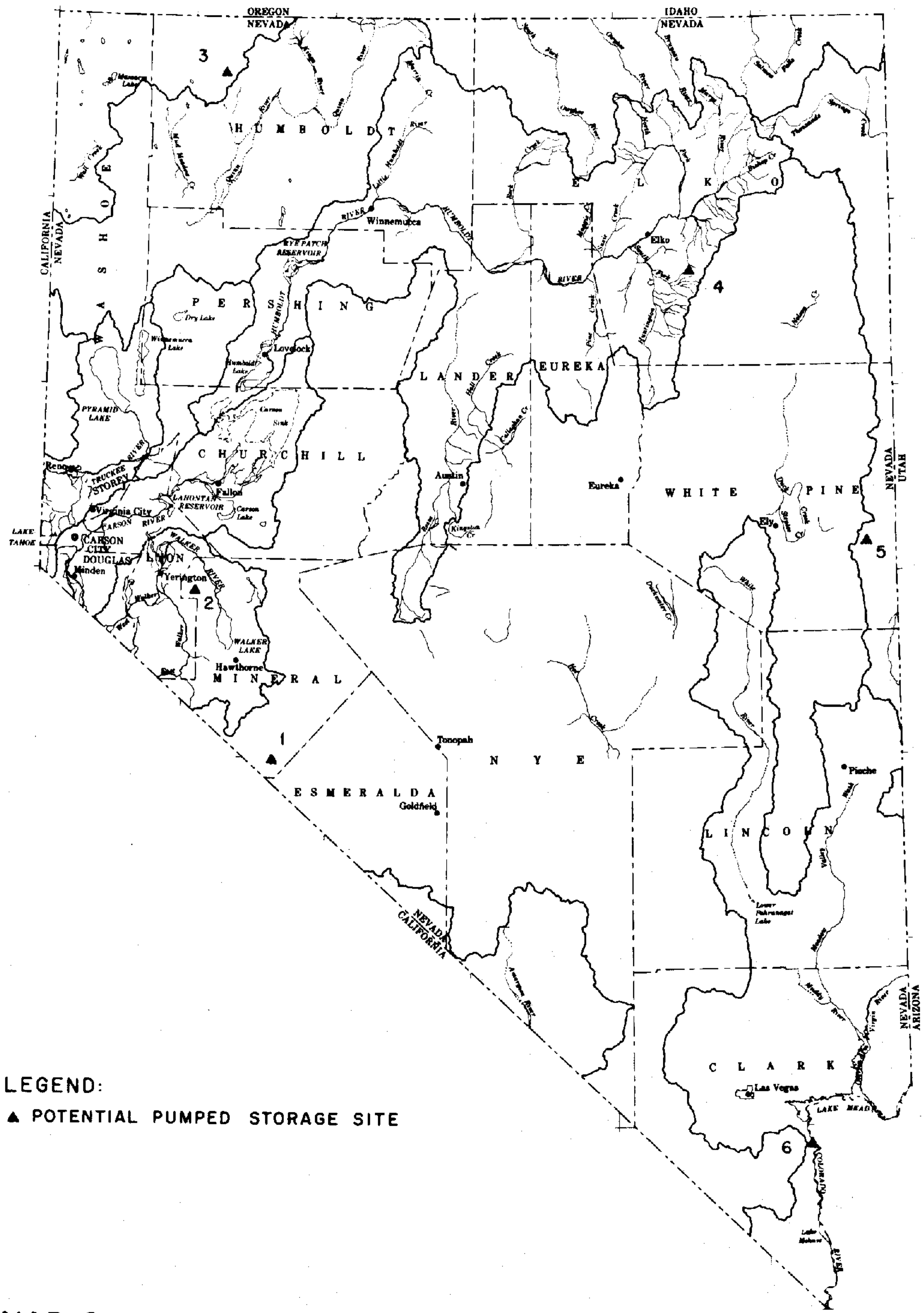
(1) The Nevada State Study Team has considered water and related land resources problems from the cooperative viewpoint of the federal and state agencies comprising the team.

TABLE 20: NEVADA POTENTIAL PUMPED STORAGE SITES

No.	Name of Site	County	Plant (1) Capacity, MW	Head, Feet	Penstock Length, Feet	Weekly Storage, Acre-Feet	Private Investment Cost, $ per KW (2)
1.	Truman Meadows (See page 122)	Mineral	1,000 3,000	1,080 1,110	11,600	15,200 38,000	165 130
2.	Black Mountain (See page 123)	Mineral	1,000 4,000	1,920 1,910	10,400	7,400 31,400	111 93
3.	Onion Valley (See page 124)	Humboldt	1,000 2,000	1,830 1,820	10,000	7,800 17,200	121 102
4.	Seitz Lake (See page 125)	Elko	1,000 2,000	1,940 1,960	10,100	7,300 16,200	122 102
5.	Miller Basin (See page 126)	White Pine	1,000 2,000	1,270 1,260	11,100	11,200 18,000	152 135
6.	Indian Rapids (See page 127)	Clark	1,000 2,000	1,290 1,330	8,200	11,000 23,500	156 120

Notes: (1) The second plant capacity figure for each site is the ultimate capacity for that site, rounded to the nearest 1,000 MW. Corresponding data are based upon the ultimate capacity before rounding.

(2) Preliminary costs in terms of 1971 dollars.



LEGEND:

▲ POTENTIAL PUMPED STORAGE SITE

MAP 8

NEVADA POTENTIAL PUMPED STORAGE SITES

presented should be considered typical of selection problems encountered prior Stage 1 of the siting process shown by Figure 9 in the narrative on siting. Field inspections of the sites selected will eliminate many of them, for any number of reasons which are not obvious from data available in an office. This type of office preparation is necessary for efficient field work.

Such field investigations, which are beyond the scope of this report, will reveal items which make some sites economically infeasible. These items include: (1) poor geologic characteristics; (2) expensive relocations of roads, bridges and other facilities not indicated on the available maps, some of which are outdated; (3) silt load on some streams may be high and would fill reservoirs quickly; (4) sites located on small intermittent streams may require supplemental water to make up for seepage and evaporation losses.

TABLE 21: SITE SELECTION CRITERIA SUMMARY

1. Operating Pattern. The sampling of sites provided will be for plants to be operated on a weekly cycle basis. As indicated by Figure 16, generation will occur during weekday peak hours and pumping during off peak hours at nights and on weekends.

2. Plant Size. Study will be concentrated on sites capable of at least 1,000 megawatt developments.

3. Topography. Sites will be limited generally to those having heads of not less than 400 feet and maximum horizontal distances between upper and lower reservoirs of not more than 15 times the head. Where existing reservoirs are used, heads of less than 400 feet may prove to be feasible.

4. Reservoir Size. A reservoir of sufficient capacity to generate for 12 hours at full plant output will be used to estimate storage requirements. This capacity would provide sufficient storage to generate for 8 hours per day at full output with 4 hours reserve capacity. Figure 17 shows the head-storage relationship for a plant with 1,000 megawatts capacity, operating at full plant output for 12 hours.

5. Drawdowns. Drawdowns will be limited to those providing a ratio of maximum head to minimum head of not more than 1.25.

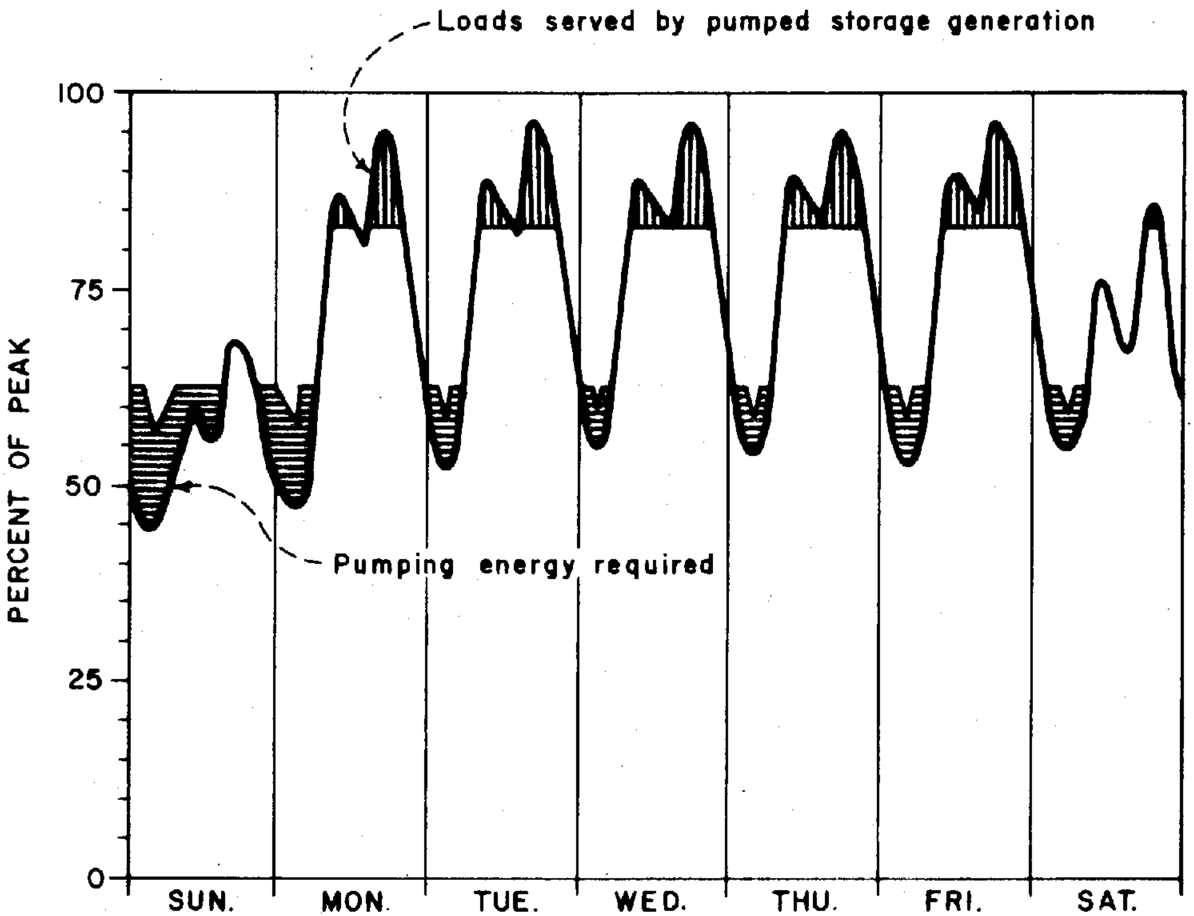
6. Waterway Size and Characteristics. Penstocks will be sized on the basis of maximum velocities of 16 to 20 feet per second. Lined tunnels will be assumed.

7. Source of Energy. It is assumed that off peak pumping energy will be available from base-load thermal electric plants.

FIGURE 16

TYPICAL WEEKLY ELECTRIC UTILITY SYSTEM LOAD CURVE

Loads served by conventional Hydro and Thermal Generation



NOTE: Refer to Operating Pattern in Table 21.

FIGURE 17

HEAD-STORAGE CAPACITY RELATIONSHIP
FOR 1,000 MEGAWATT PUMPED STORAGE PLANT FOR 12 HOURS FULL PLANT OPERATION

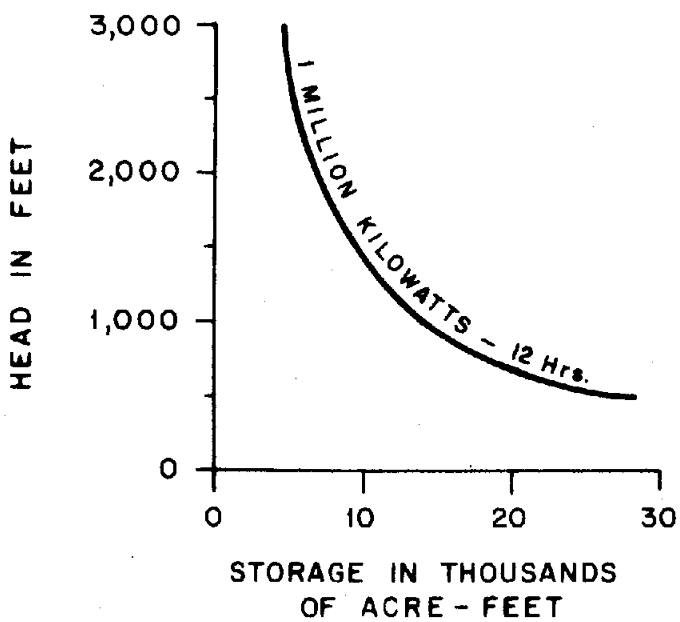
Curve based on P = 0.07 QH

Note: P is power in millions of kilowatts.

Q is flow in cubic feet per second.

H is head in feet.

At 1,000 feet of head, 14,168 acre-feet would be required to generate 1 million kilowatts for 12 hours.



NOTE: Refer to Reservoir Size in Table 21.

TABLE 21: Site Selection Criteria Summary (Continued)

8. <u>Areas Excluded</u>. Potential pumped storage sites located in special designated areas (National Parks, Wilderness Areas, Wild Rivers, etc.) will not be considered in the final analysis. A degree of efficiency in resource utilization will probably be sacrificed by excluding these areas.

BASIC DATA AND PROCEDURES

Summary

After suitable sites were located on the available quadrangle maps for the upper and lower reservoirs, storage requirements and penstock lengths were determined. Project costs, based on 1971 price levels, were then estimated for each site based on individual cost calculations for the following physical items:

1. Relocations
2. Embankment (Dams, Dikes, Reservoirs)
3. Powerhouse and Equipment
4. Penstock - Tunnel

As an example of the level of detail required in a reconnaissance study of this sort, the procedure for determining embankment costs is briefly described.

Embankment costs include the cost of earthfill dams and dikes, spillway or outlet works, and general reservoir costs excluding intakes, which costs are included in the estimated penstock costs.

Without a specific geologic examination, it is not known whether reservoir liners would be required. No allowance was made for liners. After more detailed study, it may be found that many sites will require at least minimum lining. The total embankment and reservoir costs of lined reservoirs could be as much as 100 percent greater than that of unlined reservoirs.

The cost of earthfill dams was based on the typical cross section shown by Figure 18. Since the embankment cost is usually less than 10 percent of the total project cost, a constant valley slope was assumed so that only the crest length and maximum height were required to determine the cost. In the final design of some of these projects, it may be determined that a different type of dam is more suitable or more economical. Such a cost difference would not have a significant effect on the total project cost.

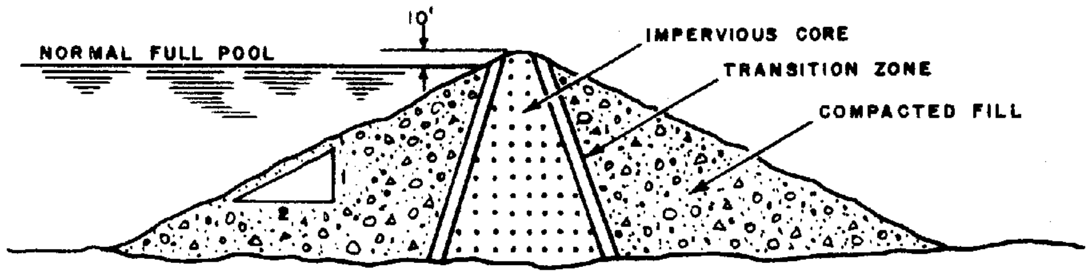


FIGURE 18
TYPICAL CROSS SECTION OF EARTHFILL DAM

SMALL PLANTS

Efficiency, Costs and Benefits

Presently, or in the near future, Nevada needs for pumped storage would probably be in the 100 MW to 500 MW range, rather than 1,000 MW or larger. For efficiency, sites would have to be located fairly close to the Las Vegas area or the Sierra Front near Reno.

Consideration of likely pumped storage sites would first include evaluation of economic costs and benefits.

COSTS

a. Cost of providing electric energy to the pumps.

b. Cost of payments on the construction loan.

c. Operating, maintenance and replacement costs, etc.

BENEFITS

d. Savings in cost for the system between pumped storage and other methods of generation to satisfy peak load.

An optimization study would indicate the necessary size of plant to balance costs against benefits to make a profit.

If a profit could not be made, or if the electric energy could be imported from outside the area at a lesser cost, the pumped storage facility would apparently not be built.

NEW DIMENSION FOR SITE INVENTORY

Remote Sensing and Computer Technology

Analysis of photographs from earth satellites (1) such as ERTS and SKYLAB inserts a new dimension for recognition of potential pumped storage sites. The idea is to try to obtain a complete inventory of reasonable pumped storage sites, and then to use field investigation to reject reservoir sites not meeting functional criteria. A probable approach has been developed in concept and is presented following.

Important functional criteria for reservoir sites would include:

FUNCTIONAL CRITERIA
BETWEEN RESERVOIRS

1. Elevation difference

2. Horizontal distance

FUNCTIONAL CRITERIA
FOR INDIVIDUAL RESERVOIRS

3. Easily closed site (closeability)

4. Large capacity

5. Tightness of material

Methods of testing, changing and refining the previous pumped storage site criteria from satellite photographs would involve experimental computer work. The approach would be to find proper combinations of satellite sensible characteristics by correlating with ground truth at many different sites which provide satisfaction of the criteria. Some useful characteristics would include:

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(1) ERTS: Earth Resources Technology Satellite, which is an unmanned orbiting sensor platform. SKYLAB is an occasionally manned orbiting experimental space station.

SOME USEFUL REMOTE SENSING CHARACTERISTICS

(1) 1. Topography

2. Shape or form

3. Color

4. Brightness

(1) 5. Temperature

(2) 6. Changes in the above

Notes: (1) ERTS and SKYLAB apparently do not have stereo imagery and sensitive temperature sensors in combination.

(2) Changes in ground truth characteristics would be seen because of seasonal changes during a number of orbits. Perspective on these changes could be enhanced by the different sun angles when viewing the same ground.

It should be noted that large capacity and closeability are functional requirements, while characteristic shape can be indicative of both. Thus function and form are related, and hopefully may be recognized by using existing remote sensing and computer technology. For purposes of correlation with satellite data, there are minimum additional data requirements. These should include high altitude aircraft photographs of pumped storage sites exhibiting selected combinations of the previous useful remote sensing characteristics.

A reconnaissance effort within the State Water Plan has been made to see what would be needed to put all this together. Needless to say, the short term effort required has been shown to be beyond the scope of this study. The technology is still incomplete; necessary overlapping ground truth, aircraft photography and satellite photography are lacking; computer programs are not available; costs appear prohibitive at present.

This technical and cost situation will probably change substantially before greatly expanded use of pumped storage for generation of energy would become practical in the 11 western states. Hopefully, the approach of using function and form coupled with remote sensing and computer technology could be used for reconnaissance level inventories of potential resources, as well as potential sites for many types of facilities.

NEVADA POTENTIAL PUMPED STORAGE SITES

Introduction

Table 20 has listed potential pumped storage sites with an installed capacity of megawatts 15,000 (MW). In a reconnaissance report soon to be released, the FPC will list sites in Nevada with an ultimate installed capacity of roughly 40,000 megawatts. As previously stated, this amount considerably exceeds the projected peak load of 6,000 MW for Nevada at the year 2000. Many of these soon to be published FPC sites would be rejected, as previously noted, because of technical, financial or other reasons. In the long term, some might be used for local service or service to portions of the region comprising the 11 Western States (1). Further study would be reasonable from an efficiency standpoint, particularly in view of the uncertain energy situation.

With these limitations, individual reservoir site maps are presented as part of the State Water Plan and the cooperative federal-state effort of the Nevada State Study Team. Townships and ranges given on the reservoir site maps are with reference to the Mount Diablo Base and Meridian (M.D.B.& M.).

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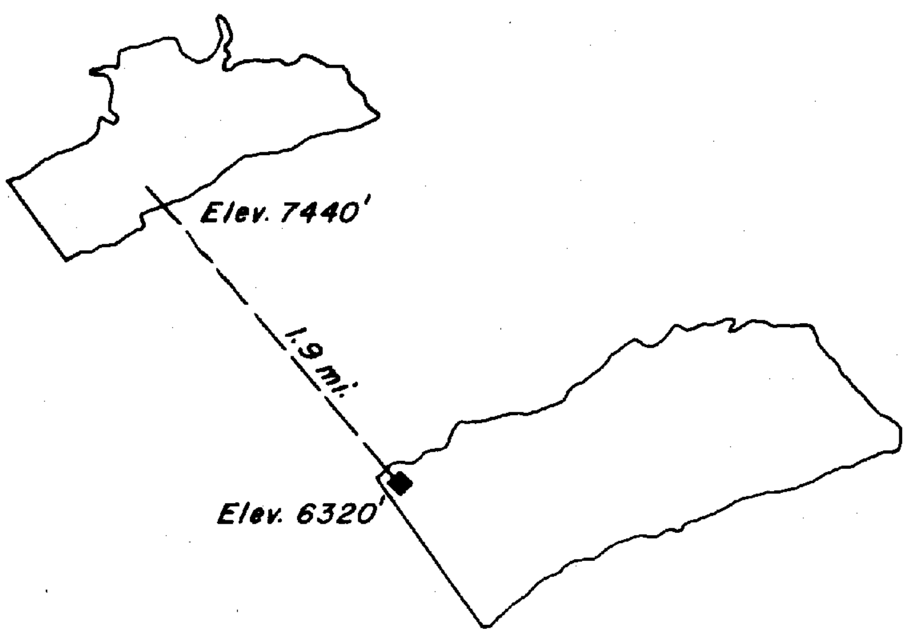
(1) Washington, Oregon, California, Idaho, Nevada, Utah, Arizona, Montana, Wyoming, Colorado, New Mexico.

TRUMAN MEADOWS RESERVOIR

Location: Mineral Co.
Queen Valley - 116
T. 1 N., R. 32 E.

15' map: Benton, Nev. - Calif.

Capacity: 1000 mw. (3000 mw. ult.)

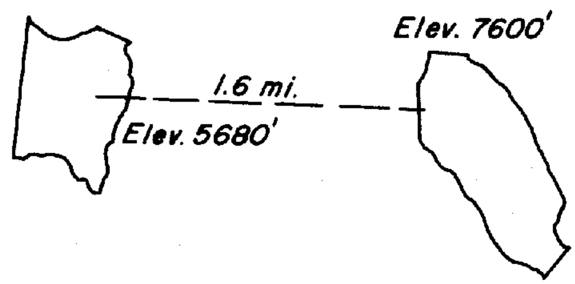


BLACK MOUNTAIN RESERVOIR

Location: Mineral Co.
Mason Valley - 108
T. 12 & 13 N., R. 27E.

15' map: Schurz, Nev.

Capacity: 1000 mw. (4000 mw. ult.)

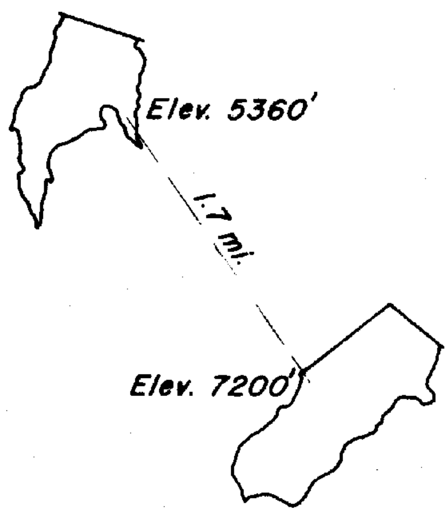


ONION VALLEY RESERVOIR

Location: Humboldt Co.
Continental Lake Valley - 2
T. 43 & 44 N., R. 28 E.

15' map: Idaho Canyon, Nev.
Duffer Peak, Nev.

Capacity: 1000 mw. (2000 mw. ult.)

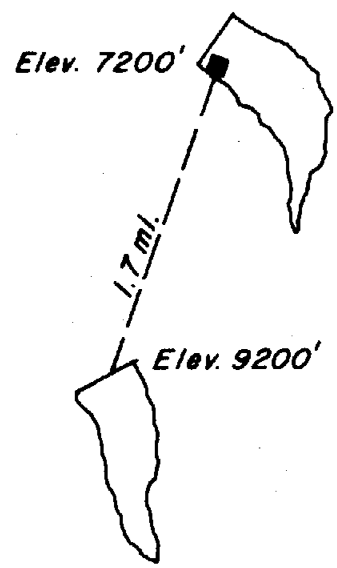


SEITZ LAKE RESERVOIR

Location: Elko Co.
Lamoille Valley - 45
T. 32 N., R. 58 E.

15' map: Lamoille, Nev.

Capacity: 1000 mw. (2000 mw. ult.)

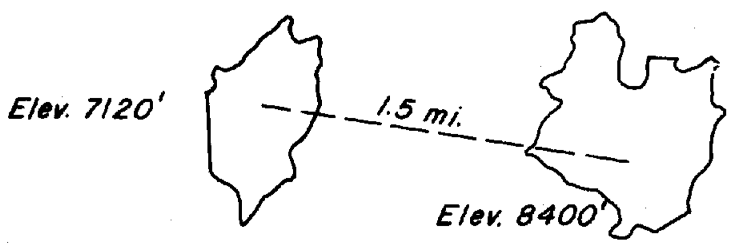


MILLER BASIN RESERVOIR

Location: White Pine Co.
Snake Valley - 195 / Spring Valley - 184
T. 16 N., R. 68 E.

15' map: Sacramento Pass, Nev.

Capacity: 1000 mw. (2000 mw. ult.)

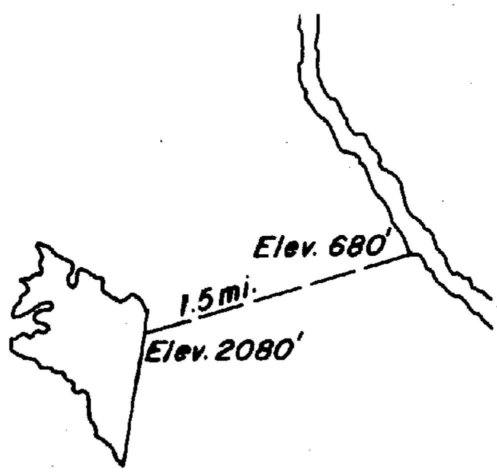


INDIAN RAPIDS RESERVOIR

Location: Clark Co.
Colorado River Valley - 213
T. 24 S., R. 65 E.

15' map: Black Canyon, Ariz. - Nev.

Capacity: 1000 mw. (2000 mw. ult.)



APPENDIX C

RATE OF USE

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CONSUMER USE

People Equivalent to Electric Energy Use

Given in the following table are estimates of the number of people -- somewhat inefficient people -- , it would take at hard manual labor for one hour to operate electrically the devices or processes listed.

TABLE 22: NUMBER OF PEOPLE AT HARD MANUAL LABOR EQUIVALENT TO ELECTRIC ENERGY TO OPERATE DEVICES AND PROCESSES

Device or Process	Number of People
100 watt light bulb	1.7
Color TV	3.5
Manufacturing one pop bottle	10
Toaster	18
Total electric energy to an average home (no air conditioning)	24
Room air conditioner	50
Electric dryer	70
Oven (baking a turkey)	75
Small lawn mower	160
Gas log (fireplace)	300
Motor bike	400
Riding lawn mower	650
Small car at 45 mph	1,000
Large car at 70 mph	4,500

Note: Estimates based upon a person's work output for one hour being 0.06 kilowatt hours.

The mix of how people actually call upon these devices and processes for their personal convenience determines what the average per capita use of electric energy will be for an area and time. On the average, Nevadans use sufficient electrical energy to employ quite a few people at hard manual labor in producing that energy. In 1970, each of us made use of electrical energy equivalent to 23 people working full time. Projections indicate that this "people equivalent to electric energy use" will become about 30 in 1980, about 39 in 1990 and about 49 in 2000.

Certainly, if each of us had to get on the treadmill to produce electric energy, the use would drop. We don't have to do this, but the previous comparison serves a useful purpose to gain attention for the problem of inefficient energy use, and therefore, the inefficient use of scarce water and related land resources. We should all focus upon making use of electric energy efficiently in order to conserve resources -- to save reasonably for the future.

Efficient Use of Appliances

In the design appendix, which follows next, brief attention is focused upon various types of electrical equipment. Industry and commerce can be more efficient in use and design of their process equipment, as well as that which they sell to the consumer. However, this report is more focused upon the pressures that the individual citizens of Nevada must face. Therefore, the efficient use of appliances will be discussed, because this is how the utility bill is reduced for residences, and the peak load upon generators is also somewhat reduced.

Unfortunately, household appliances are not rated as to their efficiency, so an individual has a difficult time finding out how to balance the purchase price against the amount of energy required for operation. The more the care in manufacture, the higher the cost, and probably the higher the efficiency will be. With long term usage, it may be possible to save money. Nobody has yet widely published efficiency versus operating cost for all of the common household appliances.

It is too early to say whether people really would rather pay more at first to save a little bit of energy, or would rather pay less at first and use more energy. Even if the efficiencies on every appliance were posted, the amount of time over its life cycle that an appliance would be in use would be a key factor in choice. In other words, for the long term, "less use -- buy cheap" and "more use -- buy costly". There are also the matters of customer acceptance and expected lifetime of the appliance, which depend greatly upon advertising and reputation of the product. So, by the time all these factors are put into the picture, what appeared to be a simple trade-off between purchase price and energy efficiency is really not simple for purposes of calculating an optimum point for application of policy. Still, the answer is that efficiency and cost correlate in general and will slowly seek their level in the market place, as we make many individual decisions with appliances as simple and invisible as pushing switches and turning valves.

In order to show the historical relative importance of various appliances to residential average annual use of electric energy, Table 23 has been provided. The Southeast was chosen because historical data were readily available in table form to illustrate how the factors in residential electric energy consumption are put together for any climatic area.

TABLE 23: SOURCES OF RESIDENTIAL AVERAGE ANNUAL USE

Electric appliance	1949			1959			1969		
	Saturation (%) (1)	Appliance annual use KWH (2)	Contribution to annual use KWH (3)	Saturation (%) (1)	Appliance annual use KWH (2)	Contribution to annual use KWH (3)	Saturation (%) (1)	Appliance annual use KWH (2)	Contribution to annual use KWH (3)
Refrigerator	69	360	248	97	415	403	98	660	647
Range	31	1,350	419	63	1,350	851	80	1,350	1,080
Water heater	16	4,050	648	44	4,490	1,976	71	5,175	3,674
Space heating	2	8,860	177	18	10,710	1,928	31	11,260	3,491
Air conditioner: 1/									
Room	5	1,250	6	15	1,355	203	36	1,680	605
Central				2	3,500	70	9	4,100	369
Television	1	400	4	74	400	296	99	400	396
Washer:									
Automatic	8	100	8	28	100	28	49	100	49
Nonautomatic	38	50	19	45	50	23	40	50	20
Dryer	4	940	38	9	1,130	102	35	1,335	467
Freezer	7	895	63	21	900	189	38	980	372
Dishwasher	1	325	3	5	285	14	16	340	54
Miscellaneous 2/			1,132			1,323			2,376
			2,765			7,406			13,600

1/Saturation is defined as the percent of residential customers having 1 or more room conditioners.
2/Lighting, small appliances, supplemental heat and other uses.

Note: The table shows the pattern and growth in residential average annual use for a system in Southeast.

Source: Federal Power Commission, 1970 National Power Survey, Part IV, page IV - 4-13.

Saturation (column 1) may be looked upon as the percentage of all residences having the particular appliance listed. Appliance annual use (column 2) gives the amount of energy the particular appliance would use if it were installed. Multiplying the percentage of residences having an appliance by that appliance's average annual energy use gives the contribution to annual use (column 3) for an average household.

This average annual energy use is therefore greatly impacted by several things:

FACTORS IN RESIDENTIAL
ELECTRIC ENERGY CONSUMPTION
FOR A PARTICULAR CLIMATE

1. Saturation, which depends highly on family income.

2. Size of residence and number of occupants.

3. Cost of electricity, which depends highly on costs of fuel for generation.

4. Efficiency of the appliances involved.

5. Attitudes of switch pushers and valve turners.

It is appropriate to now focus upon the last item -- attitudes of the people involved.

With per capita energy demands and population increasing, both total supply and peak capacity for generating electricity are coming increasingly under pressure. During peak periods of use, in the morning, at noon and in the evening, people should avoid excessive use of appliances, or schedule use for another off peak period of the day.

In addition to better scheduling, which will allow better use of existing generating capacity, just plain using less electricity is a worthwhile approach for preventing shortage.

For the purpose of promoting reduced household utility bills and lesser drain upon resources, the following 59 ideas for saving electric energy have been obtained through Sierra Pacific Power Company. None of the ideas amounts individually to a tremendous saving, but as a group they are significant.

HEATING: GOOD HABITS TO GET INTO

1. Set your thermostat at a comfortable daytime temperature - about 68-70 degrees - and leave it alone. Constantly adjusting the thermostat wastes energy. Each degree over 70° adds about 3% to your annual heating bill and each degree below 70° saves about the same. (5 degrees saves 15%).

2. Lower thermostat for sleeping. We suggest 60°. This will save about 10% on annual fuel bill. (1% saving per degree of "Nightime setback").

3. Keep bedrooms slightly cooler during the day or at any time rooms are not used.

4. "Shut off" comfort conditioning in all unoccupied rooms and shut doors to unused rooms.

5. Instruct children to close doors behind them. Don't leave the door open while you make several trips to and from the car.

6. Close windows near the thermostat. Open windows will only cool the thermostat, causing the furnace to overwork and overheat the rest of your house. If you need to open windows for ventilation, turn the thermostat off and try to do it during the warmest part of the day...or lower the thermostat and ventilate one room at a time shutting inside doors.

7. Close draperies, blinds, and window shades during the night and open them during the day. At night, the closed draperies act as insulation over cold windows; during the day the sun's warmth will supplement your heating system.

8. When you're not using your fireplace, make sure that the damper is tightly closed so heated air won't escape up the chimney.

9. Keep the area near your furnace free from obstructions, especially around the air intakes on the face of the unit.

10. Move furniture that blocks hot or cold air registers. These obstructions can reduce the efficiency of your furnace by restricting the free flow of air through the system.

11. Insulate your body - wear a sweater.

HEATING: MAINTENANCE

12. Before the start of the heating season, check your heating system to make sure it will operate at peak efficiency when you need it. (The price of a professional service call will pay for itself in energy savings.)

If You'd Rather Do It Yourself:

13. Check the color of the burner flame in your gas furnace. If the flame is yellow instead of the proper blue, there is not enough air in the combustion mixture and your furnace is wasting energy. Call a repairman and have him check the burner adjustment.

14. Press down on the belt connecting the fan motor to the blower (after turning the master power switch off, of course). When properly tensioned, the belt should have ¼ to ½ inch play at the midpoint between the two pulleys. Loosen the adjusting screws that mount the motor frame to the blower housing and slide the motor until the belt tension is right. Then retighten the screws.

15. Lubricate the bearings on the furnace fan and motor. Follow the instructions in your owner's manual or on the specifications plate attached to the motor.

16. Clean furnace filters regularly, about once a month, and replace annually. A dirty filter can reduce air flow, forcing your system to work harder - and longer - to heat your house.

17. Consider installing an automatic "Night setback thermostat" (clock controlled) to take advantage of reduced nighttime temperature energy savings automatically.

HEATING: WINTER-PROOFING YOUR HOME

18. To keep your house comfortable all year long, make sure it's adequately insulated. A well insulated house has at least six inches of insulation in the attic floor, three inches in the walls and six inches in the floors over crawl spaces. Check the effectiveness of the insulation in walls, floors and roofs. Thickness alone isn't a reliable measure of effectiveness. If more insulation is advisable, don't skimp; it pays off handsomely. Take advantage of energy conservation advice from your local Sierra Pacific Power Company office.

19. Drafts around doors and windows - caused by inadequate weatherproofing - can increase your annual heating bill by 15 to 30 percent. If you find drafts, caulk around outside window and door frames. You can also install weather stripping between sashes, at the top of the window frame, on the sill, and in the window channels. A spring bronze ribbon works best in these places. For quick and inexpensive window winter-proofing, press a sponge rubber strip into the space between the upper and lower sashes. You'll know that your house is relatively draft free when light condensation forms on the inside of the windows on the downwind side of your house during cold weather.

20. Install storm windows or polyethylene sheeting to cut by 50 percent the amount of heat lost through windows. Also, the temperature difference between the interior and exterior will be balanced, eliminating that "cold feeling" near windows.

21. Seal air leaks to the attic and crawl space - around doors, ceiling fans, electrical fixtures, plumbing fixtures, heating ducts, and pulldown stairways. But don't close the attic space louvers - they're needed for ventilation to prevent moisture buildup. Air vents under your house are necessary to provide adequate ventilation. If you partially close air vents during the winter, be sure you open them when warm weather starts, to prevent dry rot.

22. To prevent heat loss from warm air supply and cold air return ducts that go through cold spaces, wrap them with quality fireproof insulation. Check all of the ducts for leaks, especially around connecting joints. Fix any leaks you find with duct repair tape. Install a humidifier on your heating system. Adding humidity to the heated air during the dry winter months not only keeps your house more comfortable, it conserves energy. Humidified air is comfortable at substantially lower temperatures than dry air.

23. Interconnect the light and exhaust fan switches in bathroom to avoid expelling conditioned air unnecessarily. Better yet, install a clock timer switch (15 minute maximum) on the fan.

24. Make sure <u>all</u> exhaust fans have automatic dampers.

25. Your thermostat may not be 100% accurate. Check with good thermometer and mark or reset the thermostat accordingly.

APPLIANCES: IN THE KITCHEN

26. Keep your appliances clean. Clean the condenser coils on the refrigerator; dirt acts as an insulator, so your refrigerator must work harder - and longer - to maintain the proper temperature. Defrost your freezer when the frost is ¼ inch thick. And be sure the door fits tightly; if there are any leaks around the door, replace the rubber gasket. A frost-free refrigerator requires 50% to 60% more energy to operate than a standard model. The standard model costs between $2 and $4 per month to operate, and the frost-free model costs $3 to $6.

27. Limit the use of small appliances with heating elements - electric frying pans, toasters, and countertop ovens. However, use these appliances instead of the standard oven for small cooking tasks.

28. Keep the exhaust fan filter clean; don't overwork the motor by forcing the fan to pull air through a dirty filter.

29. A clear blue flame from the burners on your gas range means the burner is operating properly. If the flame is yellow, it's probably clogged with tiny bits of food. Remove the burner, and use a wire pipe cleaner to clean the ports. If this doesn't solve the problem, call a repairman - don't try to make any adjustments yourself.

30. On a gas range, don't use more flame - and gas - than necessary. The tip of the flames should just touch the bottom of your pots, pans, and other cooking utensils. Use proper size pans for burners to avoid waste of heat and use lids to speed cooking time and save heat.

31. On an electric range don't preheat the element, also turn off the burners five minutes before the end of the proper cooking time. The burner element will stay hot and your food will continue cooking--without consuming any energy. The stove accounts for 5% to 7% of your utility bill. Self-cleaning ovens are large consumers of energy. Use the self-cleaning feature sparingly.

32. When using your oven, don't set the temperature higher than you will need; your oven won't heat up any faster, but you will waste energy. Only foods containing leavening agents such as cakes and breads require a pre-heated oven for baking, and then you need to preheat for only 10 minutes. Roasts, casseroles and other foods can be placed in a cold oven and will cook perfectly. Defrosting foods before cooking is another great saver, cutting energy usage by about 2/3's.

33. Check the temperature of your oven with a thermometer to be sure that the dial is accurate and that you're not wasting energy by unknowingly using higher than necessary temperatures.

34. Run full loads in the dishwasher; that way, you don't waste water - or energy heating it, and avoid using the dishwasher during the peak period between 5:30 and 8:30 p.m.

35. Don't waste hot water flushing food scraps down your waste disposer. Cold water will do the job better.

APPLIANCES: IN THE LAUNDRY

36. Run full loads in the washer and dryer.

37. Whenever practical, wash clothes in cold water with the proper cold water detergent.

38. Use the shortest cycle possible, so you don't over-dry clothes. You'll soon learn how long it takes to dry various loads.

39. Clean the dryer lint trap after each load. A dirty lint trap lengthens the cycle time, and your clothes won't dry as well, either. Also, check the dryer exhaust to the outside of your house to make sure it isn't blocked by shrubbery or outdoor equipment. If there is a screen or nylon stocking lint collector, make sure that this is clean.

APPLIANCES: IN GENERAL

40. Become thoroughly familiar with the operation of all your appliances; you may be unknowingly wasting energy. Always read the operating instructions in the owner's manual before you start using a new appliance and keep it handy for reference.

41. Clean or replace your vacuum cleaner bag before it is filled to capacity. If there is a change in the sound of the cleaner, or if the motor housing gets too hot to touch, check for blockage in the hose or brush.

42. Your water heater is the most expensive appliance to operate after the furnace and air conditioning unit. It feeds the ever active washing machine, dishwasher and shower. Therefore, when possible run washing machine on cold water. Don't wash dishes under hot running water. Reduce the amount of time spent in hot showers. A 15 minute shower will use 30 gallons of hot water. Sediment in the bottom of your gas water heater tank may be insulating the water from the heat source. Flush the sediment out of the tank periodically by draining a couple of buckets of water from the faucet at the bottom of the tank. Also, make sure the temperature on your water heater isn't set higher than you need - 150 degrees is about right.

43. Color television sets consume more energy than the same type black and white model. Solid state sets (both color and black and white) consume less energy than filament (tube) sets. Larger screens consume more energy than smaller screens. Sets that have the instant turn-on feature are consuming electricity 24 hours a day. This feature costs more for the initial purchase and more to operate and maintain. If you have a television set with the instant turn-on feature, unplug the set when not in use, or plug it into a switched wall outlet.

44. Optional extras on all appliances use extra energy. Remember that you have the option <u>not</u> to buy them.

45. Try to avoid using your appliances during peak periods of energy use, normally 5:30 to 8:30 p.m. during the winter months.

MISCELLANEOUS

46. Turn off everything not being used, especially incandescent lights. Turning all types of lights on and off uses less power than leaving them on.

47. Use flourescent lights whenever possible - in the bathroom, family room,kitchen. Flourescent lights are about 4 times as efficient as incandescent lights, and last 7 to 10 times as long. Twenty percent of the electricity received by a flourescent tube is converted to light, whereas 5% is converted to light when the incandescent bulb is used. Use lights in specific work areas, instead of lighting the entire room. Turn off lights when room is not in use.

48. Repair leaking water faucets - especially hot water faucets. A faucet that drips once per second wastes about 2,500 gallons of water per year.

49. Eliminate unnecessary outdoor decorative lighting. Ask yourself if you really need those spotlights or those lights lining your driveway.

50. If possible, turn down your gas yard light or install a self-contained solar cell and valve which will automatically dim it during the day. It's one of the greatest consumers of energy.

51. Replace old or inadequate wiring. You'll know you have a wiring problem if the television picture shrinks when the refrigerator comes on, or if fuses blow or circuit breakers frequently trip. A voltage drop of ten percent - common in many older homes - will have an alarming effect on the efficiency of your appliances. Your toaster will work 20 percent longer, and you'll get 30 percent less light from incandescent light bulbs if the wiring is inadequate.

52. Avoid heating electrically whenever possible. It costs at least twice as much as other forms of heating.

TIPS FOR NEXT SUMMER

53. Have your cooling system checked by a qualified service man before the start of the air conditioning season.

54. Make sure that shrubs and grass don't block the flow of air through the condenser outside. And, keep the coils clean.

55. Leave your storm windows installed during the summer to help keep the heat outdoors.

56. Set your thermostat at a comfortable day-round temperature and leave it alone. But it really pays to turn it up if you're away from home; you'll save about five percent on operating costs for every degree you raise the thermostat.

57. Close draperies during the day. Light-colored curtains and blinds will reflect the sun's rays and reduce solar heat gain by up to 50 percent.

58. Use outdoor shade-makers: awnings, trees and wide eaves wherever possible.

59. Air conditioner units. Installing the correct size and most efficiently designed unit can cut your power consumption for this appliance in half. To determine the efficiency, check the numbers on the back of the machine. Divide the BTU per hour rating by the number of watts input. You will get a number ranging from 4.7 to 12.2. The higher the number the more efficient the machine. This efficiency check can also be made for clothes dryers. The most efficient unit of the correct size will guarantee the lowest overall cost.

APPENDIX D

DESIGN

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APPROACH TO DESIGN

Imposed or Free

Improvement in design of electric energy using products cannot be efficiently imposed upon the competitive structure of choice. This is because the market place shifts to absorb the effects of changes.

Costs of equipment, appliances and structures rise as increasing requirements are imposed upon efficiency of operation in order to conserve electric energy. People will then purchase relatively more of cheaper substitutes, which will not be as efficient with respect to electric energy use. If this trade off between efficiency of operation and purchase price were not basically true, what would be the basis of careful shopping? To match shopping tastes, sellers try to make a profit by convincing people that their product design is just a little better than some other group's design.

It is in the "free" individual spirit of proper reflection and adjustment in the market place that material on improving design has been presented herein, although at times it may appear that imposition is more fashionable. From the standpoints of individuals on the production side -- designers, manufacturers, architects and engineers -- each should try just a little bit extra to make the most efficient choices available at lowest cost to consumers.

Otherwise, the desired result of increased efficiency and low cost cannot occur. The opposite effect is decreased efficiency and high cost. Pressures of inefficiency, resulting largely from recent governmental interventions, are heavily felt by those who must borrow money for the short term at high interest rates. In the long run, these pressures can be translated into increased pressure on Nevada's scarce water and related land resources.

Future and Existing Structures

For improving efficiency of electric energy use, design improvements for large and small buildings, and the equipment and appliances installed, should be carefully examined.

Design changes for saving energy in small structures are not addressed here in detail, because of their extremely diverse nature. However, costs of these changes to individual homeowners are quickly reviewed. Basis of review is $1,000 of additional cost at time of purchase, at 6%, 8% and 10% interest, for such items as increased insulation, double glazing and more efficient heating and cooling equipment.

UNIFORM MONTHLY AND TOTAL
PAYOUT REQUIRED FOR ADDITIONAL
$1,000 INVESTED IN A HOME FOR
ENERGY SAVING IMPROVEMENTS

Interest		Number of Years for Loan				
Rate, %	Payout	5	10	15	20	25
6	$monthly	19.34	11.11	8.44	7.17	6.45
	$total	1,160	1,333	1,519	1,721	1,935
8	$monthly	20.28	12.14	9.56	8.37	7.72
	$total	1,217	1,457	1,721	2,009	2,316
10	$monthly	21.25	13.22	10.75	9.66	9.09
	$total	1,275	1,586	1,935	2,318	2,727

In order to convince people that they should accept design improvements totalling $1,000, to save energy at a 10% interest rate, the benefit of energy saving must exceed: $21.25 per month for the short term loan of 5 years; or $9.09 per month for the longer term loan of 25 years. With this range of monthly costs in mind, it can be seen why interest rate and term of loan are market place determinants of whether additional design improvements will be purchased. The higher the interest rate and the shorter the term, the less incentive there is to invest money for the purpose of saving energy. Of course, each price increase decreases the immediate saleability of an average home, with attendant sales and employment impacts for construction and related industries.

Design constrains operation and maintenance of large structures as systems. The role of efficiency in electric energy conservation can be illustrated by proposed design considerations for large buildings not yet constructed and by methods of maintenance and operation for existing large buildings.

Many publications relate to design, maintenance and operation of large buildings. In these regards, the June 1974 issue of Professional Engineer Magazine has provided two articles reviewing important facts and recent developments. These articles were abstracted and included in this appendix. The first article, on design for future buildings, was by the PE Magazine staff; the second, on operation and maintenance for existing structures, was by Herman Blum Consulting Engineers for PE Magazine.

Design of Large Buildings

The General Services Administration (GSA) supervises the design, construction, maintenance and operation of most Federal office buildings. GSA sees growing need for publishing recently developed (1) guidelines that will make designers, builders, managers, and owners aware of the numerous ways to save energy in building design and operation.

While much of the information contained in GSA guidelines was developed from the GSA Energy Conservation Demonstration Building study for Manchester, New Hampshire, the guidelines apply to buildings in all regions of the United States. When the construction of the Manchester Demonstration Project has been completed, the results for the various electrical/mechanical systems will be evaluated. It is anticipated that these findings will necessitate further refinements in the guidelines.

Some of the major factors which influence energy consumption in buildings are user needs, climate, sun, wind, site, orientation, building envelope, electrical, illumination, and mechanical systems.

GSA's study contains more than 170 ideas for conserving energy in building design, construction, and use. Due to the wide range of these proposals, no single building can be expected to include all of the ideas. The following is a list of some of the more important points included in the guidelines:

1. Cover exterior walls and/or roof with earth and planting to reduce heat transmission and solar gain.

2. Shade walls and paved areas adjacent to building to reduce temperature.

3. Collect rain water for use in buildings.

4. Select sites with high air quality to enhance natural ventilation.

5. Select sites that have topographical features and adjacent structures that provide wind breaks.

6. Select sites that allow optimum building orientation and configuration to minimize yearly energy consumption.

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(1) GSA's Public Buildings Service (PBS) contracted with the energy consulting firms of Dubin-Mindell-Bloome Associates, Heery and Heery, Architects, and the AIA research Corporation to develop a comprehensive set of energy conservation guidelines.

7. Select sites that allow occupants to use public transportation systems.

8. Select building configurations that give minimum north wall exposure to reduce heat losses.

9. Construct exterior walls, roof, and floors with high thermal mass, for example 100 pounds per cubic foot.

10. Consider the length and width aspects for rectangular buildings as well as other geometric shapes in relationship to building height and interior and exterior floor areas to optimize energy conservation.

11. Do not heat parking garages.

12. Consider the amount of energy required for protection of materials and their transport on a life-cycle energy basis.

13. In climatic zones where conditions are suitable for natural ventilation for a major part of the year, install windows that open.

14. Use corridors as heat transfer buffers and locate against exterior walls.

15. Consider landscaped open planning which allows excess heat from interior spaces to transfer to perimeter spaces which have a heat loss.

16. Locate equipment rooms on the roof to reduce unwanted heat gain and heat loss through the surface. They can also allow more direct duct and pipe runs reducing power requirements.

17. Use open planning that allows more effective use of lighting fixtures. The reduced area of partitioned walls decreases the light absorption.

18. Provide controls to shut down all air systems at night and on weekends except when used for economizer cycle cooling.

19. To enhance the possibility of using waste heat from other systems, design air handling systems to circulate sufficient amounts of air for cooling loads to be met by a 60°F air supply temperature and heating loads to be met by a 90°F air temperature.

20. Design HVAC systems so that they do not heat and cool air simultaneously.

21. Adopt as large a temperature differential as possible for chilled water systems and hot water heating systems.

22. Consider the use of thermal storage in combination with unit heat pumps and a hydronic loop so that excess heat during the day can be captured and stored for use at night.

23. Consider the use of solar energy collectors for heating in winter and absorption cooling in summer.

24. Consider the use of a total energy system integrated with all other systems.

25. Use high efficiency transformers which are good candidates for life-cycle costing.

26. To reduce the quantity of hot and cold water used, consider the use of a single system to meet hand washing needs.

27. Consider the use of solar water heaters using flat plate collectors with heat pump boosters in the winter.

28. Heat building to no more than 68°F in winter when occupied and 60°F when unoccupied.

29. Cool building to no less than 78°F when occupied and no cooling when the building is unoccupied.

30. Light a building when occupied only.

31. In selective lighting, consider only the amount of illumination required for the specific task, taking into consideration the duration and character and user performance required as per design criteria.

32. Turn off lights that are not needed.

33. Schedule cleaning and maintenance for normal working hours or when daylight is available and sufficient for task.

34. Draw drapes over windows or close thermal shutters when daylight is not available and when the building is unoccupied.

Copies of the complete guidelines are available for $2 per copy from GSA Business Service Centers throughout the country.

Operation and Maintenance for Existing Structures (1)

Broad brush analysis may not be effective in many existing structures. Here, the greatest impact of thrift will result from a large number of people solving a multitude of small problems. Some of the items which may be considered are:

1. Cleaning--check this first. An accumulation of dirt can reduce the capacity of air and water systems by as much as 30 percent. This item always seems to lose the battle of the budget.

2. Ability of the system to function--check this second. Are there signs of extensive maintenance and repair? Are the coils in good shape--not chopped up by leak repairing? Are the covers of the starters indicating extensive trouble tracing or marginal overload selection? Are the dampers connected to the control motors? If not, this is strictly manual operation.

3. System operation--check this third. Most of the time the people involved will be doing a good job considering the existing equipment.

a. Is the system started at 3 a.m. Sunday morning to be ready for Monday operation? Does the system run all night? Why? Is the system supplied with 38 degree water when designed for 45 degree? Why?

b. Has a change in occupancy made operational changes necessary? What can be done to reduce operational cost?

c. Is there one office which requires a 68 degree temperature when the remaining spaces are satisfied at 75 degrees? What can be done to reduce operational cost?

d. Are there traditional operating procedures which are no longer required?

4. Energy consumption--check this fourth. Do power and gas billings show any heavy increases in consumption between any two months? Don't forget the cost of district steam. This is going to be a very expensive item in the future.

5. Efficiency of operation--check this fifth.

a. Has a combustion analysis been made on fuel burning equipment recently? Surprises often occur here.

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(1) From an article by Herman Blum Consulting Engineers, published in the June, 1974 issue of Professional Engineer Magazine.

b. Have amperage readings been made on large motors recently?

c. Has a power factor survey been made recently?

6. General condition status--check this along with the other five.

a. Have several additional piping and duct systems been connected to the original installation?

b. Is part of the system marginal due to leaks, noise, or high energy consumption?

c. Is the pneumatic temperature control piping system free of oil and water? Does the control compressor run more than it should? Is practically all control accomplished by manual adjustment?

d. Is the condenser water piping and steam condensate piping in good condition?

e. Have the bolted joints in motor control centers and starters been torqued to specification lately?

f. Are any of the branch circuit conduits warmer to the touch than they should be? Do all of the breakers stay on?

g. Are any of the electric motor bearings warmer than they should be? Is there any noise or vibration originating in a part of the system that should not be there?

h. What is the condition of the insulation? Should more surface be covered?

APPENDIX E

NATURAL LIMITS

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APPENDIX E

Parts 1 and 2: AVAILABLE ENERGY AND PROCESS OPERATING TEMPERATURE

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Parts 1 and 2: AVAILABLE ENERGY AND PROCESS OPERATING TEMPERATURE

CONCEPT OF NATURAL LIMIT

Judgment of the Market Place

Subject to the judgment of the market place, it would be useful for future energy planning to have a concept of natural limit against which to measure proposals and achievements. Such a concept is embodied in the words "available energy". These words point to a rational and technically sound basis for examining sources and uses of energy for increased efficiency within the total national energy system.

The long term need to conserve energy has only recently been forcefully brought to the public consciousness. Because of the newness of the situation, many regulatory, economic and technical proposals are being hastily considered.

It is necessary to quickly confront problems involving available energy. Our economy and cultural existence depend upon energy use, as is reviewed in Part 3 of this appendix, under "Paramount Position of Energy". However, in our rush to do something about the energy "crisis", it is important to remember that natural laws of thermo-dynamics govern the amount of available energy from any fuel in any process for doing work. The fuels and processes--the source-use combinations--which we have at our disposal are undeniably wasteful of available energy, but practical limits upon improving their technology will cause savings to be difficult.

Concept of Available Energy

The concept of available energy describes practical limit because fuels contain known amounts of chemical energy not all of which is actually available for use, and processes can only obtain some of this available energy in performing work, (i.e. useful jobs). In energy terms, what is available from a refined fuel, what we take in operating a process, and what is obtained as work for any job at hand are greatly different in amount. There is certainly great potential for saving available energy by more efficient practices in areas indicated by the following description:

POTENTIAL FOR SAVING
AVAILABLE ENERGY BY
INCREASED EFFICIENCY

Areas to Increase Efficiency (1)

1. W means useful work obtained from a process.

2. C means energy consumed by a process in doing work.

3. A means energy available from a fuel to do work, usually referred to as thermodynamic availability (2).

Inter-relationships

(A - W) = total possible energy saving for combination of fuel and job.

(A - C) = possible energy saving associated with combination of fuel and process.

(C - W) = possible energy saving associated with combination of process and job.

The first area, indicated by W, depends primarily upon what jobs people want and need to have done at any time and place to make use of energy. Proper reflection upon whether a job needs to be done, and if so, where and when are factors of efficiency subject to the invisible reasoning of individual choice. A smooth flow of jobs usually indicates greater efficiency than short busy periods followed by long quiet periods.

The second area, indicated by C, depends primarily upon the process chosen at any time and place to make use of energy. Approaches to choosing a process in various industries are most often connected with minimizing the sum of first cost and operating cost over the life of the process equipment -- in short, economics. Residential and commercial users may be more subject to simply minimizing first cost, particularly in tight money and high interest rate situations. Overall, despite the obvious economic primacy in choosing a process, the factors of individual choice are still invisible to planners, and set limits upon efficiency.

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(1) In relative magnitude, W is always less than C, which is in turn always less than A, by definition herein.

(2) Recognition of the extent to which the energy of a fuel can be used to obtain work is attributed to Josiah W. Gibbs (1839 - 1903), an American physicist.

The third area, indicated by A, depends primarily upon the fuel chosen at any time and place to supply energy. The fuel may be converted at the place of use, or the fuel may be converted remotely, and the energy brought in over a power line or pipeline. In this manner, the market place may judge increased saving or loss of thermodynamically available energy through substitution of fuels, together with any transportation required.

Three differences, (A-W), (A-C) and (C-W) show the mutual influences among pairs of the previous three individual areas. The total possible available energy saving, indicated by (A-W), depends upon the combined choice of fuel and job, and is the sum of the component differences, (A-C) and (C-W). The difference (A-C) depends upon the possible available energy saving due to the combined choice of fuel and process. The difference (C-W) depends upon the possible available energy saving due to the combined choice of process and job. It is the two component differences which must be targets for more efficient use of thermodynamically available energy.

When attempting to make more efficient use of available energy, the proper conceptual approach is to decrease the size of each of the three individual areas while also decreasing the size of the three difference terms. How these differences might best be reduced within thermodynamic limitations has not yet become strongly obvious. There simply has not been enough private and government money and time expended on this new situation to form a strong judgment within the market place.

Process Operating Temperature

Process operating temperature is a category which should be closely examined for potential saving of total available energy. Typically, fossil fuels and electric resistance heating are capable of reaching much higher temperatures than required for much of the useful work being accomplished. For instance, it does not make sense in energy terms to burn the same fuel in a residence to heat domestic water as is burned in a power plant to make steam for generating electricity. The power plant steam cycle may be more efficient, but the residence does not need water even coming close to steam temperature. From the standpoint of saving total available energy, why use a fuel which burns hot enough to operate a large scale power plant when all that is needed is a little bit of hot water for washing people, clothes and dishes? The same question would be applicable to residences equipped with electrical water heaters.

This simple example involving process operating temperature shows why efficient use of energy by the customer is a developing field for investment of research money and time. Solar heating and cooling studies and experimental equipment for residences and buildings are related to this effort. Replacing non-renewable fossil fuel resource use with renewable solar resource use in this case is doing no more than supplying the needed work with a process more appropriate to the need. Where and when economically feasible, substitution can pay big dividends in fossil fuel available energy saved, particularly when considering low "end use" efficiencies achieved by the average customer.

Useful work actually obtained from the end user's equipment is usually in the neighborhood of 1% to 10% of the available energy of the fuel before conversion. Thus, low efficiency of fuel conversion in the production of electric energy and low efficiency of electricity use by the customer's equipment serve to show that all the branches in the energy picture should be traced.

Combustion of fuels, heat transfer and end use equipment with methods of use account for the largest losses of available energy. For example, in the production of electric energy, about 90% of a fossil fuel's original energy content is available energy. Upon combustion, 25% is lost. Heat exchange in the boiler loses another 15%. Still another 15% is lost by combination of heat rejected in the plant cooling system and in distribution of energy. This leaves about 35% (usually between 30% and 40%) of original energy content for the customer as electrical energy. The customer may subsequently obtain in the neighborhood of 10% of available energy content because of inefficiency in converting electrical energy into work.

Conclusion

This last description involving electrical energy highlights the fact that useful work is the end product of a long chain of steps. When there is abundant energy, work is the only thing we care about. When energy becomes scarce, we must look at parts of the long chain for saving of available energy, in order to make sure there is energy available for doing work.

Nobody has been wise enough to know the full energy situation. We must be content with a few ideas which stand out. There are a lot more jobs than processes, and only a few fuels, and their choices in the market place are collectively interrelated as shown by the differences, (A-W), (A-C) and (C-W). Once chosen, both A and W are thermodynamically determined, while C is determined by choice from available technology and process thermodynamic limitations. Therefore, the elements of choice in the market place, technology and thermodynamic limitations have mutual influence and limitation.

The concept of available energy allows individual choice in areas indicated separately by W, C and A. In order to conserve energy through greater efficiency, each area can make a contribution. However, inter-relationships among W, C and A must be considered, as shown by the differences (A-W), (A-C) and (C-W). These differences, along with individual components, are the products of tremendous, long term forces behind the elements of choice and technology, within thermodynamic limitations.

Previous conditions, for areas in which the concept of available energy must be applied, indicate that increased efficiency will be difficult to secure. Still, with or without governmental conservation policy, applying the concept of available energy in a thermodynamic limitation sense, will increase the efficiency with which we use our energy resources.

APPENDIX E

Part 3: AMOUNT AND ITS DISTRIBUTION

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Part 3: AMOUNT AND ITS DISTRIBUTION (1)

OVERVIEW

Reasons and Bases for Preparation

This report may seem like a lot of preparation just to attempt to define some sort of a balance in Nevada.

Remember that the amount of electric energy which Nevada imports from California and other States is in the neighborhood of 1/2% of California's total production, but has been about 1/4 of our total usage. That almost 1/2% means a lot to the people of California under energy short conditions, but it means half a hundred times more to Nevadans.

Energy policy shifts in California or the West or the nation with regard to electric energy use and generation, or the availability of fuels, could have major impact upon Nevada. This report can strengthen Nevada's ability to influence development of Western regional energy planning, consistent with Nevada's long range needs.

With regard to electric energy generation and use, natural limitations are the bases in Nevada, as part of the West and the nation, of trying to reach:

GOAL

Reasonable economic-environmental balance at a high level of efficiency.

We believe it is realistic to try to reach this goal, and have provided this report as a basis for making the attempt.

Planning, Population Control and Efficiency.

The thrust of planning is to influence -- directly or indirectly --numbers of people and their distributions (2), along with associated activities. For whatever purposes, this amounts to population control. There are natural limits upon population control, the bounds and meaning of which are soon to be described.

---

(1) Amount or number and its distribution, for population and related activities. Electric energy generation and use and general resource uses and economic activities are included.

(2) Numbers of people are distributed by place and other important classifications which might include age, sex, race, religion, wealth, health, education, skill, housing, employment status, etc.

If planning accomplishments are kept in bounds by natural limits upon ability to control population, then these limits are a measure of what goals can reasonably be accomplished and thereby provide a practical basis for planning.

In short, natural limits upon the ability to control population provide the basis, measure and limit of efficient planning. Under these limitations, there is no use planning for goals which cannot be efficiently accomplished.

MEANING

Natural Limits and Efficiency

The remainder of this appendix is organized in reasonable detail to show in terms of natural limits and efficiency for electric energy, the meaning of:

TABLE 24: ORGANIZATION OF APPENDIX TO SHOW MEANING

1. Highly predictable nature of amount and distribution for population, economic activity and resource use (1).
2. Paramount position of energy production and use as they behave as cause and effect of amount and distribution.
3. Consequent limitations upon what public and private entities may expect to accomplish by planning.

Highly Predictable Nature

Tremendous Forces - Smallest Pieces

Figures 6, 7 and 8, along with Table 6, are reproduced in this section. The figures visually demonstrate the highly predictable nature of the tremendous forces involved with determining amount and its distribution for:

---

(1) Amounts and distributions for population, economic activity and resource use are relatable, because people participate in economic activity and resource use. For instance, people use electric energy in their everyday economic activities -- residential, commercial and industrial. Generation of electric energy makes use of resources, such as fuel, water, land and air. Since electric energy involves both economic activity and resource use, in which people participate, it makes sense to think in terms of per capita electric energy.

FIGURE 6

POPULATION GROWTH PATTERNS FOR THE NATION AND GROUPINGS OF STATES BY AREA AND CLASS, 1920-2020 (Data taken from table 6)

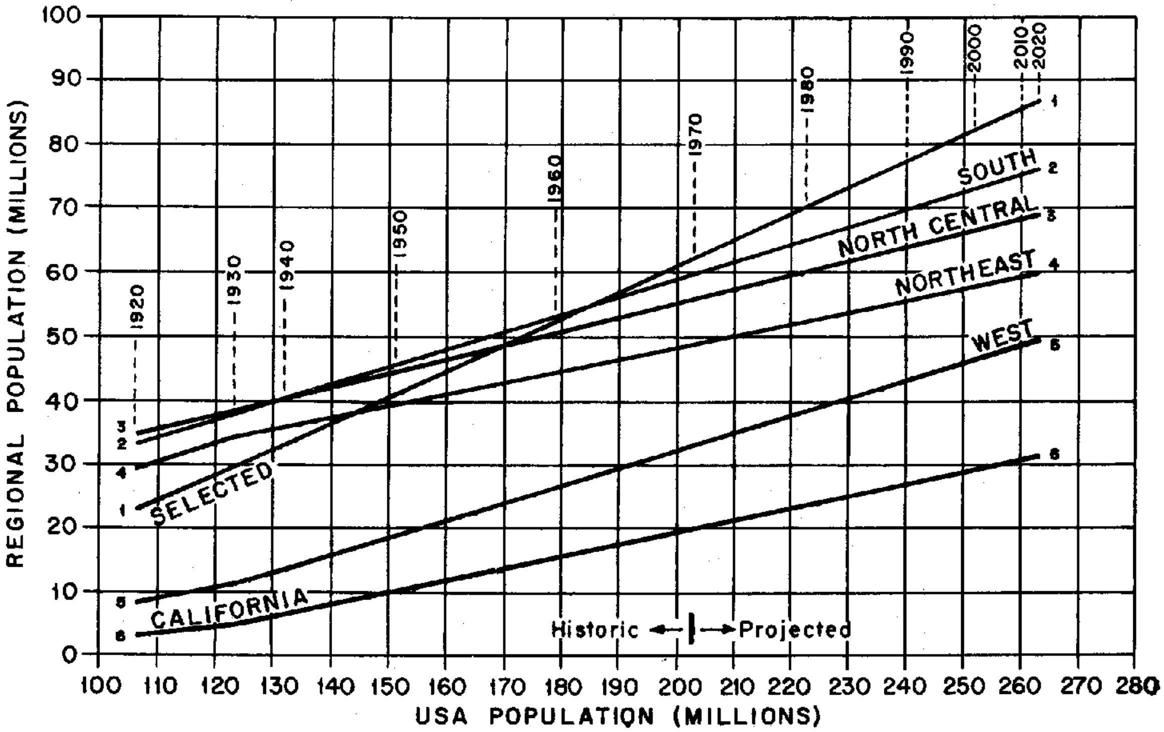

FIGURE 7

ELECTRIC ENERGY GENERATION GROWTH PATTERNS FOR THE NATION AND GROUPINGS OF STATES BY AREA AND CLASS, 1920-2020 (Data taken from table 6)

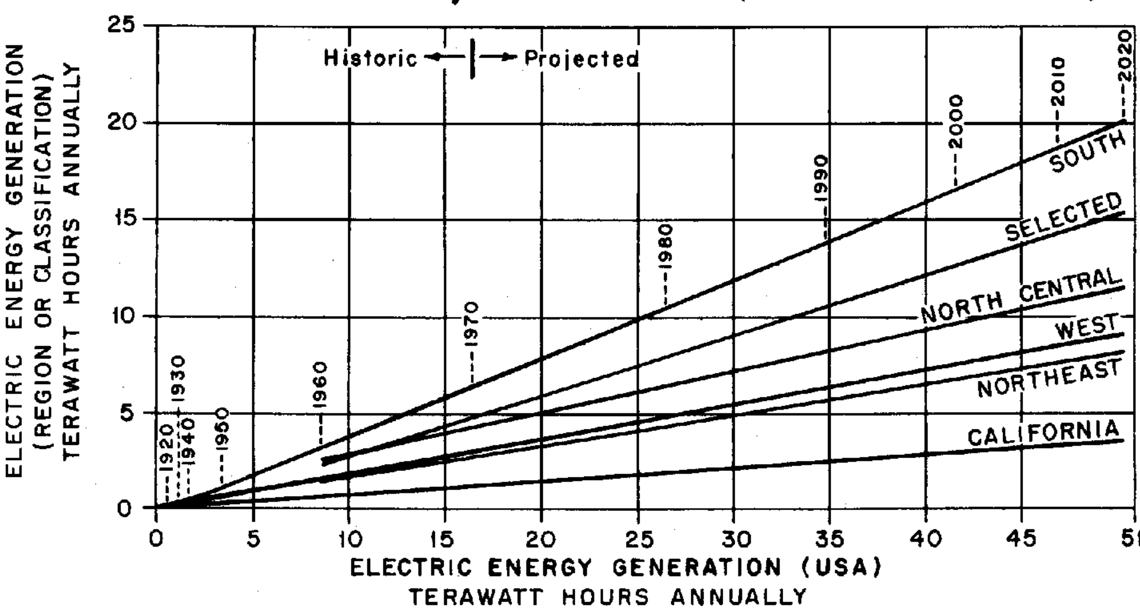

FIGURE 8

PER CAPITA ELECTRIC ENERGY GENERATION GROWTH PATTERNS FOR THE NATION AND GROUPINGS OF STATES BY AREA AND CLASS, 1920 - 2020 (Data taken from table 6)

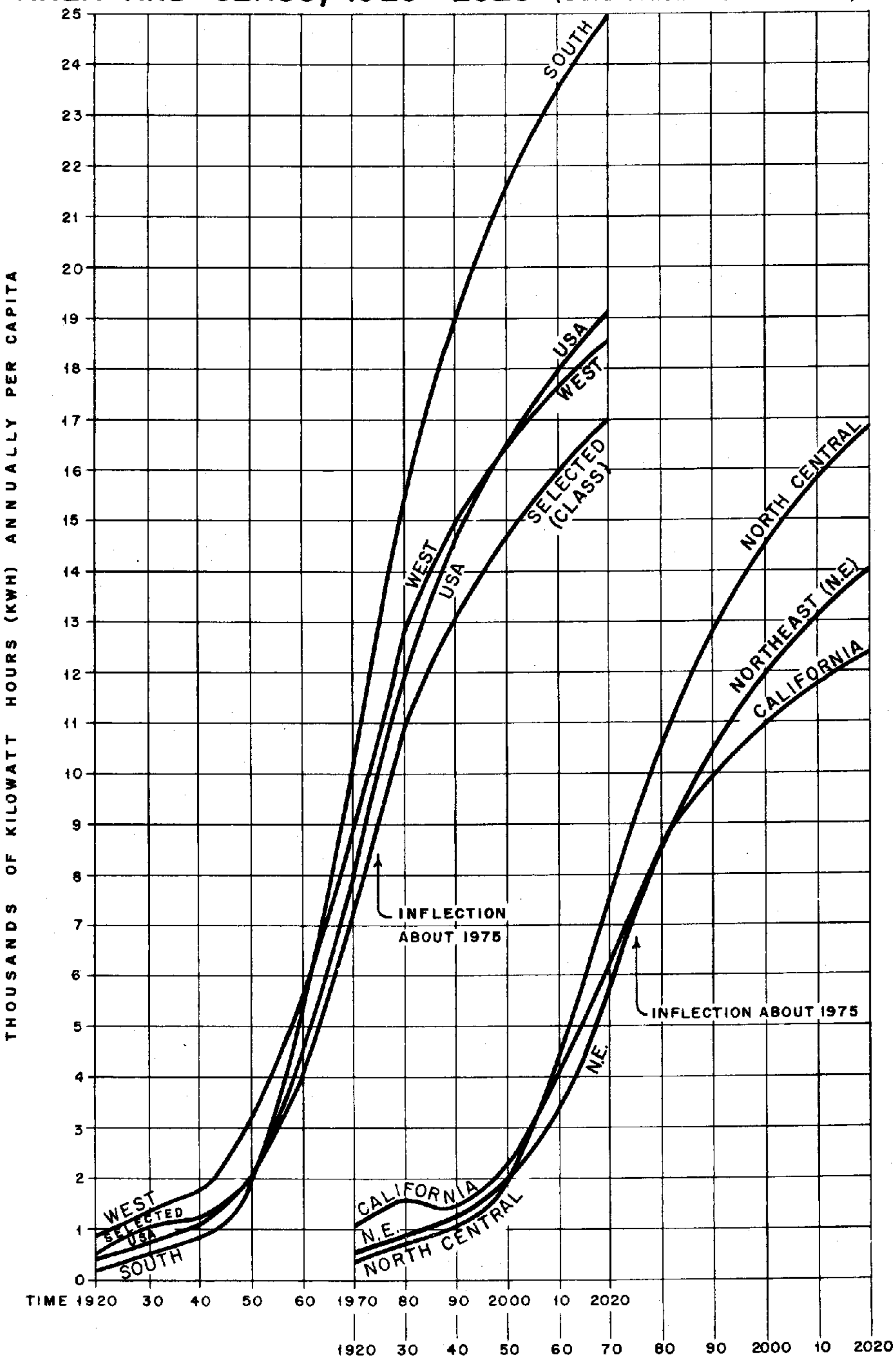

TABLE 6:

POPULATION AND ELECTRIC ENERGY GROWTH PATTERNS FOR GROUPINGS OF STATES BY AREA AND CLASS, 1920-2020

Population data were taken from Table 14 of the 1973 Statistical Abstract of the USA. Electric Energy generation data for 1960 and 1970 were taken from Table 834 of the same source. Comparable tables from prior Abstracts were consulted to obtain data for 1920, 1930, 1940 and 1950.

	Historic						Projected				
	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010	2020
POPULATION											
USA (Thousands)	106,022	123,203	132,165	151,326	179,323	203,212	223,000	239,000	252,000	260,000	263,000
Northeast	29,662	34,427	35,977	39,478	44,678	49,041	52,900	55,800	58,000	59,400	60,000
North Central	34,020	38,594	40,143	44,461	51,619	56,572	61,100	64,900	67,800	69,400	70,200
South	33,126	37,858	41,666	47,197	54,973	62,795	68,300	73,100	77,000	79,500	80,500
West*	8,902	11,897	13,882	19,562	27,194	33,734	38,900	43,100	46,800	48,700	49,500
Selected	23,111	30,400	33,954	42,270	54,854	65,051	73,500	80,500	86,500	89,800	90,800
California	3,427	5,677	6,907	10,586	15,717	19,953	23,500	26,400	28,800	30,100	30,800
ELECTRIC ENERGY GEN.											
USA (TWH)	43.6	95.9	145	329	842	1,640	2,654	3,492	4,158	4,680	5,023
Northeast	15.8	31.5	454	79.6	155	287	455	590	695	780	840
North Central	13.1	28.1	421	94.6	232	416	645	835	980	1,100	1,180
South	6.7	19.8	33.5	90.7	301	627	1,040	1,380	1,658	1,870	2,010
West*	8.0	16.4	24.0	64.2	153	304	492	644	771	860	920
Selected	13.6	31.2	41.0	86.7	225	467	790	1,055	1,260	1,430	1,540
California	3.7	8.9	9.8	24.8	64.9	124	200	264	315	355	380
PER CAPITA GEN.											
USA (KWH Per Cap)	411	778	1,097	2,174	4,695	8,070	11,900	14,613	16,500	18,000	19,100
Northeast	531	916	1,261	2,016	3,465	5,854	8,600	10,573	11,980	13,130	14,000
North Central	386	729	1,049	2,127	4,496	7,353	10,550	12,866	14,454	15,850	16,809
South	201	524	805	1,922	5,482	9,977	15,200	18,878	21,532	23,520	24,969
West*	897	1,380	1,730	3,284	5,640	9,018	12,650	14,950	16,467	17,660	18,586
Selected	588	1,026	1,208	2,051	4,102	7,179	10,748	13,106	14,566	15,924	16,960
California	1,080	1,568	1,419	2,343	4,129	6,215	8,511	10,000	10,938	11,794	12,338
PER CAPITA RATIOS FOR: (GROUPINGS/USA)											
Northeast	1.292	1.177	1.149	.927	.738	.725	.723	.724	.726	.729	.733
North Central	.939	.937	.956	.978	.958	.911	.887	.881	.876	.881	.880
South	.489	.674	.734	.884	1.168	1.234	1.277	1.293	1.305	1.307	1.307
West*	2.182	1.774	1.577	1.511	1.201	1.117	1.063	1.023	.998	.981	.973
Selected	1.431	1.319	1.101	.943	.874	.890	.903	.897	.883	.885	.888
California	2.628	2.015	1.294	1.078	.879	.770	.715	.684	.663	.655	.646

Notes: *West does not include Alaska and Hawaii in this table. States included are: Washington, Oregon, California, Idaho, Nevada, Montana, Wyoming, Utah, Arizona, Colorado and New Mexico.

One terawatt hour (TWH) is one billion kilowatt hours (KWH). See Table 1 for further information.

Per capita ratios are obtained by dividing per capita generation for groupings, such as area or class, by per capita generation for the nation.

See Map 4 for selected states, which include: California, Texas, Florida, New York and Michigan.

Data tabulated for the priod subsequent to 1970 are the product of numerical and graphical interpolation techniques. Accuracy to the number of significant figures provided is not intended; likewise for the period 1920-1970.

HIGHLY PREDICTABLE NATURE OF
AMOUNT AND DISTRIBUTION FOR

1. Population

2. Electric Energy (Generation and Use)

3. Per Capita Electric Energy

The lines on Figures 6 and 7 are essentially straight to the eye, except close to the origin, which is during the period of early and somewhat undeveloped growth. The lines on Figure 8 are smooth, S-type curves, which inflect about 1975. Again, the exception is during the period of early growth. Barring huge upsets, behavior of these figures will continue to be essentially straight and smooth.

Why is this? To understand why, we have to learn to describe the highly predictable nature of amount and its distribution as being broken into its smallest pieces. The basis for doing this is that individual people or establishments handle decisions for economic activity and resource use. This description results in per capita electric energy and per customer hookup electric energy -- both use and generation.

Use

After describing amount and distribution as being broken down into its smallest pieces -- per capita and per customer hookup electric energy use -- how do we properly measure what we are focusing on? Every day usage indicates the answer in terms of place, classification of users, number of users, amount of use and time interval:

TABLE 25: DESCRIPTION AND MEASUREMENT OF FOCUS

Place	Classification of Users	Number of Users	Amount of Use	Time Interval
Nation	Commercial	More than one	Kilowatt-hours	Year
Region	Industrial			Month
State	Residential			Week
County	Other			Day
City	Person			Hour
Block				
Hookup				

Utilities know their place of service, the classifications of users and how many users in each classification together with associated use, and the time interval involved. Census information will provide the number of people in any particular area. From this information, per capita and per customer hookup usage may be calculated for large and small areas. With areas having larger populations it is customary to calculate on the annual bases of: total electric energy, per classified customer use and estimated per capita use.

Generation

Generation of electric energy may be broken into its smallest pieces, and the description of focus would be the same as for use of electric energy -- except "generation" would be substituted for "use" in the descriptions, and classifications would become hydro, fossil fuel and nuclear (1). Figures 6 and 7 were produced on the bases of population and associated annual generation spaced at 10 year intervals, 1920 - 2020. Due to the large areas and numbers involved, only total census population and total electric energy generation were necessary to arrive at per capita electric generation for Figure 8.

Essential Questions

From the previous discussion of electric energy use and generation, the practice which has developed is that descriptions have been related to number or amount, place and time, where amount was distributed by place, and by classification within place. Hence, the essential questions only concern number, distribution and time.

ESSENTIAL QUESTIONS

1. Number (How many people? How much electric energy generation and use?)
2. Distribution (Place and Classification within place?)
3. Time (When?)

By answering these questions, population, total electric energy and per capita electric energy have been obtained. For the nation, generation and use must be in balance. For the regions and

---

(1) Total electric energy generation predictions provided in this report may be separated into the individual classifications of hydro, fossil fuel and nuclear. After estimating the percentage of total generation for each classification, the corresponding amounts would be determined. This information is useful, but not pursued in the report.

selected States, not necessarily. For instance, Figure 8 shows generation and use to be in balance for the West about 1998. This is when the West's share of national population and electric energy generation are expected to become equal.

Theoretical Basis

There is a theoretical basis for the essential questions only being concerned with number, place and time. It comes from wave theory, for specific application to population and electric energy generation and use. Because of space limitations, only a brief analysis (1) may be presented here of why theory and practice should agree.

The three variables chosen are mass, distance and time, where area is freely substituted for distance and number for mass. Number is distributed by area through time. So, if area is thought of as place, the essential questions of number, distribution by place, and time are again posed. Since there are three variables, there are three single combinations of these variables, which may be presented as an identity:

TABLE 26: VARIABLES AND COMBINATIONS AS AN IDENTITY

Variable	Symbol	Three Combinations as an Identity
Number	(N)	
Distribution	(D)	$\frac{N}{D} \times \frac{D}{T} \times \frac{T}{N} = 1$ (Identity)
Time	(T)	

Each of the three combinations has its own special meaning which can be explained by again referring to Figures 6, 7 and 8.

TABLE 27: MEANINGS OF COMBINATIONS OF VARIABLES IN THE IDENTITY

$\frac{N}{D}$: This means that distributions of people or classifications of people are related to total numbers of people. It also means that distributions of electric energy generation or classifications of electric energy generation are related to total electric energy generation:

---

(1) More detailed information will be maintained open file at the Division of Water Resources and may be obtained by calling Vic Hill, at 702-885-4380, or writing to the State Engineer's Office, Division of Water Resources, 201 South Fall Street, Carson City, Nevada 89701, Attention: Planning Section.

which is T, is determined and may be solved for by any appropriate method. There is only one most likely time for any one future value of the N/D relationship. However, times close by are highly probable because of usual small forces which slightly deflect the D/T and T/N relationships.

The entire solution outlined above has not been presented here due to space limitations. However, the most essential part, the relationship of N/D, has been shown by Figures 6 and 7. In addition, the necessary quantities are presented in Table 6. As previously noted, open file information in this regard may be obtained by contacting the State Engineer's Office.

Paramount Position of Energy

Electric Energy, Population and Related Matters

Total use and production of energy are an all pervading economic activity of society. Amount and distribution of energy use and production are the composite most descriptive measure of the technical development of a society. Without increased energy use, available material resources cannot be increasingly utilized. There has been no other practical, known way for significant advancement above past poverty, both materially and culturally. The position of energy is paramount in this regard.

There are many energy sources available for extraction, but the present major extractive processes are limited. They include combustion of gas, liquid and solid fossil fuels and wood, flowing water conversion, nuclear reactions, geothermal, harnessing of draft animals and men, and solar conversion. Conversion to electric energy in central stations is presently the most efficient, large scale extractive process, which allows for large scale distribution.

The mix of energy extractive processes and the related total amounts of energy available for use are constantly changing in both the underdeveloped and industrialized parts of the world. Electric energy use is small on a per capita basis in the underdeveloped areas. By comparison, it is large in the industrialized societies.

For industrialized societies, electric energy has almost without exception processed or transported the components of tools, machines, rolling stock, fuels, chemicals, buildings, clothes, food, water, etc.

Long term electric energy use depends directly upon two basic quantities -- population and per capita use.

Factors indirectly influencing the amount and distribution of population and per capita electric energy use, and therefore total electric energy use, include a mix of:

MIX OF FACTORS

1. Demand and supply for goods and services.

2. Household or personal income (1), and family or individual choices on spending of income.

3. Technology available, and its regulation.

4. Sufficient material resources (land, water, fuel) to support generation of electric energy in the vicinity.

As time passes for a particular area, such as Nevada, California, the West, or the nation, these factors involve what people are actually doing and how they are doing it, measurable in terms of their economic activity and material resource use.

Referring to the previous background, electric energy may be thought of as being related to each of the following:

ELECTRIC ENERGY RELATED TO

1. Technical development.

2. Population.

3. Economic activity and material resource use.

If electric energy use and production, as well as population, are described at any time by the <u>total amount</u> and <u>distribution</u>, then technical development and the composite of economic activity and resource use may be described similarly. Distribution of an amount over an area is what we know as density. For instance, distribution of people by area or place is known as population density. When all the distributions of amounts by areas are accounted for, an average density can easily be determined.

People in the various areas of the world find themselves living under different established density conditions, which are all possessed of tremendous stability. Change in one of the average densities must influence the other densities. It is possible to damage established density relationships by events which can shockingly upset any social system, such as major magnitude wars, depressions, booms, energy deprivations, epidemics and famines.

---

(1) On a national, state or regional scale, analysts may compare use of electricity with one of several economic measures, such as gross national product, total personal income, disposable personal income or family income. Income would have to be in terms of constant dollars, and consistent with total electric energy use in terms of time interval and place.

Milder upsets are capable of progressively distorting the extremely long term density expectations. Environmental impact is a case in point. We know that economic activity and resource use influence and are influenced by the total number of people in an area and their distribution. Also, we know that energy use and transportation are completely intertwined in this situation. Further, we know that the influences of people on the total environment are due partly to their numbers and how they are distributed and partly to the activities associated with these numbers and distributions. Hence, average density enters the picture for environmental impact, which is seemingly mild at any time, but is a cumulative, extremely long term distortion, with potential for great detriment.

Put into symbols, the previous background and reasoning about densities reduces to:

TABLE 28: RELATIONSHIPS AMONG DENSITIES

^{D} energy $\sim$ ^{D} population $\sim$ ^{D} technology $\sim$ ^{D} composite for economic activity and resource use $\sim$

^{D} environmental impact $\sim$ ^{D} per capita energy (Electric or other)

^{D} means average density

$\sim$ means is influenced by, for better or for worse.

It is not difficult to see how society is tied together in every respect by a set of densities, or the number of people and their distribution in an area, together with their associated activities. Over time, changes to the set of densities may proceed smoothly or abruptly, subject somewhat to choice and chance, but mostly subject to the accumulated past human efforts.

The future has been constrained by the past through stability of densities. When something goes wrong, or is about to go wrong, we must expect to ask some pertinent questions. The present petroleum shortage and the looming electric energy shortage are apparent. Confusingly, some say they were inevitable, give or take a few years. Still, it is uncertain why we must be made to undergo the disruption and human misery which accompany shortage. However, one thing is certain. We can all benefit by conservation through increased efficiency.

As stressed in many ways by this report, the key long term economic and environmental concept for Nevada is efficiency. Nevada must import energy. Locally generated electric energy depends upon fuel which is almost entirely imported. Fuel for transportation is in the same status in a fuel short nation. On top of this, water is in short supply in some areas in Nevada. A choice must be made in some cases whether to "drink it or use it for coolant" in electric energy generating plants. Environmental impact depends upon water use and production of electric energy. A premium is therefore placed upon efficient plant siting, from both economic and environmental viewpoints.

In summary, referring to Table 28, people are building their future densities at any time and place. Per capita energy density is the density which is the most descriptive measure of the technical development of a society, without which, significant material and cultural advancement cannot occur. For advancement, per capita energy density is paramount.

What people have accomplished in the way of densities will determine to a great degree what they can and will do, because the mutual influences of densities travel together characteristically and stably. Hence, the future change is subject somewhat to both choice and chance, but mostly to the past. If shortages or unexpected events begin to constrain the accustomed and expected densities, conservation through efficiency can mitigate an otherwise difficult situation.

Consequent Limits

In normal large and small scale situations, the entire public and private system has a long term "memory", as previously described. Memory applies to the per capita electric energy density relationship, and the smoothing effects of memory will in time dissipate or relax distortion in this relationship. Thus, unfortunate investments of human and material resources are greatly wasted upon attempts at "relocation" of lines and points on Figures 6 and 7.

Industrial and government entities have been increasingly working together in the nation since the Great Depression. As pointed out in the following paragraphs, working separately or in combination, neither group of entities has a reasonably easy, efficient option to undertake large scale, regional, long term distortion of the relationship between total number and its distribution. Distortion in this case refers to attempting to move away from the essentially straight lines shown by Figures 6 and 7. Reduced to simplest terms, attempting to distort the per capita electric energy density on a large scale is a very inferior option.

For smaller areas and populations, over the short term, the per capita electric energy density relationship can be deliberately distorted somewhat easier and more efficiently than on a large scale. Still, at any time, resulting economic penalties must be large. Resistance of tremendous forces, from both inside and outside the area of distortion, will assure large economic penalties.

Relative to distortion, public and private decisions can easily and efficiently advance or retard the timing at which the per capita density relationship progresses. Advancing or retarding refers to progress along the lines of Figures 6 and 7, and not away from these lines. A caution applies, in that investments of human and material resources to secure alterations in timing are not exempt from dissipation due to system memory.

In summary, system memory of the per capita electric energy density relationship cannot reasonably be distorted, but it can more easily be thrown off in timing. This is a statement of natural limits upon the ability to control population. Major practical consequences for public and private decisions are:

MAJOR CONSEQUENCES FOR PUBLIC AND PRIVATE DECISIONS

1. On a large scale: cannot with any semblance of ease or efficiency distort amount with respect to distribution or distribution with respect to amount.

2. On a small scale: can only somewhat easily and efficiently distort amount with respect to distribution or distribution with respect to amount.

3. On large and small scales: can relatively easily and efficiently advance or retard timing at which amount and distribution occur.

As a matter of degree for large and small scales, distortion and alteration in timing are not as efficient as normal progression of the per capita density relationship. In terms of "dollars right out of the wallet", somebody must pay for the relative loss of efficiency.

In view of the fact that somebody must pay, the big question is, "who pays?". The answer is that the public -- each individual -- ends up paying for <u>everything</u>. Mechanics of the system by which we deal in public and private matters allocate when, where and how much we pay. If the mechanics of the system are efficient (1), we are better off.

Lately, it has become fashionable to say that the government may take (2) without compensation, for environmental reasons, property which is owned by individuals and corporations. The larger the scale of "taking", the larger the inefficiency involved, which can result in widespread waves.

These largely policy generated swings cause each of us to pay in proportion to the high degree of resulting inefficiency. Policy swings amount, at best, to an attempted large scale change in the timing of progress along tremendously stable lines similar to those shown by Figures 6 and 7. At worst, these policy swings amount to attempted large scale distortion of tremendously stable lines.

Here, it is appropriate to relate back to the beginning of this appendix, where it was stated that natural limits upon the ability to control population provide the basis, measure and limit of efficient planning. Under these natural limitations, there is no use planning for goals which cannot be efficiently accomplished. Since the foremost question here is efficient limits upon planning for population control, we should look once more at the components of population, what they are caused by, and what it means to try to "control the whole thing", before stating a conclusion. Table 29 examines aspects of heavy controls.

CONCLUSION

Degree, Limits, Tolerance

Planning and regulation are necessary as a matter of degree, and can be most efficiently accomplished by not trying to exceed natural limits upon the ability to control population. That is why extensive preparation has gone into this report and why its goal has been stated in this manner:

---

(1) Usually, efficiency is defined by comparing the dollar values of what you get in the way of benefits with how much you had to pay for these benefits -- in other words, per capita benefits compared with per capita costs.

(2) Book prepared for the Council on Environmental Quality, July 1973, Entitled, "The Taking Issue", by Bosselman, Callies and Banta. The book analyzes governmental regulation of private land use, without paying compensation to the owners.

GOAL

Reasonable economic-environmental balance at a high level of efficiency.

Mutual tolerance by the public, private entities and government entities will be required in attempting to efficiently reach this goal.

TABLE 29: WHAT IT MEANS TO TRY TO "CONTROL THE WHOLE THING"

1. Population participates in economic activity and resource use. Hence, population, economic activity and resource use are relatable.

2. Population in an area is caused:

   a. Directly by three causes: births, deaths and migrants.

   b. Indirectly by the influences of economic activity and resource use.

3. There are slowly changing long term average relationships:

   a. Among births, deaths and migrants.

   b. Between economic activity and resource use.

4. To act heavily upon:

   a. Any of the three direct causes of population is to act very recognizably upon the others, thus inviting alienation from large segments of the public.

   b. Either of the indirect causes of population is to act in a relatively concealed manner upon the other, thus quickly inviting formation of special interest groups, together with acclaim or alienation from these special interest groups, usually with little public response.

   c. Combinations of direct and indirect causes of population give a mixed reaction, thus inviting lack of public confidence in the ability of government to cope reasonably with problems.

5. Attempts at acting heavily upon direct and indirect causes have not been reasonably successful because:

   a. The highly stable multiple density relationships between number and its distribution, as previously described, and listed in Table 28, are very difficult to alter.

b. Direct causes of population in an area are highly protected by the Constitution of the United States.

c. Hardly anybody possesses the concepts, data and authority to carry on the necessary action in a reasonably efficient manner. In addition, the funding may not be dependable.

d. The public lacks faith in unlimited governmental activities.

APPENDIX F

REGULATORY SITUATION

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Note: The Energy Research and Development Administration was created subsequent to the narrative in this report, and prior to the report's publication.

BACKGROUND ON ENERGY REGULATION

National Interest

Interest in the total energy regulation problem has caught the attention of the American people. To date, in the consumption of gasoline, the demand has outpaced the supply in some locations. Also many utilities using natural gas to generate electric energy have been forced to switch to fuel oil, which is more expensive. What the immediate future holds for heating oil remains to be experienced, hopefully not too painfully. Availability of mid-East oil is very necessary for normal economic operations nation wide, because we are not now self sufficient in meeting energy needs.

Nevada Interest and Great Dependence

Nevada is economically sensitive to energy shortages of more than short duration:

NEVADA'S SENSITIVITY

1. The leading entertainment industry is dependent upon people coming to Nevada, mostly in personal automobiles. A gasoline shortage would cause severe economic hardship, due to the accompanying unemployment.
2. An electrical energy shortage would impact first upon electric lighting for business and industry, and then upon heating and cooling for buildings. Without progressing to later stages, these conditions would be economically damaging to Nevada.

Nevada's vulnerability to energy shortage is brought clearly into focus by realizing that almost 100% of local fuel needs must be imported, and that probably 3/4 of the electrical energy used is actually generated within the state's boundaries, while the remaining 1/4 is imported. As the situation now stands, Nevada is greatly, almost completely dependent upon total energy conditions in the surrounding states and the rest of the nation.

Long Term Character

The national interest and Nevada interest are of long term character, although only the short term interest has been portrayed in this appendix so far. In order to gain perspective on how the present shortage came about, and to serve as a basis for a long term viewpoint, it is useful to briefly review energy developments since WW II, with more recent emphasis.

The nation emerged from WW II in an energy hungry status. Economically, there was a boom progressing, which placed additional demand on the available scarce energy resources. Increasing prices were the result. Spurred by increasing prices, producing techniques and exploration techniques were technologically improved. Foreign oil sources were explored for and developed at the same time.

The foreign exploration and development program soon became so successful that it was damaging the domestic oil industry. In order to protect this industry, and in the interest of national security, the government placed restrictions on the importation of foreign crude oil.

Restrictions on import of foreign crude oil resulted in a somewhat higher price for U. S. crude, thus keeping viable the domestic industry. The domestic natural gas industry has been artificially depressed by government restrictions on a selling price far below its market value. Under present world conditions, and with the natural gas industry unable to serve electric energy generation users on a firm basis, it is fortunate that the domestic oil industry is available.

By the late 1950's the petroleum industry, both U.S. and foreign, had developed substantial excess capacity to produce crude oil. Actual production in Texas and Louisiana was regulated as a conservation measure and to meet the market fluctuations, while allowing foreign crude oil to be imported in modest quantities. This extra capacity acted as a buffer in allowing the U. S. to assist other countries when their petroleum supplies were curtailed. The 1967 Suez Canal crisis was the most recent example of the U.S. buffering action.

Under present conditions, even with oil supplies looming from the North Slope of Alaska, we are realizing that the excess production capacity of the U.S. has been used up to the point of extreme vulnerability to the mid-East situation. Unfortunately, we do not presently possess an alternative source of energy.

The present energy shortage, with its potential for escalation, is stimulating a tremendous ground swell for increasing prices, just as at the early post WW II period. However, in contrast, the government has been holding back prices, which are an essential ingredient in stimulating and paying for technological improvements in producing and exploration techniques. This does not seem to be consistent with developing alternative energy sources, although the government itself has begun to spend huge sums for this endeavor.

At this point, the public should ask itself some questions about whether there is going to be an abrupt energy crunch, or an adjustment to reasonable conservation of energy. Is the problem one of poor management, where both the government and oil companies did not look far enough ahead to see a world shortage of crude oil, and do something about it? Or, did "other" factors bring about a series of unfortunate events?

The public has a vested interest in knowing where the competition between service stations has gone. There are no more gasoline price wars in the summer. Road maps and a look under the hood are beginning to cost money. Why was the increasing demand for petroleum products not met or else underestimated? Where are the new refineries? Where are the increased supplies of oil and gas? Above all, where are the new electric energy generating facilities?

Regulatory Effects and Agencies

The previously mentioned "other" factors leading to an energy shortage are examined in Table 30, which shows the major factors and their major effects for major sources of energy:

MAJOR ENERGY SOURCES

petroleum
natural gas
coal
nuclear
hydro.

Table 30 provides a look at the cumulative effects of regulation versus energy availability, from a generally economic point of view. However, the other side of the coin -- the environmental side -- needs to also be examined in terms of regulatory inefficiency.

TABLE 30: MAJOR REGULATORY FACTORS AND THEIR MAJOR EFFECTS ON THE MAJOR SOURCES OF ENERGY

Factors	Effects
PETROLEUM	
1. Pollution related modification to automobile engines.	1. Reduction in engine efficiency and increased gasoline consumption.

Factors	Effects
PETROLEUM (Continued)	
2. Maintain the U.S. prices of gasoline at about half the price in Europe.	2. Large cars and greater gasoline use in the U.S. are subsidized and encouraged, while the oil industry is artificially depressed.
3. Pollution related restriction on use of oil containing sulfur.	3. Reduction in refining capacity and the supply of suitable oil for refining. Use of "good" oil now saving "bad" oil for later.
4. Pollution related controls on refinery emissions.	4. Increase capital and operating costs, and reduce efficiency.
5. Environmental legal action against new refinery sites.	5. Delay or eliminate almost all new sites, while tying up capital at high interest rates prior to construction.
6. Environmental legal action against oil from the North Slope of Alaska.	6. Delay utilization of North Slope oil, and tie up capital at high interest rates.
7. Environmental legal action and regulations against offshore oil operations.	7. Slow all offshore oil production and exploration operations and stop some.
8. Introduce regulatory uncertainty into the amount of crude oil which may be imported.	8. Refinery expansion and new construction will be virtually stopped due to the economic threat involved.
9. Introduce regulatory and legal uncertainty into the EPA requirements, which must be followed.	9. Further curtail refinery expansion and new construction because of engineering and technical lead times.
NATURAL GAS	
10. Federal legal action against the largest energy companies for being allegedly noncompetitive.	10. Confusion and distrust in the public mind for both the government and the major energy companies, because the question arises, "Who caused the energy shortage?"

Factors	Effects
NATURAL GAS (Continued)	
11. Maintain a ceiling price at about half the market value, despite inflation.	11. Increased use is subsidized and encouraged. However, new pipelines are not built at a rate to cover increasing demand, which will eventually guarantee a shortage. Exploration is also curtailed.
COAL	
12. Pollution related restriction on use of coal containing sulfur.	12. Reduction in supply of suitable coal, saving high sulfur coal for later.
13. Environmental related controls on strip mining.	13. Further reduction in supply of suitable coal.
14. Occupational safety related regulation on mining.	14. Cut output from existing mines.
15. Freeze prices.	15. Operators cannot offset unit cost increase from reduced output, hence cannot justify further investment. Employment suffers.
NUCLEAR	
16. Environmental legal action against new nuclear generating sites.	16. Delay or eliminate almost all new sites, while tying-up capital at high interest rates prior to construction.
17. Environmental legal action against existing nuclear generating facilities.	17. Possible reduction of capacity or shut down, with attendant uncertainty.
18. Introduce regulatory and legal changes into the AEC requirements, which must be followed.	18. Further delay, cost and confusion.
19. After construction, restrict operation to less than full power.	19. Inefficiency in use of all inputs - fuel, water, capital, labor, technology - per unit of electrical energy produced.

Factors	Effects
HYDRO	
20. Prevent or curtail construction of new dams.	20. Inefficient use of the scarce water resource for electric energy, agriculture, municipal and industrial, fish and wild life, recreation, and environment including continued erosion and flood damage.

Note: Tax treatment for the previous energy sources has not been enclosed in this table. Certainly, its on again -- off again application has caused uncertainty. If the degree of uncertainty is too great in the face of the potential gain, the incentive to invest in development and exploration will be drastically depressed.

Table 31 provides a brief description of some of the influential agencies, commissions and offices etc. out of the more than 60 which handle regulatory and advisory energy functions. It is a fair statement that about a half dozen major agencies almost completely handle the regulatory functions, while dozens more have proliferated to cover smaller concerns, sometimes at cross purposes with each other.

TABLE 31: REGULATORY AND ADVISORY AGENCIES AND FUNCTIONS WITH RESPECT TO ENERGY

Description of Institution	Function, Makeup or Both
1. Energy Czar	1. Too early to assess impact. Is supposed to get at the problem of adequate energy at reasonable cost that meets environmental and national security requirements, in a coordinated manner.
2. Subcommittee on Energy of the Domestic Council	2. Possibly the most important committee with respect to energy decision. Includes the President, Vice President and nine Cabinet Members plus other members of the Executive Office. Prepares option papers for the President and shows important agency positions.

Description of Institution	Function, Makeup or Both
3. Department of the Interior	3. Impacts nearly every form of energy.
a. Office of Oil and Gas	a. Self evident
b. Geological Survey	b. Appraises energy resources of the earth's crust - oil, gas, coal and uranium.
c. Bureau of Reclamation	c. Markets hydroelectricity through power administration: Bonneville, Southwest, Southeast and Alaska
d. Bureau of Mines	d. Responsible for coal (and helium)
e. Office of Coal Research	e. Does research designed to insure adequate future coal supplies.
f. Energy Board	f. Interacts with Domestic Council
4. Federal Power Commission	4. Controls about 1/4 of primary U.S. energy consumption. Has jurisdiction over: rates at which producers may sell gas in interstate commerce; numerous accounting and reporting requirements; licensing of construction, operation and maintenance of water power projects on public domain.
5. Atomic Energy Commission	5. Responsible for development, use and control of nuclear energy. Does in-house or contracts for a tremendous amount of environmental research.
6. Environmental Protection Agency	6. EPA has something to do with any energy source affecting the environment in any degree whatsoever. Its function overlaps the functions of many other agencies. Under this condition, there is serious question whether any agency really has its own jurisdiction.
7. Additional Executive Branch Institutions	7. As described following:

Description of Institution	Function, Makeup or Both
a. Office of Science and Technology	a. Serves staff function for integration of overall federal energy effort. Works closely with Office of Management and Budget.
b. Office of Economic Advisors	b. Conducts studies on various aspects of energy situation and comments on rationality and economic efficiency.
c. State Department, Office of Fuels and Energy	c. Deals with oil, gas, coal and uranium as products on the world market. Concerned with national security and the increased dependence upon foreign fuel sources.
d. Department of Defense	d. Same as c. prior. Maintains oil reserves as an energy asset.
e. National Science Foundation	e. Funds research about energy conversion, solar energy systems, energy transport, and improved use of existing energy resources.
f. Office of Emergency Preparedness (OEP)	f. Basic authority over the oil import program, and monitors overall energy situation. Director of OEP chairs the Oil Policy Committee and the Joint Committee on Fuel Supply and Fuel Transportation, which provides him with a substantial voice in policy making.
g. Department of Commerce	g. Decisions by the previous institutions have an effect on the balance of payments. Balance of payments policy is the responsibility of this department, including international economic policy, the fuel import program and maritime considerations under the Maritime Administration. The National Bureau of Standards conducts research on energy conservation, and superconductivity materials. Liquid helium is required for this effort.

Description of Institution	Function, Makeup or Both
h. National Aeronautics and Space Administration (NASA)	h. Develops fuel cells, isotope generators, and other work in planning stages.

Facts of Life for Nevada

In looking at Tables 30 and 31, it is a fact of life that Nevada must move within the greater national regulatory context for energy matters. Several agencies control the big picture, but no agency is in complete charge. In order to maintain local economic and environmental options under these conditions, it is important to know:

IMPORTANT TO KNOW
FOR SELF DEFENSE

1. History of energy decisions and their impact.
2. What energy decisions will be coming up.
3. What agency (s) have been involved and will be involved.
4. What the surrounding states are doing energywise.

Summary

In summary of Tables 30 and 31, the subject has been energy availability versus governmental regulation, from a generally economic efficiency point of view. Environmental quality versus governmental regulation is an important viewpoint also. In the end, reasonable economic-environmental balance at a high level of efficiency should be the defined goal.

Balance between economic considerations and environmental considerations is proving to be very elusive. In this regard, the legislators, the levels of federal and state government, the courts, the energy companies and the environmentalists are all trying to do what is believed to be in the best interest of the public.

CONCLUSION

Referring again to Tables 30 and 31, it may be seen that the whole process has caused tremendous agency participation, economic inefficiency in use of the scarce resources and tremendous delay in doing what will be done anyway, if we are not to have a severe economic crisis.

Is this process of over regulating essential to achieving a reasonable balance between future economic efficiency and environmental quality? Probably as a matter of degree such a balancing process is necessary, but apparently not to the uncomfortable and inefficient extent now practiced. However, there is more to the entire situation in which we find ourselves than just conservation and efficiency.

Regulations or their relative absences, are part of the process by which industrialized societies control their population density. In this regard, regulations are highly similar in function to customs in more primitive societies, where the effects of man upon himself and the remainder of the environment are not heavily magnified by technology.

Therefore, the real problem is to achieve reasonable economic-environmental balance at a high level of efficiency -- in a reasonable amount of time. To do this in a reasonable amount of time, we must learn how to avoid the huge swings attendant to over regulating. The set point of regulations should not be right up against the natural limits described in Part 3 of Appendix E, just as the set point on the heater should not be up against the "hot" side of the thermostat. Any other setting is more efficient.

APPENDIX G

TECHNOLOGY OF WATER USE FOR ENERGY PROCESSES

Page

WATER DEMANDS FOR EXPANDING ENERGY DEVELOPMENT

The preceding title has been chosen by the U. S. Geological Survey, for their Circular 703, published in 1974. The entire text of the circular has been reproduced in this appendix, because it is highly appropriate to the purposes of this report to present water needs for various energy processes of concern to Nevada and the West.

Note: The formula on page 193 should be:

$$\text{Gallons evaporated/kwhr} = 0.39\left(\frac{a}{H} - 1\right)$$

WATER DEMANDS FOR EXPANDING ENERGY DEVELOPMENT

By George H. Davis and Leonard A. Wood

GEOLOGICAL SURVEY CIRCULAR 703

1974

United States Department of the Interior
ROGERS C. B. MORTON, *Secretary*

Geological Survey
V. E. McKelvey, *Director*

Free on application to the U.S. Geological Survey, National Center, Reston, Va. 22092

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CONVERSION FACTORS

Length

1 inch=25.4 millimeters (mm)
1 mile=1.60934 kilometer (km)

Area

1 acre=0.4047 hectares (ha)

Volume

1 gallon=0.0037845 cubic meters (m^3)
1 barrel (42 gal)=0.15899 cubic meters (m^3)
1 acre-foot=1,233 cubic meters (m^3)
1 cubic foot=0.0283 cubic meters (m^3)

Mass

1 ton (2,000 lbs)=0.907185 metric tons (t)

Flow

1 gallon per minute=0.0037854 cubic meters per minute (m^3/min)

Temperature

°C=5/9 (°F-32)

Pressure

1 pound per square inch=0.0703 kilograms per square centimeter (kg/cm^2)

Energy

1 British thermal unit (Btu)=0.252 kilogram calories
1 British thermal unit (Btu)=0.000293 kilowatt hours (kwhr)

Energy – Volume

1 British thermal unit per cubic foot (gas)=0.01035 kilowatt hours per cubic meter (kwhr/m^3)
1 British thermal unit per cubic foot (gas)=8.9046 kilogram calories per cubic meter (kcal/m^3)
1 gallon (water) per kilowatt hour=0.0283 cubic meters per kilowatt hour (m^3/kwhr)
1 gallon (water) per million British thermal units=0.01292 liters per kilowatt hour (l/kwhr)

Water Demands for Expanding Energy Development

By George H. Davis *and* Leonard A. Wood

ABSTRACT

Water is used in producing energy for mining and reclamation of mined lands, onsite processing, transportation, refining, and conversion of fuels to other forms of energy. In the East, South, Midwest, and along the seacoasts, most water problems are related to pollution rather than to water supply. West of about the 100th meridian, however, runoff is generally less than potential diversions, and energy industries must compete with other water users. Water demands for extraction of coal, oil shale, uranium, and oil and gas are modest, although large quantities of water are used in secondary recovery operations for oil. The only significant use of water for energy transportation, aside from in-stream navigation use, is for slurry lines. Substantial quantities of water are required in the retorting and the disposal of spent oil shale. The conversion of coal to synthetic gas or oil or to electric power and the generation of electric power with nuclear energy require large quantities of water, mostly for cooling.

Withdrawals for cooling of thermal-electric plants is by far the largest category of water use in energy industry, totaling about 170 billion gallons (644 million m³) per day in 1970.

Water availability will dictate the location and design of energy-conversion facilities, especially in water deficient areas of the West.

WATER DEMANDS FOR EXPANDING ENERGY DEVELOPMENT

Much concern has been expressed recently as to whether water supplies will be sufficient to support accelerated energy development foreseen in Operation Independence. Taking the Nation as a whole, sufficient water is available for energy growth, but locally, as in arid parts of the Colorado River Basin, limited water supplies will dictate economies in water use and affect plant siting. As Young and Thompson (1973) point out with respect to electric-power generation, the term "water requirements" is misleading because demand for water for cooling is sensitive to price of water and thus is quite flexible rather than inflexible or fixed as implied by the word "requirement." Much the same is true of other energy-conversion systems.

Water is used in many aspects of energy production including mining and reclamation of mined lands, onsite processing, transportation, refining, and conversion to other forms of energy. In the East, South, Midwest, and along the seacoasts, water supplies are generally adequate for energy industries; most water problems in those regions are related to pollution rather than to supply. West of about the 100th meridian, however, runoff is generally less than potential diversions, and energy industries must compete with other users for the limited available water supplies. Water is especially short in areas having less than 10 inches (254 mm) mean annual rainfall, generally not enough for establishing vegetation without irrigation.

EXTRACTION

The principal categories of extraction comprise coal mining, oil and gas production, uranium mining, and oil-shale mining.

Coal-mining water demands are modest, and include water for dust control, fire protection, and coal washing. These needs are nominal and quality is not a limiting factor in any of them. In areas where natural precipitation is less than 10 inches (254 mm), an additional water demand exists for establishing vegetation on disturbed areas following surface mining. The amount of water needed is related to natural precipitation and area disturbed and thus is highly variable. In most arid areas, application of 0.5–0.75 acre-ft/acre (152–229 mm) should be sufficient to establish seedlings that would survive without further water application (National

Academy of Sciences-National Academy of Engineering, 1973). This water must be of reasonably good quality to encourage plant growth (preferably less than 2,000 mg/l dissolved-solids concentration). Even now, water demands for revegetation pose serious problems, particularly in the Four Corners area of Arizona, New Mexico, Utah, and Colorado.

Oil and gas extraction generally involves only nominal water demands for drilling, some 37,000 acre-ft (45.6 million m^3) of freshwater annually nationwide. However, where water flooding is employed as a secondary recovery technique, somewhat larger quantities of water are needed to drive oil toward recovery wells. Where saltwater is available for this use (that is, formation waters produced with oil), it is generally preferable to freshwater, but in some fields freshwater is used for water flooding. Magnitude of use is highly variable and depends upon formation characteristics, but generally is modest compared to other energy-industry demands. Buttermore (1966, p. 6–8) calculated that the total demand for secondary recovery nationwide in 1962 was about 560,000 acre-ft (690 million m^3) of which 157,000 acre-ft (194 million m^3) was freshwater. The remainder was saline water, most of which was produced with oil.

Uranium mining involves water demands for dust control, ore beneficiation, and revegetation similar to coal mining, but tonnage handled is much less than for coal; thus, the total water requirements are lower. As in coal mining, quality of the water generally is not critical for these uses. Where surface mining is practiced, water requirements for revegetation are comparable to those of coal mining.

The U.S. Atomic Energy Commission (1972, table S-3A) estimates that the area disturbed in surface mining of uranium, normalized for annual requirements of a typical 1,000 mw (megawatts, electric output) light-water reactor generating station, would be 17 acres (6.9 hectares). The water requirement for revegetation at that rate would be trivial even for great increases in nuclear generation. For a rough comparison, it is estimated that mining for comparable energy production by a typical coal-fired electric plant would result in about 10 times more land disturbance.

Oil-shale mining is expected to become a major industry in several parts of Colorado, Utah, and Wyoming underlain by the Green River Formation. Shale will be extracted by surface mining, underground mining, and perhaps as an adjunct to in situ underground retorting. Retorting of shale mined by surface or underground conventional methods will be done on or near the mining site, and large volumes of loosely compacted waste will be produced in the retorting process. Water demands for mining, processing, waste disposal, and land reclamation are intimately related. One of the largest demands is for compaction and revegetation of retort-plant waste which comprises some 40 percent of the total water use. The Department of the Interior's Final Environmental Impact Statement for the Prototype Oil Shale Leasing Program (U.S. Department of the Interior, 1973) estimates consumptive water demand of from 121,000 to 189,000 acre-ft (149 million to 233 million m^3) per year at a production rate of 1 million barrels (158,899 m^3) per day of shale oil, or from 2.5 to 4 volumes of water consumed per volume of oil produced.

TRANSPORT

The only significant use of water in energy transport, aside from in-stream navigation use, is for slurry lines. Slurry lines have been used for many years in the eastern coal districts, but one of the more recent installations is the slurry line extending from the Black Mesa coal mine in northeastern Arizona to the Mojave Power Plant on the Colorado River at the southern tip of Nevada 273 miles (440 km) away. A slurry line was adopted because the terrain made it economically attractive vis-a-vis rail transportation, the only other reasonable mode of conveyance. Another plant, the Navajo Power Plant (under construction) near Lake Powell is to be supplied from the same mine by a railroad built for that purpose. Water for the Mojave slurry lines is supplied by wells pumping some 3,200 acre-ft (3.9 million m^3) per year from a thick extensive sandstone aquifer that underlies Black Mesa. In this area, recharge from precipitation is negligibly small, and the pumped water is mainly withdrawn from storage. The power plant, rated at 1,500 mw, consumes about 23,000 acre-ft (28 million m^3) per year for cooling and other plant uses; thus, the water use for transport is only about one-sixth that of the plant consumption. At the plant the slurry water is separated from the coal and treated, and part is used in the plant water supply.

REFINING

Most energy fuels require some degree of refining before ultimate use. Some or parts of these processes are carried out at or near the site of extraction, that is, gas scrubbing, coal washing, oil-shale retorting, and uranium-ore concentration. In other instances, the raw material may be transported to industrial centers for all or part of the refining process as is the case with crude oil, solvent refining of coal, and uranium enrichment and reactor-fuel fabrication.

The energy fuels that involve a refining process distinct from both extraction and subsequent conversion or consumption are nuclear fuels and oil (including shale oil and synthetic oil from coal), and are described in the following section.

Water demands in the nuclear fuel cycle have been calculated by the Atomic Energy Commission (1972) on the basis of annual requirements of a typical 1,000-mw light-water reactor steam-electric plant operating 80 percent of the time. Of a total consumption of 163 million gallons (617 thousand m^3), 65 million gallons (246 thousand m^3), or about 40 percent, is assigned to the uranium-ore milling stage, almost entirely as evaporation from tailings ponds. The remaining consumption of water occurs mainly in evaporative cooling in the uranium enrichment plant, which is normalized to 90 million gallons (341 thousand m^3) annually for a 1,000-mw plant. The remaining 8 million gallons (30 thousand m^3) is assigned in about equal proportions to the production of uranium hexafluoride and reprocessing of used fuel elements. Not included in the above water consumption calculations is water consumed at power plants supplying electricity for the enrichment process. This annual power requirement is estimated at 310,000 mwhr (megawatt hours) that, if produced in a fossil-fuel plant, would indicate an evaporative requirement of roughly 160 million gallons (604 thousand m^3). To keep this demand in proper perspective, it should be remembered that the electrical power produced by the model 1,000-mw nuclear station annually (at 80 percent load factor) amounts to about 22 times the energy consumed to produce an annual fuel requirement for a 1,000-mw station (U.S. Atomic Energy Commission, 1972, p. D5).

Water demand for petroleum refining is highly variable, depending upon such factors as process employed, refinery design, and cost and availability of water. A sampling of refineries producing 30 percent of the petroleum products in the United States in 1955 (Otts, 1963, p. 299), indicated an average withdrawal demand of 468 gallons (1.76 m^3) of water per barrel (42 gallons or 0.159 m^3) of crude-oil input. Some 90 percent of this water was used in cooling processes at various stages of refining. A more meaningful measure of water demand, however, is the consumptive use, which averaged 39 gallons (0.14 m^3) of water per barrel of crude-oil input, or roughly 1 volume of water consumed per 1 volume of crude. Of this consumption, 71 percent was accounted for in evaporative cooling, 26 percent as boiler feed water, and the remaining 3 percent for sanitary and other in-plant uses.

CONVERSION

Conversion embraces the concept of changing an energy raw material into a more usable form of energy. Examples include burning of coal, gas, or oil to produce electricity, or converting energy of nuclear fission to electricity. Other examples include changing coal or oil into gas, a cleaner, more convenient fuel for space heating, or even changing coal into a form of oil for further refining. Much of the present emphasis on conversion seeks to use fuels abundant in the United States, such as coal and oil shale, to meet the present energy crisis without sacrificing air quality objectives. Generally, this involves processing near the site of extraction to produce a nonpolluting fuel which can be transported to a distant market. Alternatively, the coal can be used near the mine to produce electricity for transport to market.

The processes of particular interest in the present energy shortage are coal gasification, coal liquefaction, oil-shale retorting, use of geothermal energy for electric generation, and increased use of coal-burning plants and nuclear reactors for power generation. In each mode considerable flexibility is possible in plant design, process employed, and location of processing facilities with respect to site of extraction, source and use of water, and location of market. It is impractical, if not impossible, to assign rigid values of water use per unit of energy produced to all processes because of economic trade-offs, but ranges of water demand are useful for planning purposes. Moreover, in electric-power generation the need for high fuel efficiency generally dictates water demand within close limits; accordingly, water demand for electric generation can be estimated reasonably well.

STEAM-ELECTRIC GENERATION

The most efficient method of meeting large steady electric demand (base load) is by use of a steam turbine to drive a generator (fig. 1). The steam may be produced from geothermal wells, by burning coal, oil, or gas, or by heat given off by nuclear fission. The power output of a steam turbine is greatly increased by reducing the pressure on the outlet side of the turbine. This is done by use of a condenser, which lowers the temperature of the exhaust steam, causing condensation and thus significantly reducing the pressure. The cooling capacity needed for the condensation phase accounts for the greatest consumption of water in the entire energy-production process.

Various systems are used for condenser cooling— once-through circulation, cooling ponds, sprayers, wet cooling towers, dry cooling towers, and combinations of the preceding systems. Once-through cooling commonly

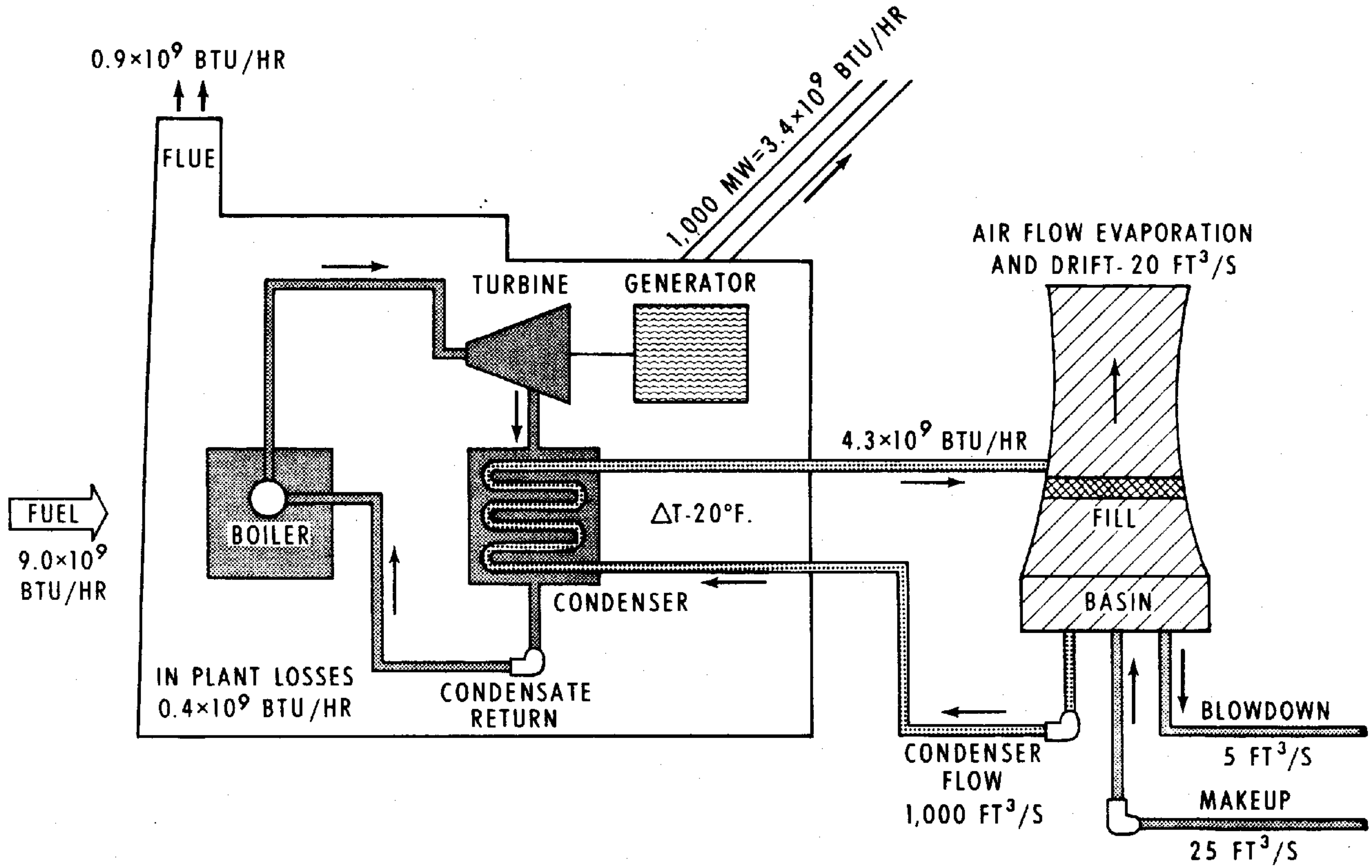

Figure 1.—Heat balance diagram of typical 1,000-mw fossil-fueled thermal-electric plant.

is used where the plant is near an abundant source of water, such as the sea, a large lake, or a large river. As the name suggests, water from an infinite (for practical purposes) source is circulated through the condenser and carries the waste heat away to a point of discharge elsewhere on the water body. The heat is dissipated through increased evaporation from the slightly warmer water body and by conduction to the atmosphere.

Where no large water body is available, a natural or artificial pond may be used for storage and as a heat sink. In this mode, heat is dissipated mainly through surface evaporation from the warmed pond. Where the cooling capacity of the pond is inadequate, sprayers may be used to increase evaporation. Sprayers may also be used together with canals in once-through systems to reduce the impact of heated discharge on fish and other aquatic biota.

Where water is in short supply or discharge of heated water is unacceptable, and ponds are not practicable, cooling towers generally are employed. In wet cooling towers some of the warm water evaporates through contact with an air draft, either naturally induced or driven by fans, thus cooling the remaining water. Dry cooling towers dissipate heat directly to an air draft in a fashion similar to an automobile radiator. Although dry cooling towers are effective in reducing water consumption, their capital cost greatly exceeds that of wet cooling processes, and their use results in a loss of thermal efficiency as well. They find their greatest use in cold climates and to date have seen little use in the United States in steam-electric power generation.

Various combinations of these cooling techniques are applied to achieve maximum economy in combination with acceptable environmental effects. The cooling system is quite independent of the type of fuel; rather, it depends mainly on local factors such as availability of water, terrain features, and potential environmental impacts.

The cooling demand, regardless of how the waste heat is dissipated, is governed by the thermal efficiency of the plant, which is expressed as electrical output as a percentage of energy input. Maximum thermal efficiency is achieved by use of very high steam temperatures and inlet pressures. In the newer modern fossil-fueled plants, for example, thermal efficiency of 40 percent is achieved with inlet temperatures as high as 1,000°F (538°C) and pressures of 3,500 psi (246 kg per cm^2).

The evaporative demand of a fossil-fueled steam-electric generator may be expressed as (Cootner and Löf, 1965, p. 74):

$$\text{Gallons evaporated/kwhr} = 0.39\ (aH - 1),$$

where H is overall thermal efficiency, and a is boiler-furnace efficiency (usually about 0.9). The boiler-furnace efficiency, normally about 90 percent, represents the fuel energy that is not lost in flue gases. The heat energy lost in flue gases is about 10 percent. An additional 5 percent of the input is dissipated to the atmosphere through in-plant losses and uses. Thus about 85 percent of the input energy is used in driving the turbines or is disposed of as thermal waste in the form of warmed water.

Present nuclear plants are less efficient than fossil-fueled plants because of safety restrictions on maximum steam temperatures, and nuclear plants dissipate waste heat almost entirely to cooling water because no flue gases are emitted. A typical nuclear plant of 31-percent thermal efficiency releases about 50 percent more heat to cooling water than a fossil-fueled plant of comparable power output.

With respect to consumption of water, geothermal plants are the least efficient form of steam-electric generation. Because of inherent low temperature and pressure of natural steam used, the geothermal plants at the Geysers Field, Calif., for example, have an overall thermal efficiency of only about 14 percent, the remaining energy being dissipated by evaporative cooling with comparably greater water consumption. The source of cooling water is the condensed geothermal steam, about 80 percent being consumed in the cooling process. The remaining 20 percent, which is of poor quality, is injected into the producing formation (Finney, 1972).

The rapid growth of electric consumption in the United States in recent decades is reflected in increased water withdrawals for thermal-electric power. Surveys of water use compiled at 5-year intervals by the U.S. Geological Survey (fig. 2) show that by 1965 withdrawals by thermal-electric plants exceeded irrigation withdrawals, to become the leading class of withdrawal use in the Nation. This reflects not only the rapid growth of electric demand but also the fact that most plants employed once-through systems for condenser cooling. Concern over thermal pollution of water bodies, however, has resulted in a trend to greater use of closed evaporative systems employing cooling towers, ponds, or sprayers. Thus the rapid growth of thermal-electric withdrawal should level off considerably in coming decades. This effect, coupled with the influence of improvements in thermal efficiency, can be observed in figure 3. Nonetheless, consumptive use by thermal-electric generation will continue to grow and will increase relative to withdrawals. This seeming paradox is due to the fact that closed cooling systems have a greater evaporation loss relative to once-through systems as well as additional water consumption not applicable to once-through systems. The principal water economies of once-through systems are attributable to a greater proportion of conductive heat

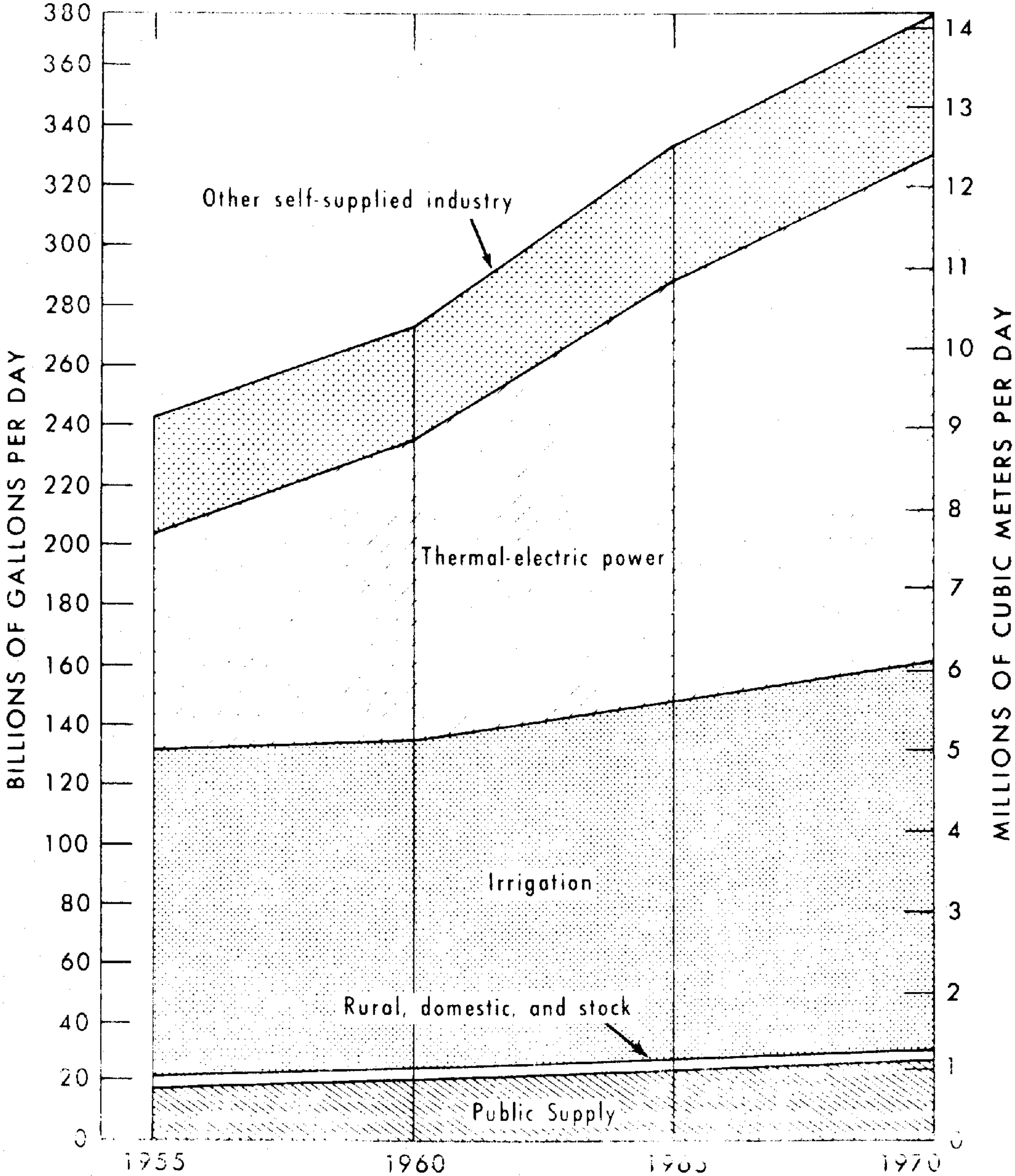

Figure 2.- Withdrawal of water for major uses

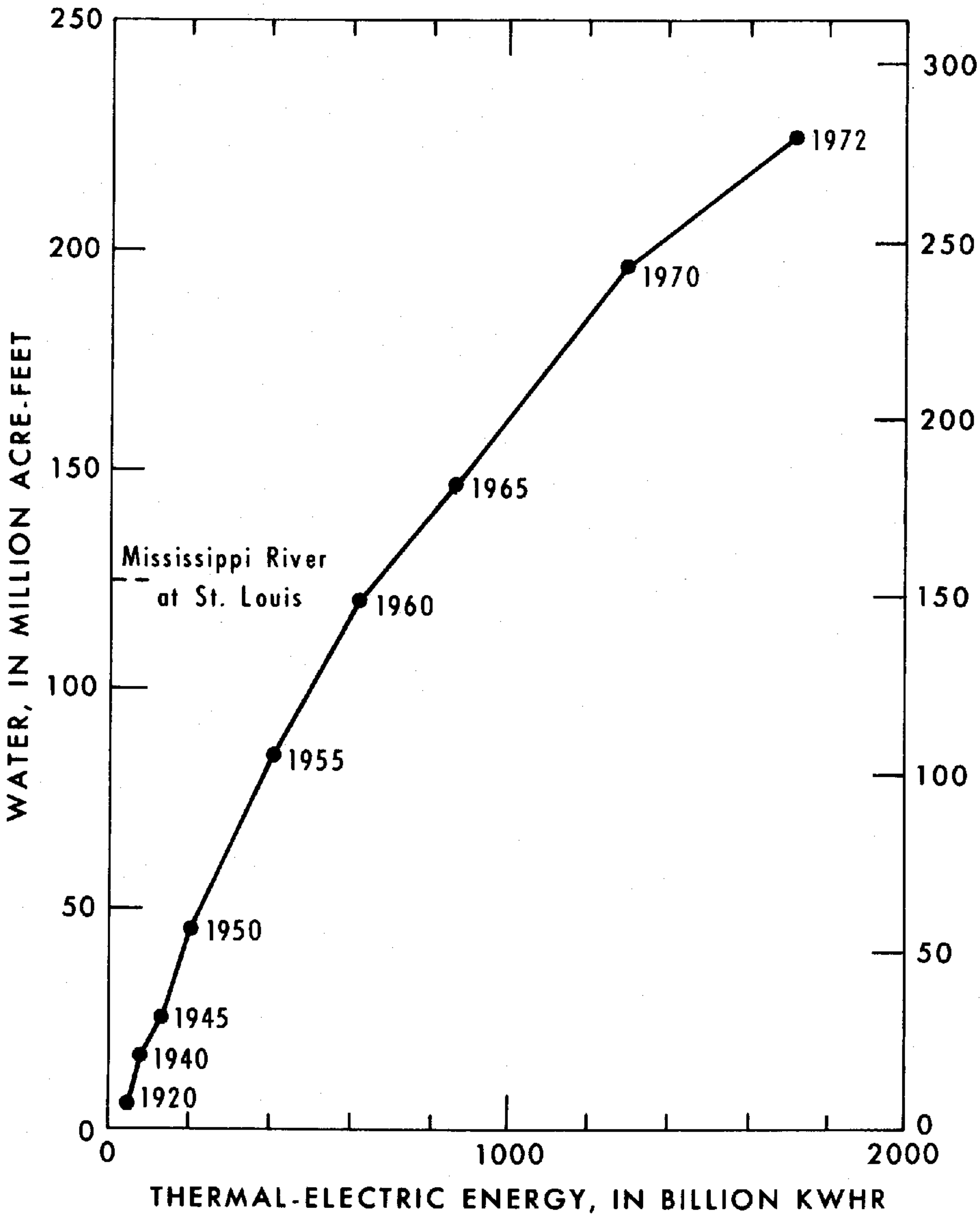

Figure 3.—Annual withdrawals of water for thermal-electric power generation in the United States, 1920–72.

loss vis-a-vis evaporative loss from natural water bodies than from high temperature ponds or cooling towers. Cooling towers, moreover, waste a small proportion of their water supply as drift (small droplets of water escaping the tower without contributing to the evaporation process) and, in most cases, have additional consumption chargeable to "blowdown," disposal of poor-quality waste water that cannot be returned to the natural system. A thorough examination of the question of unit consumption of water in power-plant cooling is not warranted here, but expert opinion ranges from Cootner and Löf's (1965, p. 58) observation that water loss from a receiving stream in once-through cooling is nearly the same as in a recycle system, to an estimate by the Water Resources Council (1968, p. 4-3-2) that cooling towers have consumptive use roughly twice that of once-through systems. These differences stem from a general lack of information on evaporation from open water bodies. Although makeup water for recycling systems can be measured directly with relative ease, precise measurements of evaporation from open water bodies is very difficult. Moreover, where water is in abundant supply, as where once-through cooling is employed, the question of consumptive use is rather academic. Furthermore, much of the consumption of water associated with once-through systems is of saline water, mainly seawater, or from the Great Lakes where such consumption is a small consideration. Indeed, in 1970 withdrawals of saline water (Murray and Reeves, 1972, p. 7) comprised 28 percent of the total withdrawals for thermal-electric power. This figure itself probably is disproportionately low because many power plants drawing water from estuaries or downstream of competing users are classed in Federal Power Commission reports as freshwater withdrawals, although this water would soon waste to the sea if not used in this way.

Consumptive use becomes a serious consideration only where it is in competition with other socially beneficial water consumption. Thus, the main focus on consumptive use by electric-power plants and other energy industries is in the West where freshwater has high value for alternative uses.

The table below shows the average evaporative requirement of modern thermal-electric plants by various classes. In each instance, most efficient design is assumed. As noted earlier, water consumed per kwhr (kilowatt hour) is governed mainly by thermal efficiency, although the type of cooling system employed may also affect consumption to some degree. Little future improvement can be expected in fossil-fueled plants, which already are crowding theoretical thermal-efficiency limits. Similarly, little improvement can be expected with geothermal systems, which are constrained by the relatively low temperature and pressure of the natural steam sources tapped. Nuclear generation, however, has a potential for significant improvements in thermal efficiency and water requirements. High-temperature gas-cooled reactors (HTGR) now coming into use are expected to have an overall thermal efficiency of 40 percent, as are breeder reactors now being planned.

The other principal types of energy conversion of concern with respect to water consumption are conversion of oil shale to oil, coal to gas (coal gasification), and coal to oil (coal liquefaction).

OIL SHALE

Oil shale may be mined either in open pit or in underground mines and then retorted on the surface. Below-ground retorting experiments have been tried using several methods, but until recently in situ processes were not claimed to be competitive with mining and above-ground plants. However, late in 1973 one firm announced high recoveries of oil and lower cost for a combination of underground mining and in situ retorting in which 25–30 percent of the shale is mined and retorted on the surface. The remaining shale is fractured, collapsed into the mined-out void, and retorted where it lies. Although a commercial-sized plant of any kind remains to be built, technology may change rapidly during the next decade.

The operators of the two Federal Prototype Leases in Colorado probably will use above-ground processing. Pilot plants have tested many methods of mining and above-ground and in situ retorting, but none of the processes has been done on a commercial scale. The pilot mines and plants have handled a few tons of shale up to as much as 1,000 or more tons (907 metric tons) per day; the Department of Interior's Prototype Lease

Consumptive demand of water-cooled thermal-electric plants

Type[1]	Heat rate (Btu/kwhr)	Thermal efficiency (percent)	Atmospheric dissipation (Btu/kwhr)	Percent	Evaporative dissipation (Btu/kwhr)	Gallons consumed per kwhr
Fossil fueled	9,000	38	1,350	15	4,230	0.5
Nuclear	10,700	32	535	5	6,741	.8
Geothermal	24,000	14	1,200	5	19,440	1.8

[1] Most efficient design. At normal operating rates (80 percent load factor), the water consumption of these types of plants is approximately 15 acre-ft/year/mw capacity for fossil-fueled, 22-acre-ft/year/mw for nuclear, and 48 acre-ft/year/mw for geothermal plants.

Program envisions mining more than 50,000 tons (45,359 metric tons) a day from an underground mine and more than 100,000 tons (90,718 metric tons) a day from an open pit mine.

The oil shale must be heated to about 900°F (482°C) to convert the solid organic material in the oil shale to gas and oil vapors. The three most advanced retorts developed for heating oil shale are the Union Oil Retort, the Gas-Combustion Retort, and the TOSCO Retort. The first two maintain controlled combustion of shale within the retorts, but the TOSCO process uses heated ceramic balls with finely crushed shale in a rotating cylindrical drum. The shale oil produced by all these retorts is a low-gravity, moderate-sulfur, high-nitrogen oil that has a high pour point and is rather viscous. The shale oil probably will be upgraded by hydrocracking, or some other process, to reduce its viscosity and make it suitable for pipeline transport to a refinery located where more abundant water supplies are available.

The largest use of water in the production of shale oil is for disposal of the dry spent shale after it has been crushed and roasted to extract the hydrocarbons. The water is used for dust control while the spent shale is being transported (possibly as a slurry), but its most important use is in compacting and stabilizing the disposal pile. Spent shale that contains 20–30 percent water will set up like a weak portland cement. In fact, if the slope of the face of the pile is 18° or less, the limiting parameter on the height to which a box canyon can be filled is the load-bearing strength of the alluvial floor of the canyon. (U.S. Department of the Interior, 1973, v. I, p. I-42–I-43.)

Estimates of the most likely amounts of water consumed by an oil-shale mine, retort, and upgrading plant of 100,000 barrels (15,899 m^3) per day capacity of shale oil range from about 7,500 gpm (gallons per minute) (28 m^3 per minute or 12,150 acre-ft per year) to about 11,400 gpm (43 m^3 per minute or 18,420 acre-ft per year). Associated urban uses would increase the estimated range to 8,350–12,400 gpm (31.6–46.9 m^3 per minute or 13,400–20,100 acre-ft per year). The average of the high and low estimates for each use is (in gallons per minute):

Processed shale disposal	4,500
Shale oil upgrading	2,300
Power requirements	1,100
Retorting	800
Mining and crushing	550
Revegetation	220
Sanitary use	30
Associated urban	900
Total	10,400

A series of mines and plants will probably be required to produce 1 million barrels (158,899 m^3) per day of shale oil. The Final Environmental Statement for the Prototype Oil Shale Leasing Program assumed a mix of 17 mines and plants including 11 underground, 2 open pit, and 4 in situ mines would be needed for 1 million bpd (barrels per day). Based on the assumed technology mix, the Final Environmental Statement estimated that 121,000–189,000 acre-ft (149 million–233 million m^3) per year of water would be consumed in producing 1 million barrels (158,899 m^3) per day of shale oil (table 1).

The source of water for oil-shale developments must be the Upper Colorado River Basin, although the initial mines on the Prototype Leases in the Piceance Basin in Colorado may develop enough ground water to satisfy all their water needs. A long-term, large-scale oil-shale industry in Colorado, Utah, and Wyoming will depend on diversion of stored surface water from the Colorado River Basin. Table 2 shows the status of water use in the Upper Basin. Water is available for an industry of more than 1 million bpd of shale oil if water not committed to other uses is made available to oil-shale developments. A much larger industry (several million barrels per day) would require purchase and transfer of water rights from agriculture to industry.

COAL GASIFICATION

As there are no modern-design coal-gasification plants of commercial scale in the United States, estimates of water demand must be based on research operations, foreign experience, and design data of projected plants. One of the chief sources of information is an engineering report of the El Paso Natural Gas Co. Burnham I Coal Gasification Complex planned for a site near Farmington, N. Mex. (Stearns-Roger Inc., 1973). The processes being considered for that complex, designed to produce 288 million scf (standard cubic feet) per day (8.15 million m^3 per day) of pipeline-quality gas (954 Btu per ft^3 or 9.87 kwhr per m^3), include coal gasification by the Lurgi process followed by shift conversion, gas cooling, gas purification, and methane synthesis. In simple terms, the Lurgi process produces a low Btu product (about 400 Btu per ft^3 or 4.14 kwhr per m^3) which is upgraded by methane synthesis to pipeline quality. In various stages water is consumed in the chemical reaction; cooling requirements contribute additionally to the overall water demand. Because water is scarce in the region of the plant, recycling will be used to the maximum, and air cooling will be used insofar as practicable. The water input will consist of about 7,000 gpm (26 m^3 per minute) diverted from the San

Table 1.—*Contingent water consumption forecasts, in acre-ft per year, for a 1-million-barrel-per-day shale-oil industry*

[After table III-6, vol. 1, U.S. Department of the Interior, 1973]

	Lower range	Most likely	Upper range
Process requirements			
Mining and crushing	6,000	6,000– 8,000	8,000
Retorting	9,000	9,000– 12,000	12,000
Shale oil upgrading	17,000–21,000	29,000– 44,000	44,000
Processed shale disposal	24,000	47,000– 70,000	84,000
Power requirements	10,000	15,000– 23,000	37,000– 45,000
Revegetation	0	0– 12,000	18,000
Sanitary use	1,000	1,000– 1,000	1,000
Subtotal	67,000–71,000	107,000–170,000	204,000–212,000
Associated urban			
Domestic use	9,000–11,000	13,000– 17,000	17,000
Domestic power	0	1,000– 2,000	2,000
Subtotal	9,000–11,000	14,000– 19,000	19,000
TOTAL	76,000–82,000	121,000–189,000	223,000–231,000
Ancillary development			
Nahcolite/dawsonite	....	....	[1] 32,000– 64,000
GRAND TOTAL	76,000–82,000	121,000–189,000	255,000–295,000

[1] Estimates based on one or two plants; however, future markets may support three plants (see Chapter I, Section C-1-f). With three plants, the upper limit would approximate 327,000 acre-ft of water per year. Development above the 1-million-barrel-per-day level, including a commitment to develop the Naval Oil Shale Reserves, would require additional water.

Table 2.—*Present and future water use, in thousands of acre-ft per year, in the Upper Colorado River Basin*

[After table II-4, vol. 1, U.S. Department of the Interior, 1973]

Use	Colorado	Utah	Wyoming	Total
Allocated share of 5,750,000 acre-ft[1]	2,976	1,322	805	5,103
1970 use	-1,788	-684	-304	-2,776
Committed future use	-955	-397	-392	-1,744
Evaporation from storage units	-342	-152	-92	-586
Credit for water salvage	+121	+18	+31	+170
Not identified as to use	12	107	48	167
Committed future use that could be made available for oil shale	[2] 155	....	[3] 19	174
Total potential water that could be made available for depletion for oil-shale development[4]	167	107	67	341

[1] Arizona received the right to the consumptive use of the first 50,000 acre-ft per year.

[2] From the existing Green Mountain and Ruedi Reservoirs and the authorized West Divide Project.

[3] From the existing Fontenelle Reservoir—Seedskadee Project.

[4] This includes water not presently identified for a particular use, plus water from authorized projects committed to oil-shale development and water from existing reservoirs not presently committed to a particular use. Additional water can be made available if the States permit the industry to purchase some of the water rights from those presently using water and if the use category is changed from some of the future commitments.

Juan River plus 765 gpm (2.89 m^3 per minute) of moisture in the coal input, and 630 gpm (2.38 m^3 per minute) produced by the methane-synthesis reaction. Of this total input, some 2,200 gpm (8.3 m^3 per minute) will react to form gas, 1,300 gpm (4.9 m^3 per minute) will be piped to the coal mine and other offsite users, 900 gpm (3.4 m^3 per minute) will evaporate from waste ponds, 190 gpm (0.72 m^3 per minute) will leave as wet ash, 2,965 gpm (11.2 m^3 per minute) will escape in the cooling system, and the remaining 840 gpm (3.2 m^3 per minute) is accounted for in numerous small plant discharges. This represents an extreme case of water conservation as the plant is engineered so that only 15 percent of gross cooling requirements is met by evaporative cooling. In other areas and under other conditions water consumption might be considerably higher. In terms of annual consumption at an assumed load factor of 91 percent, the above estimates indicate total water consumption of 14,000 acre-ft (17 million m^3) per year of which about 2,500 (3 million m^3) is supplied to the mine and other offsite uses, leaving a consumptive demand for the plant of about 11,500 acre-ft (14 million m^3) per year. Of the total consumption of 14,000 acre-ft (17 million m^3) per year, 11,700 acre-ft (14 million m^3) per year is supplied by imported water, 1,300 acre-ft (1.6 million m^3) per year is moisture contained in the input coal, and the remaining 1,000 acre-ft (1.2 million m^3) per year is produced in the methane-synthesis reaction.

The Synthetic Gas-Coal Task Force (1973, p. XII–3) calculated substantially higher make-up water demands for typical coal-gasification plants. The following table summarizes their estimates of the annual water requirements of a typical 250 billion Btu per day (≃ 250 million scf per day or 7 million m^3 per day) plant as follows:

It was assumed in the first instance that the above plants would be totally water cooled; the different rates of make-up reflect different requirements for blowdown which depends upon the quality of input water. The 3-percent rate would apply to high-quality supply water while the 7-percent rate would apply to brackish or highly turbid supplies. The lower line of the table estimates water demand for in-plant use based on partial air cooling; the lower ranges of these estimates are comparable to the design estimates for the Burnham Complex.

To summarize, water consumption in coal gasification plants producing pipeline gas of 250 million scf per day (7 million m^3 per day) capacity can be expected to range from about 10,000 acre-ft (12 million m^3) per year where water is at a premium to 45,000 acre-ft (55 million m^3) per year where abundant but poor-quality water is used for cooling. The principal differences are in evaporative cooling requirement and relate to the extent to which air cooling is employed and greater waste-water disposal where input water is of low quality.

Production of low Btu gas for power-plant consumption onsite rather than high Btu pipeline-quality gas is considered feasible in many situations. This can be accomplished in essentially the way planned at the Burnham Complex except that the methane-synthesis process is omitted. As the methane synthesis does not play a major role in water consumption, it is believed that this alternative mode of gas production would have little bearing on consumptive demand for comparable Btu outputs.

COAL LIQUEFACTION

Estimation of unit values of water consumption in producing oil from coal is tenuous at best because no

Make-up rate, in percentage of cooling water circulation

	Bituminous and subbituminous			Lignite		
	3	5	7	3	5	7
Process water, gpm	1,742	1,742	1,742	1,705	1,705	1,705
Boiler make-up, gpm	396	396	396	359	359	359
Cooling make-up, gpm	12,107	20,178	28,249	10,096	16,828	23,559
Total, gpm	14,245	22,316	30,387	12,160	18,892	25,623
Total, acre-ft per year at 90 percent load factor	20,714	32,451	44,187	17,682	27,472	37,259
Minimal demand assuming partial air cooling, acre-ft per year at 90 percent load factor	10,358	16,225	22,094	8,845	13,682	16,630

commercial-scale operations exist in the United States and none of several possible processes has been shown to be competitive with alternate fuels. Among processes under consideration are the following: Consol, solvent refining, H-Coal, and COED (Hottel and Howard, 1971, p. 161–182). Unit water-consumption estimates range from as little as 0.2 acre-ft (247 m^3) annually per bpd of synthetic-oil output to as much as 1.3 acre-ft (1,600 m^3) per year per bpd capacity. The National Petroleum Council (1973) adopted a unit consumptive-use value of 0.2 acre-ft (247 m^3) per year per bpd capacity. Until better data become available, this figure is probably as good an estimate as any other for planning purposes. The 0.2 acre-ft (247 m^3) per year per bpd capacity translates into 20,000 acre-ft (25 million m^3) per year for 100,000 barrels (16,000 m^3) per day of oil.

SUMMARY

Consumptive demand for water in various energy processes is summarized in table 3 and figure 4. Here consumption of water is compared on the basis of energy output in millions of Btu. The larger consumptive uses are associated with large cooling requirements, particularly in thermal-electric power generation, where under the best present design nearly two-thirds of the energy input is dissipated as waste heat, mostly through evaporation of water. It should be noted that figure 4 includes both refining and conversion processes; hence, at least some of the fuel produced in oil refining becomes energy input in fossil-fueled electric generation, and the uranium fuel processed becomes energy input in nuclear-electric generation. To this extent these water requirements are additive in the total fuel cycle; however, much of the fossil-fuel product goes to other energy uses such as transportation, space heating, and industrial uses, and is not additive. Conversely, much of the electric power is not used to produce heat (measured in Btu's) but is used to make light or, in electric motors, to perform work. The work output of electric motors relative to input of electric current generally exceeds 80 percent compared to the efficiencies of engines using fossil fuels which are generally less than 30 percent. The comparatively large consumption of energy and water in generating electricity is largely compensated for if the electricity is used to produce torque.

Table 3.— *Water consumption in refining processes*

Process and product	Consumptive use (gallons per 10^6 Btu)	Remarks
Uranium	14.34	Reactor fuel for 1,000 mw nuclear plant annualized for 80 percent load factor. Includes water consumed at power plants supplying electricity for processing.
Oil	6.7	Average for U.S. refineries (Otts, 1963).
Pipeline gas from coal	....	Lurgi gasification followed by methanation stage. Product about 1,000 Btu per standard cubic foot.
a. Water cooling (90 percent load factor).	72–158	Consumption varies with amount of blowdown required; directly proportional to mineral content and turbidity of cooling supply.
b. Partial air cooling (90 percent load factor).	37–79	Assumes 85 percent of cooling demand met by nonevaporative air cooling.
Synthetic oil from coal	31–200	General estimate based on several potential processes using pressure hydrogenation technology.
Oil from shale	19–29	Includes water requirement for spent shale disposal.

Average water consumption in electrical generation

[Most efficient design assumed; at 80 percent load factor]

Process	Water consumption, (gallons per kwhr)	Water consumption (gallons per 10^6 Btu of electrical output)
Fossil-fueled	0.5	146
Nuclear	.8	234
Geothermal	1.8	527

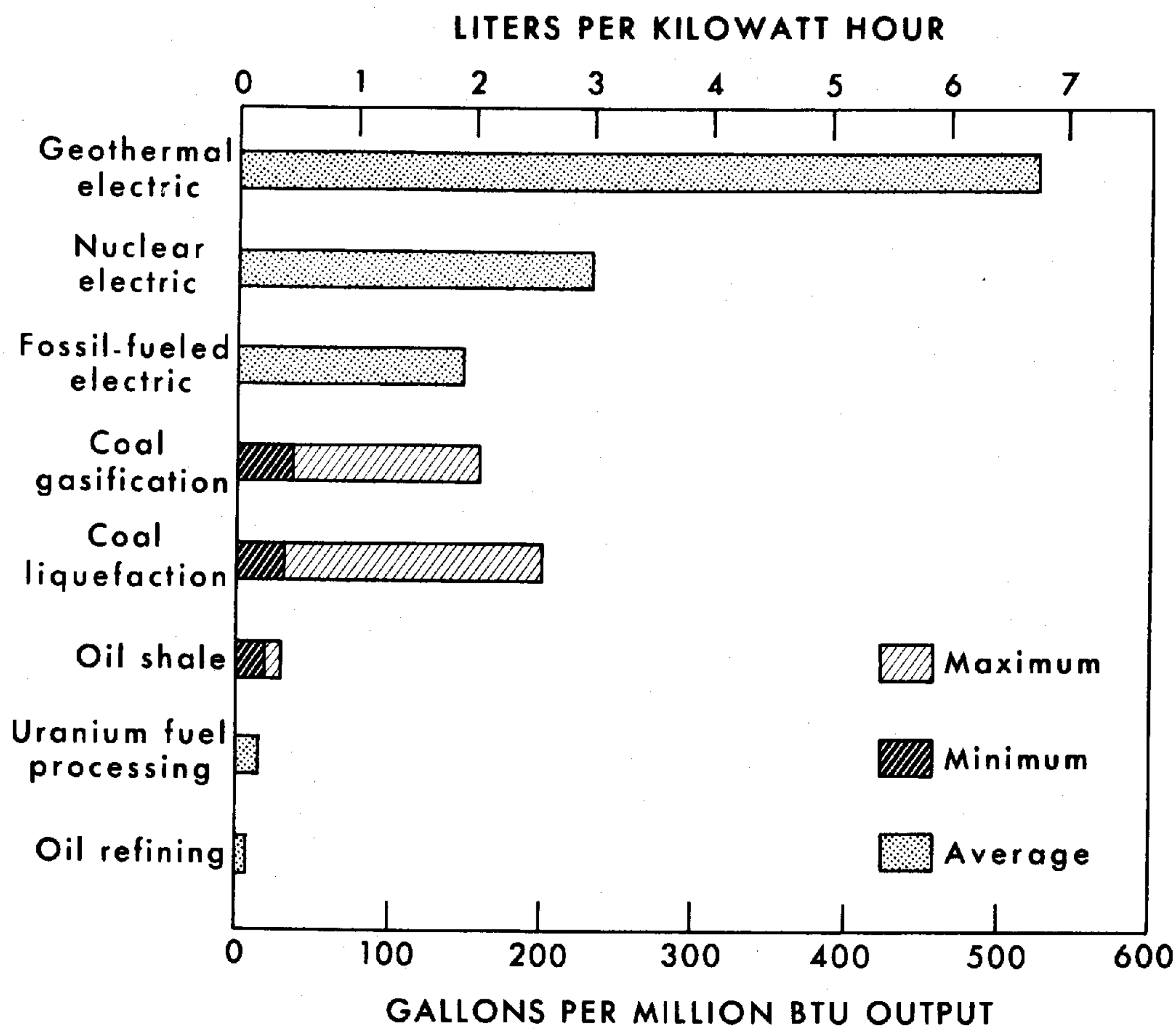

Figure 4.—Water consumption in refining and conversion processes.

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In producing this report, a tremendous quantity of written material was researched. So many valuable facts and concepts stood out that documentation and cross referencing was omitted due to the immensity of the task.

However, the economic and environmental aspects of electric energy generation and use, on national and regional bases, have been well studied by the sampling of organizations listed following. Many other organizations have made equally important contributions to the literature on energy, but there is not sufficient space allocated within this report to list them. Rather than list many specific titles of publications, it is suggested that persons interested in deeper study contact the organizations below for publication lists on energy matters.

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5. California Institute of Technology, Environmental Quality Laboratory, Pasadena, California (EQL reports 1 through 8 plus paperbacks and reprints).

6. Western States Water Council, Salt Lake City, Utah (Western States Water Requirements for Energy Development to 1990).

7. Western Interstate Nuclear Board, Lakewood, Colorado (Energy Resource Development for the West).

8. State of California, The Resources Agency, Sacramento, California (Energy Dilemma, California's 20-Year Power Plant Siting Program).

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2. Report No. 2, January 1971,
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   "Water for the Future in Southern Nevada"
4. Special Report, May 1971,
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   "Nevada's Water Resources"
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   "Forecasts for the Future - Mining"
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   "Forecasts for the Future - Electric Energy"

15. Special Report, September 1974,
   "Input-Output Economic Models"
16. Special Report, September 1974,
   "Water - Legal and Administrative Aspects"

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"Alternative Plans for Water Resource Use"

1. Walker River Basin Area I (September 1973)
2. Carson-Truckee Rivers Area II (December 1973)
3. Humboldt River Area III (February 1974)
4. Central Area IV (April 1974)
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*These reports each include a separately published appendix.