# REVIEW OF ALTERNATIVE ENERGY SOURCES
# FOR IRRIGATION USE IN IDAHO

By
C. C. Warnick
Professor of Civil Engineering

for the
Idaho Office of Energy

Idaho Water Resources Research Institute
University of Idaho
Moscow, Idaho

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## FOREWORD

The Idaho Water Resources Research Institute has provided coordination for this study and organized the team that conducted this review. It is the Institute policy to make available the results of significant research on water and related land resources conducted in Idaho's universities and colleges. The Institute neither endorses nor rejects the findings of the author. In this study an effort has been made to make contact with those involved in energy use and production and expose all facets of energy sources as they relate to irrigation in Idaho. Policies and problem needs have been assessed in light of the present day restraints on energy use and the related resources, particularly water use as it relates to energy use in irrigated agriculture.

## ACKNOWLEDGEMENT

The author wishes to acknowledge the support of the Idaho Office of Energy in partially funding this research. The project was carried out under the supervision of Dr. John S. Gladwell as Director of the Idaho Water Resources Research Institute. The cooperation of the Engineering Division of Seattle City and their publisher Cone-Heiden in allowing permission to reproduce certain illustrations of energy alternatives is especially commended. The cooperation of various utilities both private and public entities in supplying useful information has been most helpful.

Special thanks goes to my colleague Dr. John R. Busch of the Agricultural Engineering Department who was project leader on this project concerned with energy use in irrigated agriculture. Thanks is expressed for the secretarial assistance of Linda Fulton and Gloria Hall and the drafting assistance of Robert Townsend and Candelario Eguia.

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# ABSTRACT

Alternative electrical energy sources for meeting the power needs of irrigated agriculture in Idaho are discussed in light of present energy restraints and the escalation in prices of non-renewable fuels for energy production. Six alternatives have been identified that involve renewable energy sources and three non-renewable sources are suggested. A brief explanation is made of how each of these alternatives function in producing electrical power suitable for serving irrigated agriculture.

An assessment of the technical feasibility in Idaho's irrigated agricultural region of these various alternative energy sources is made and a presentation is likewise made of the social and political acceptibility of each of the alternatives to serve as a source of power for irrigation pumping as conditions exist in 1979.

Finally an estimate is made of the cost of producing electrical energy for irrigation operations in Idaho for each alternative to indicate possible choices of the future. Conclusions are drawn and recommendations made to encourage development of the most promising alternatives that might meet the conservation needs of the state and meet possible new load growth that now appears to be facing those involved in irrigated agriculture.

# INTRODUCTION

This report on alternative sources of energy for supplying power for irrigation pumping in Idaho defines possible ways of obtaining energy in the future to meet the needs of agriculture. Alternative energy sources are defined as any means of energy production and location that is not now producing energy for irrigation use in Idaho. The justification for this report is the energy shortage that has become evident and the escalation in prices of the non-renewable fuels that have normally been relied on in much of our country.

## Need for Electrical Energy for Irrigation Pumping in Idaho

Presently about 1,800,000 acres are being irrigated with pumping operations in Idaho, using an estimated 2,100,000,000 kilowatt hours of electricity annually. This usage is projected to increase by three to four percent each year and may be more depending on the amount of switching from surface irrigation to sprinkler irrigation as well as new policies on desert entry lands.

Various methods of supplying electrical energy to supplement that produced from the present large scale hydroelectric plants for irrigation pumping in Idaho are described. These alternative methods of production are classified on the basis of using renewable or non-renewable energy sources. The technical feasibility of each method is described. The social and political acceptability of the alternative energy sources is assessed, and estimates of the costs of supplying energy for Idaho agriculture by alternative methods are summarized.

For reference purposes, two maps are presented. Figure 1 shows where present irrigation is practiced and where there is potential for new irrigation, thus showing where existing electrical energy use and future energy need will be located in the State. The second map, Figure 2, shows where existing energy production is concentrated in Idaho. These maps present a brief picture in a geographic sense of where there is a problem. It should be noted that need for alternative energy is and will be concentrated in Southern Idaho along the Snake River.

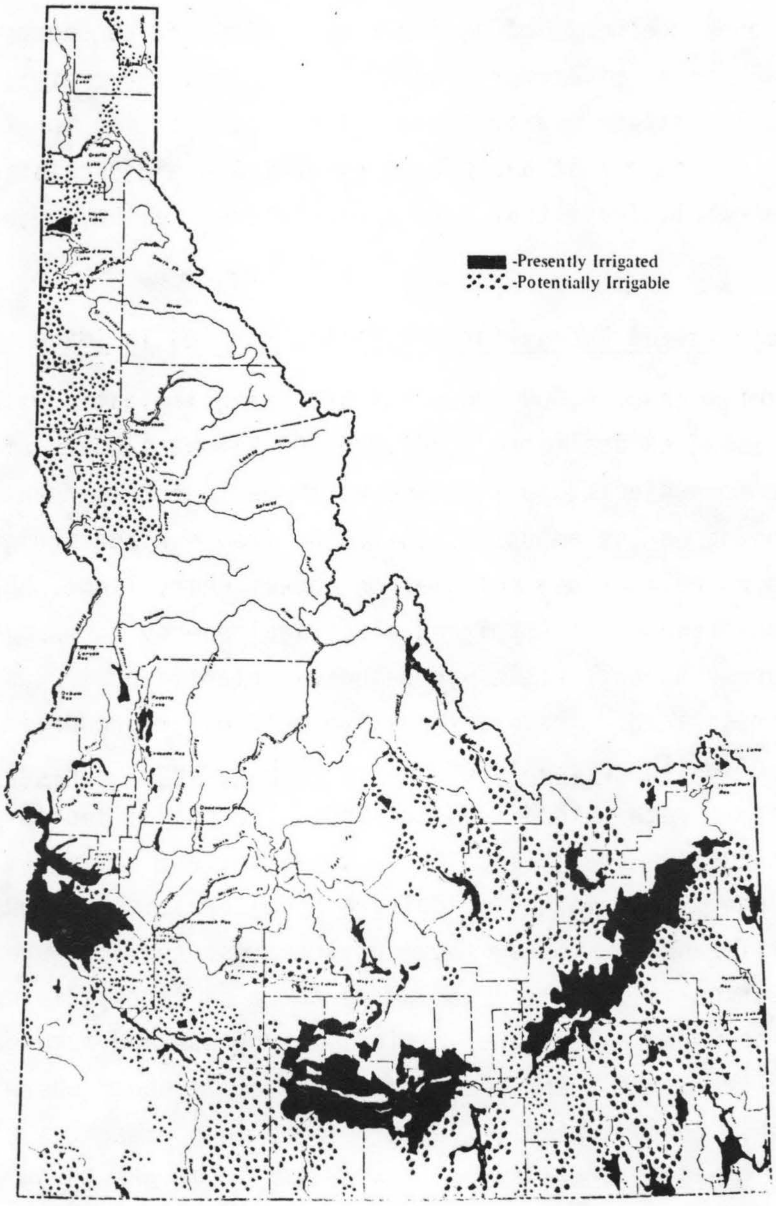


Figure 1. Irrigation energy load areas.

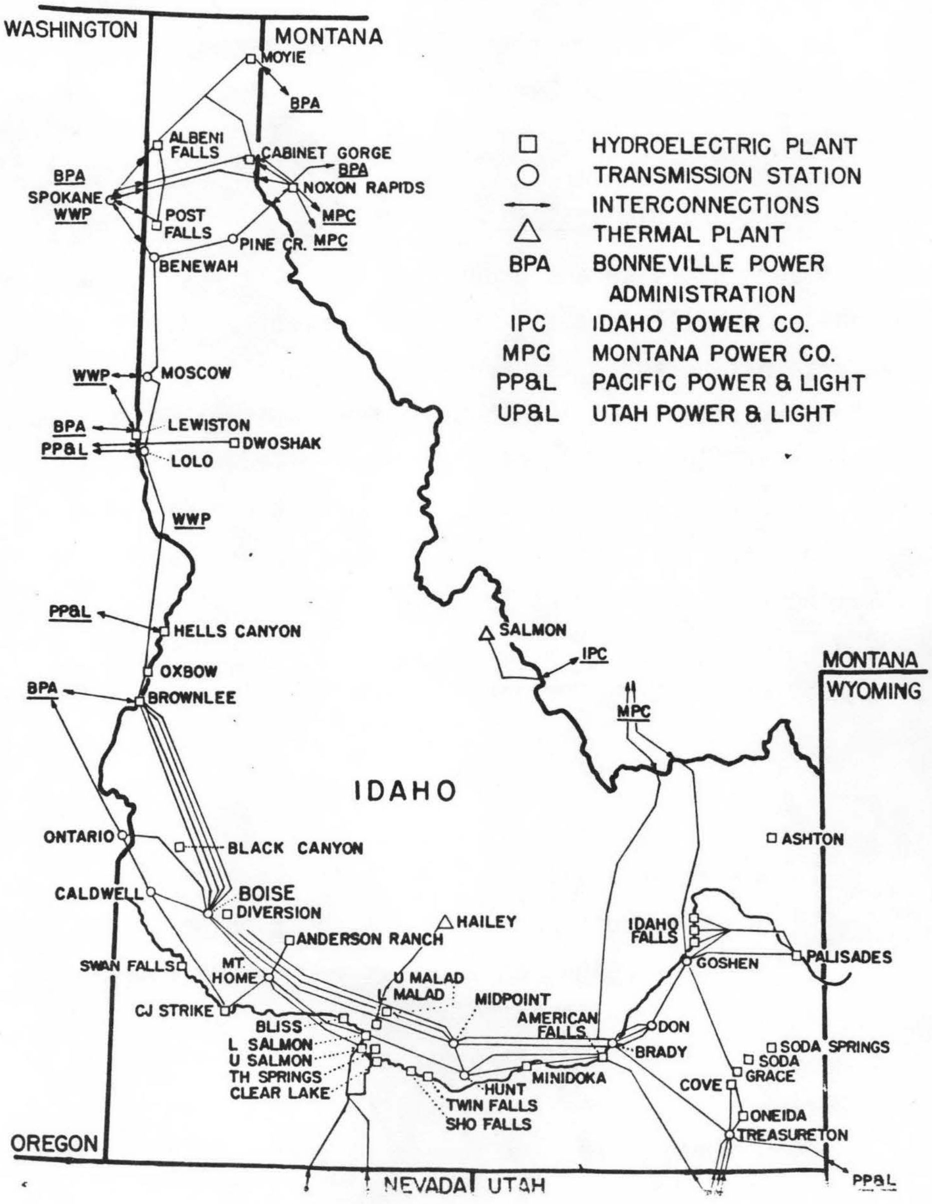


Figure 1. Existing energy production plants and main transmission facilities.

## RENEWABLE ALTERNATIVE ENERGY SOURCES

In each of the following sections, a brief description is given of how electrical energy is produced at the present state of the art.

As illustrated by Figure 2, existing energy supply for irrigation in Idaho is almost totally from hydroelectric production. The difficulty is that nearly all the good high head sites for production of electrical energy have been developed or eliminated by reserving rivers for uses such as wild and scenic rivers.

### Small Scale Hydroelectric Systems

Improvement in design and production of small scale, low-head hydraulic turbines has made building small sized hydroelectric plants attractive and this offers an alternative energy source in many locations in Idaho. Small scale hydro systems are plants of less than 15 megawatts capacity usually of heads less than 60 feet (20 meters). It may also include higher head plants having relatively low discharges. Figure 3 shows the types of systems that can be utilized. An example of this type of production is featured in the new units being developed for the City of Idaho Falls (International Engineering Co., Inc., 1978).

The basic mathematics for energy production is covered by the following equation:

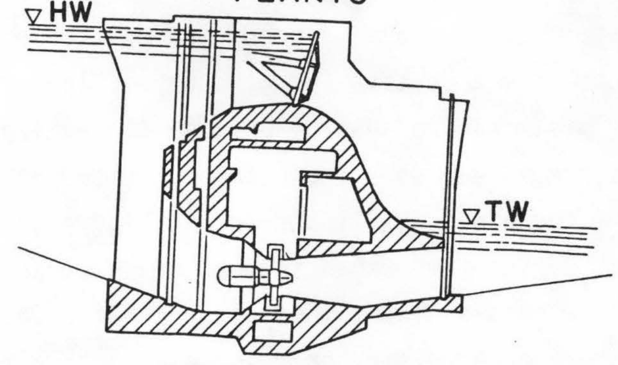
$$P = \frac{Q\gamma He\ (0.746)}{550}$$

where:

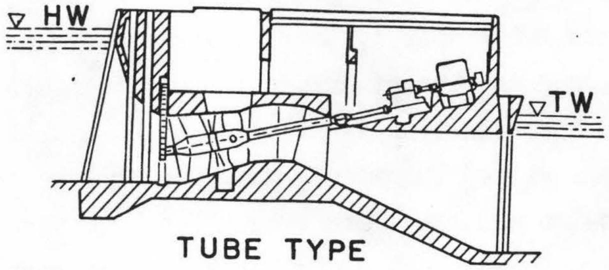
$P$ = power available in kw (kilowatts)
$Q$ = water discharge through the turbine in cfs (cubic feet per second)
$\gamma$ = unit weight of water in pounds per cubic foot
$H$ = head in feet
$e$ = efficiency of turbines
0.746 = conversion from horsepower to kilowatts
550 = number of foot pounds of energy in 1 horsepower unit

A water flow of 36 cfs operating under a head of 60 feet will produce approximately 200 kw of electrical energy. This amount of energy would supply approximately 600 acres of irrigated land under average pumping lift conditions in Idaho. Opportunities for development exist in stretches of undammed rivers, water waste ways, existing dams without power plants, and irrigation canal system drops. A

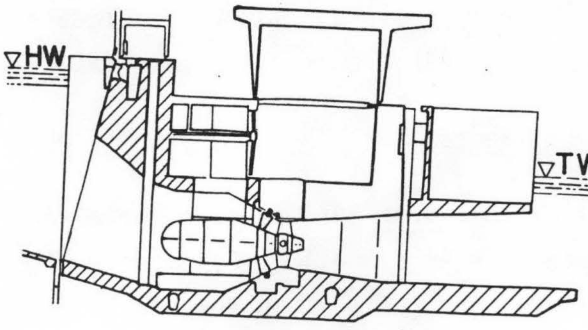
SMALL CAPACITY, LOW-HEAD HYDROELECTIC PLANTS



RIM-GENERATOR TYPE



TUBE TYPE



BULB TYPE

Figure 3. Illustrative drawings of small capacity hydroelectric units.

survey of the potential for this so-called "low-head" hydroelectric energy is nearing completion, (Heitz, et al, 1979). Preliminary results indicate there is about 10,000 MW (megawatt = 1000 kw) of ultimate theoretical capacity in the state, of which 500 to 1500 MW are likely to be developed.

## Pumped Storage Hydroelectric Power Plants

Using water as the means of producing peak power by pumped-storage represents another alternative energy source. In a real sense it represents a net loss in production of energy because it requires more energy to pump water to an upper storage reservoir than can be created by passing the water through turbines. The technique is illustrated in Figure 4. This operates on the principle that during times when another means of energy production is producing "dump" or surplus low-valued power, that energy is used to pump water to an upper storage reservoir for release through a reversible pump turbine during periods of peak demand when the value of energy is much greater than during dump periods. Fortunately for the State of Idaho, because of numerous existing reservoirs and the abrupt change in relief in many of its canyons and valleys, there are good opportunities for developing pumped storage hydro units in Idaho. It should be emphasized that their main use will be in power peaking operations which will require new base load production from steam power plants or other sources of energy. How such might operate, in a sort of dual system, is illustrated in Figure 5. Pumped storage might be termed a renewable energy source but it may require a non-renewable enery source to make it feasible.

## Biomass Steam Power Plants

The energy available from burning of organic renewable residues represents an alternate source of energy. All are biomass residues which might be available in Idaho include: (1) wood residues in forests and at lumber mills, (2) crop residues, (3) animal wastes, (4) municipal solid wastes, (5) sewage sludge, (6) fiber from fuel plantations. A system would consist of a collection and preparation phase, and an incineration and power phase including a steam boiler, turbine and generator. The advantage to this system is that most of the heat source represents a waste in some other industry or activity. Boilers to burn such biomass wastes are more costly than conventional fossil fuel systems and do

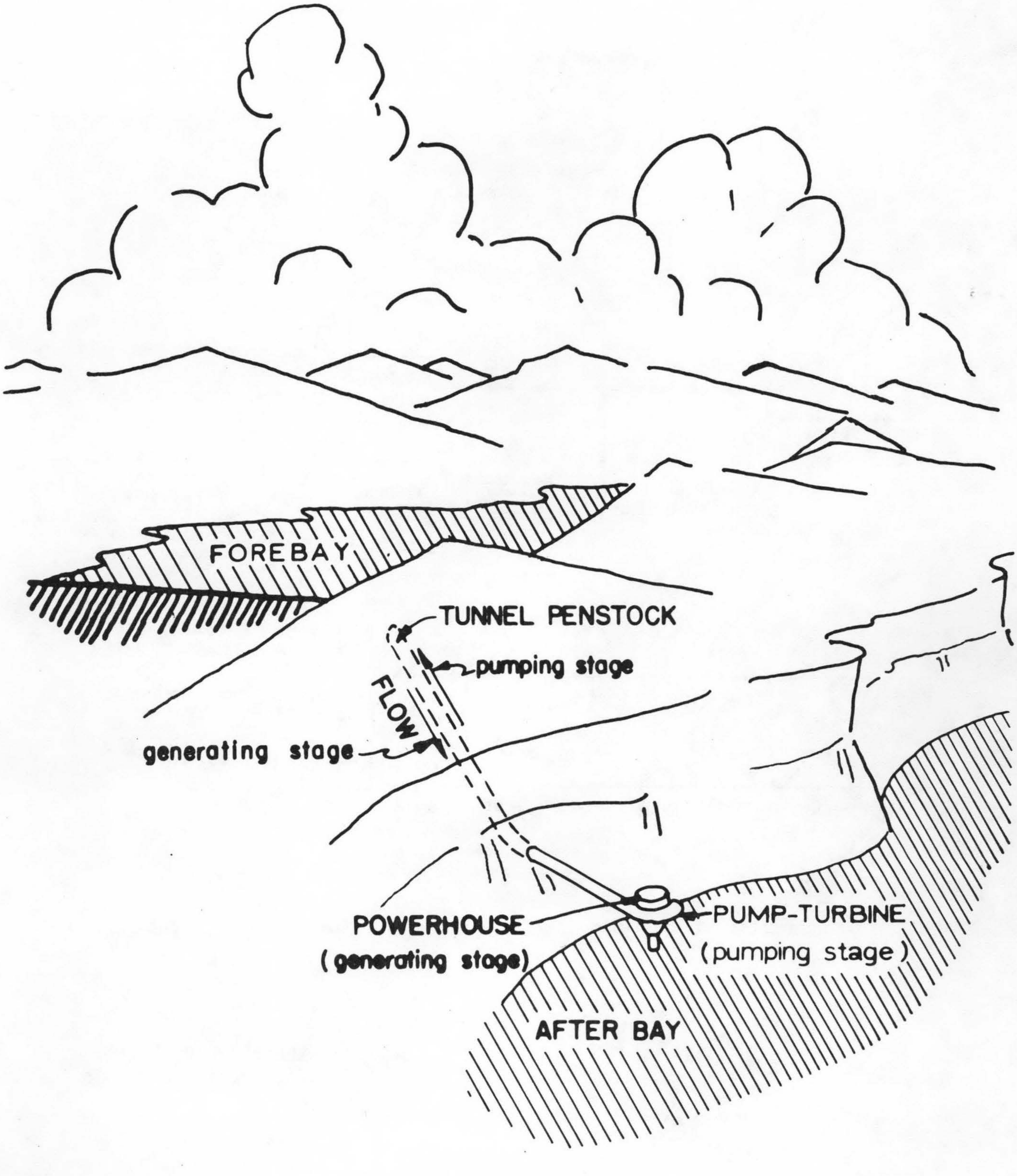


Figure 4. Sketch of pumped storage hydroelectric power plant.

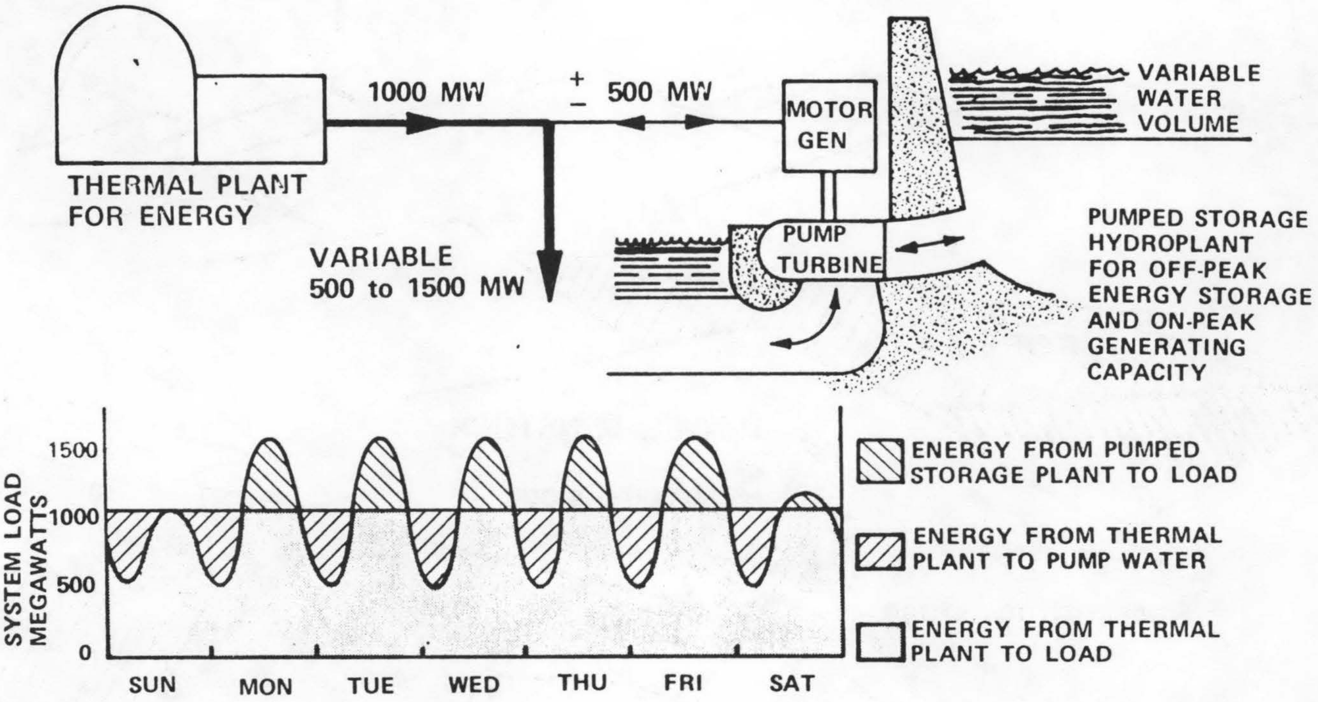


Figure 5. Schematic of combined thermal and pumped storage power plant.

Source: Seattle City Light,
Engineering Division
&
Cone-Heiden

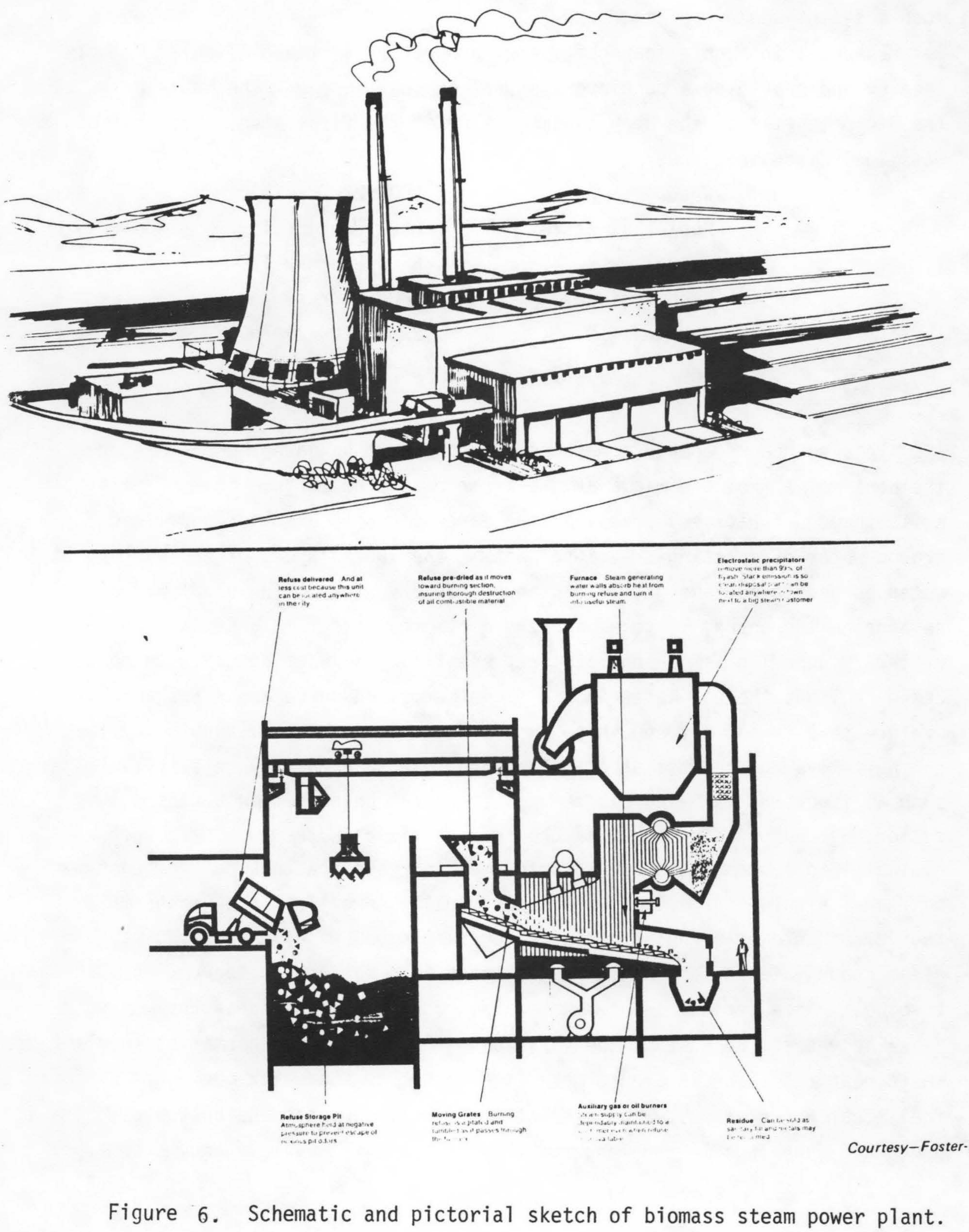
not achieve as high a combustion efficiency. Figure 6 shows schematically how such a system would operate.

Inherent in such a means of energy production is the difficulty of collecting and providing a continuous source of fuel supply. The table below gives the Btu potential of the high heating value of the first five sources of biomass fuel discussed above:

| | |
|---|---|
| Wood | 8500 Btu/dry lb. |
| Municipal waste | 8500 Btu/dry lb. |
| Animal waste | 8750 Btu/dry lb. |
| Crop residue | 8000 Btu/dry lb. |
| Sewage | 7250 Btu/dry lb. |

## Geothermal Steam Plants

This source of energy comes from trapped heat beneath the earth's crust, the heat comes from the magma at the interior of the earth. Some of this heat exits through faults and cracks in the earth's crust, and is transmitted to ground water circulating or trapped within the upper layers of the earth. If the water is heated hot enough, it can appear as dry steam. The usual way of developing the energy is to expand the geothermal steam in a steam turbine cycle. Figure 7 gives a schematic representation of what occurs. In most cases in Idaho the hot water in known geothermal resource areas has a temperature that is not hot enough to expand directly in a steam turbine cycle. At the Raft River geothermal area in Southern Idaho a binary cycle of using a gas such as isobutane is being planned. The gas can be heated in a closed loop system instead of using steam as the driving fluid in the turbine. Such a closed fluid system frees the rotating machinery of the turbine from contamination of highly mineralized water that usually comes from the geothermal source. Such exotic engine cycles do present problems of disposal of the steam condensate and are not expected to be as efficient as conventional steam turbines. Some serious problems are also posed in disposing of the non-condensable gases. Because of the very low efficiency of goethermal steam plants, waste heat rejection is even a more severe problem than with conventional fossil fuel steam power plants. The extraction of heat depletes the heat within the earth and therefore in the long run this is a non-renewable energy source.



*Courtesy—Foster-Wheeler*

Figure 6. Schematic and pictorial sketch of biomass steam power plant.

Source: Seattle City Light,
Engineering Division
& Cone-Heiden

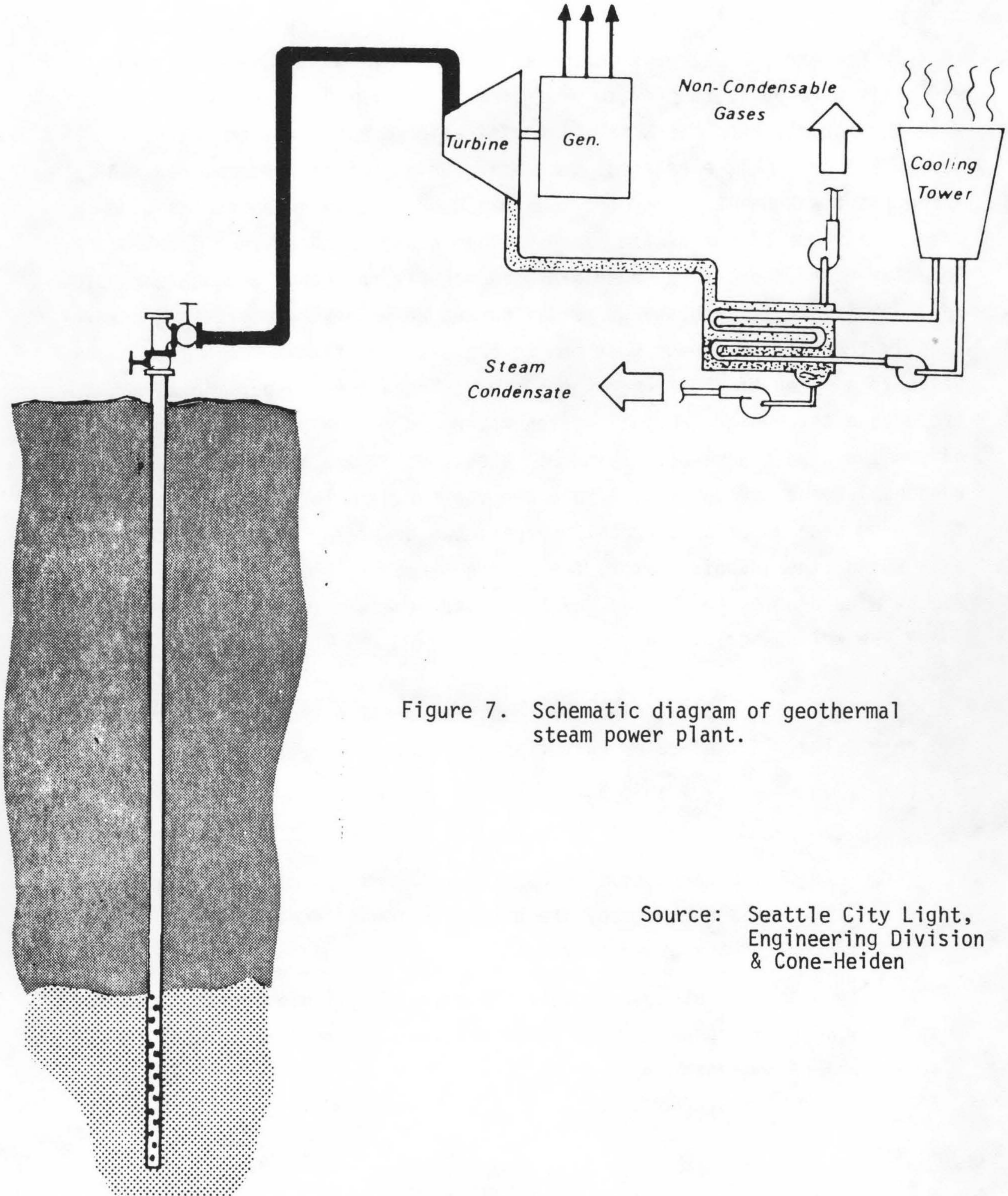


Figure 7. Schematic diagram of geothermal steam power plant.

Source: Seattle City Light,
Engineering Division
& Cone-Heiden

## Wind Power Plants

In the early history of the development of the West several million small windmills were built to provide power for remote rural residences and farm units. With the formation of the Rural Electrification Administration in the 1930's nearly all the small electrical generating units were abandoned. In 1943 a large plant was built in Vermont that produced 1.25 MW in a wind of 13.4 m/sec. Failure of one of the blades led to abandonment of that development. Recently much interest has been expressed in a wind energy production system. This involves a large blade propeller hooked up with an electrical generator. Usually there is a step-up gear box to increase rotational speed from a low value to a speed of 1800 rpm. The system in recent new experimental units includes a three-blade variable-pitch rotor and mechanism that automatically aligns the wind generator. Speeds in excess of 10 mph are required to obtain reasonable power production. There are various forms of wind driven machines that have been under development the past two decades. These include vertical axis mills (the Savonius rotor, the Darrieus rotor), the Giromill, the DOE-NASA 200 KW wind dynamo, the Boeing DOE MOD2, and Schachle rotating tripod dynamo. These are well described in a new book Windpower and Other Energy Options, by Ingles (1978).

A sketch of a typical wind power unit of small output is illustrated in Figure 8. The wind generator output is given by the equation:

$$P = 2.1 \times 10^{-6} A V^3$$

where:

P = power output in kw.
A = area swept by the blades in square feet
V = wind speed in mph.

It may often be valuable to know the energy available or extractable from the wind on an annual basis. This has been reported by Caton's analysis (Caton 1975) as follows:

$$E_a = 3.2289 D^2 V_{50}^3$$

where:

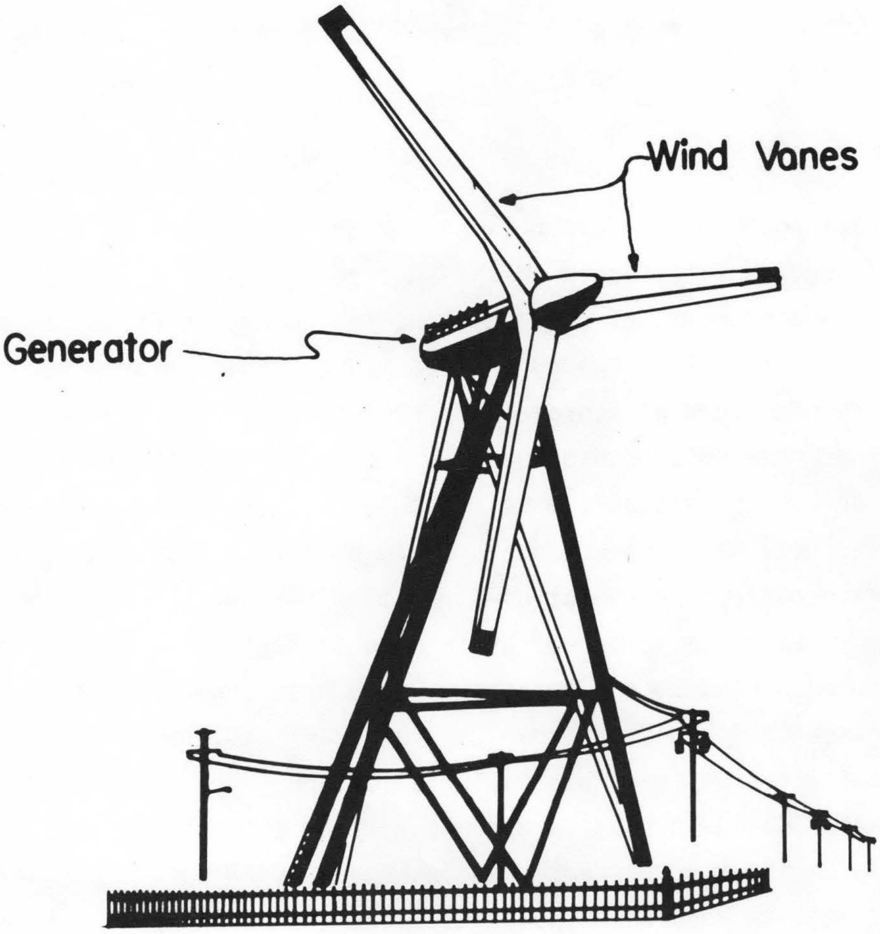


Figure 8. Sketch of wind power electrical generator.

$E_a$ = extractable energy per year in KWH

D = rotor diameter in meters.

$V_{50}$ = wind velocity exceeded 50% of the time in m/sec.

A critical item necessary for windpower to be economically feasibile is a reasonably high value of wind density and a means of storing energy. Unfortunately the need for the energy extracted from wind generators does not often match the load requirements and a means of storing the energy produced is needed to make it effective for irrigation use. Because wind is available naturally due to air mass movements and gradients caused by the earth's rotation, this is a renewable resource.

## Solar Power Plants

Radiation reaching the upper layers of the atmosphere is a tremendous source of energy, but losses in the passage to the earth's surface, reradiation losses, and problems of concentrating the energy to cause solar power to be an expensive electrical energy source. Large scale solar power generation would require some form of storage of energy to take care of the cyclic nature of the periods when solar radiation does not reach the conversion or production device. Figure 9 shows a pictorial sketch of a large scale solar thermal power plant. Solar heat could be concentrated to operate a heat engine system. Figure 10 shows a schematic representation of a solar electric power plant. Such a scheme might be a system where solar energy is used to heat metal tubes containing molten mixtures of sodium and potassium. The heat conceiveably could be stored at essentially constant temperature in an insulated chamber that has enough capacity for at least one day's collection. Heat extracted from the storage chamber would be used to operate a steam electric plant. Efficiency would likely be about 30 percent. In Idaho a 1000 MW solar thermal power plant would require an area of solar collectors of about 30 square miles in the winter period to concentrate the heat. In summer it might be as low as 4 square miles. Thus such power plants would have extremely high capital cost expenses but would have no fuel cost. This then can be termed a renewable energy source.

The production of electrical energy by photo voltaics is also possible Silicon solar cells have been developed for space missions and cadmium sulfide photovaltaic cells represent a newer development that is somewhat less

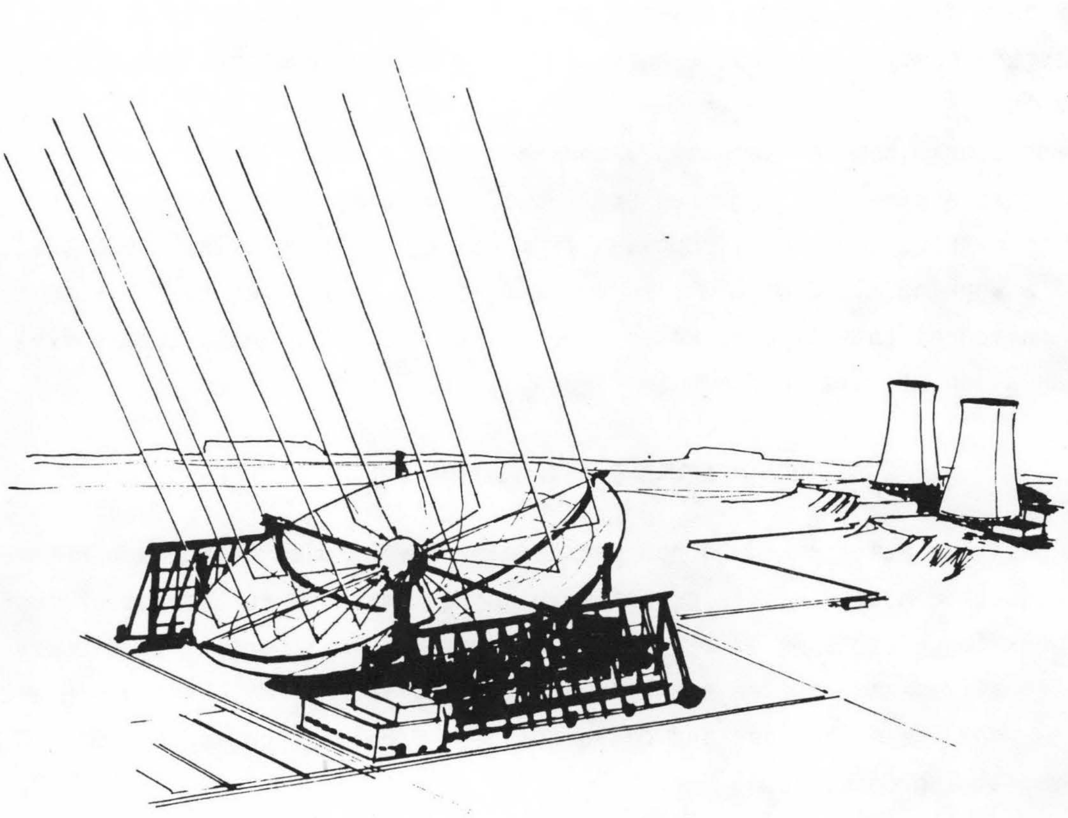


Figure 9. Pictorial sketch of solar thermal power plant.

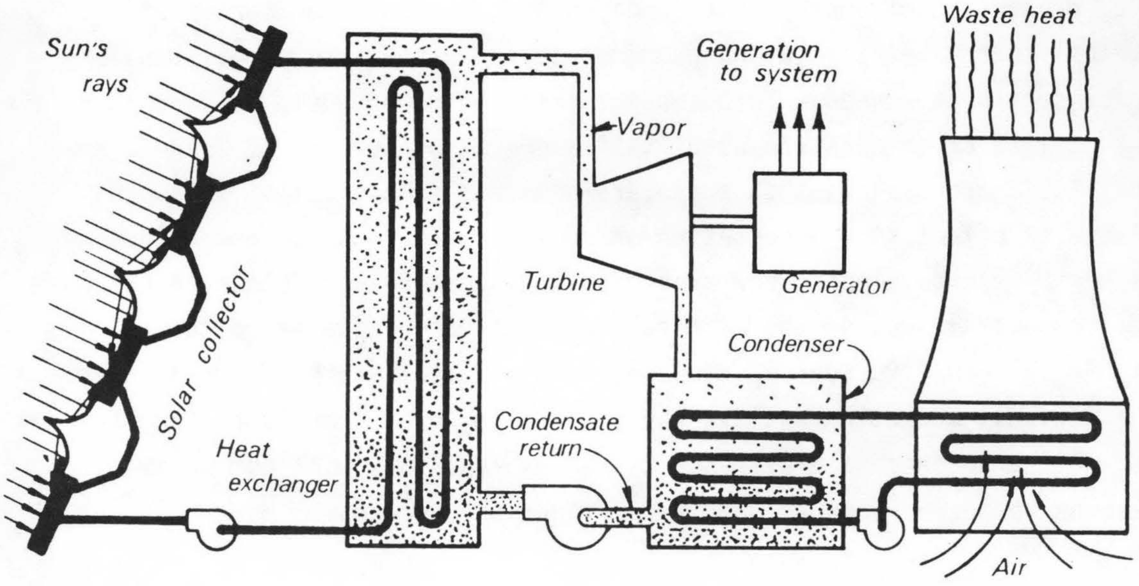


Figure 10. Schematic diagram of solar electric power plant.

Source: Seattle City Light,
Engineering Division
& Cone-Heiden

efficient than silicon cells. Present costs for even small quantities of from sunlight energy are around twenty times the cost of conventional steam power plants.

An additional type of technology that has been proposed is the use of a rankine heat engine that requires boiling of a working fluid and expansion of vapor to extract the energy supplied from solar radiation. This uses the motion of a working fluid within a rocker arm to transmit power to a piston pump. A device of this type is under investigation by Honeywell, Inc. (1978). A representation of this is shown in Figure 11.

## NON-RENEWABLE ALTERNATIVE ENERGY SOURCES

Although the State of Idaho has not developed very much in the non-renewable energy production mode, this is extensively being mentioned as a means of meeting future needs for production of electrical energy. It is important to discuss these alternatives and compare non-renewable energy sources with renewable energy sources to show the advantages and disadvantages of relying on any one or several modes of production.

### Commercial Importation

Commercial importation of electrical energy is actually not a separate mode of production of energy, but in discussing alternative sources of electrical energy for irrigation pumping use in Idaho it is a real possibility for serving the need. This implies that the power would be purchased from a utility or combination of utilities operating outside of Idaho. Reference to Figure 2 shows that there are numerous transmission lines now available to effect such importation of power. Such an arrangement in some cases might mean developing new transmission interties with other electrical energy producers. One of the difficulties that has necessitated the search for alternative sources, though, is the fact that the Federal government's regional marketing entity, the Bonneville Power Administration, has served notice to present preference customers that they will not be able to furnish new expected energy loads for irrigation pumping.

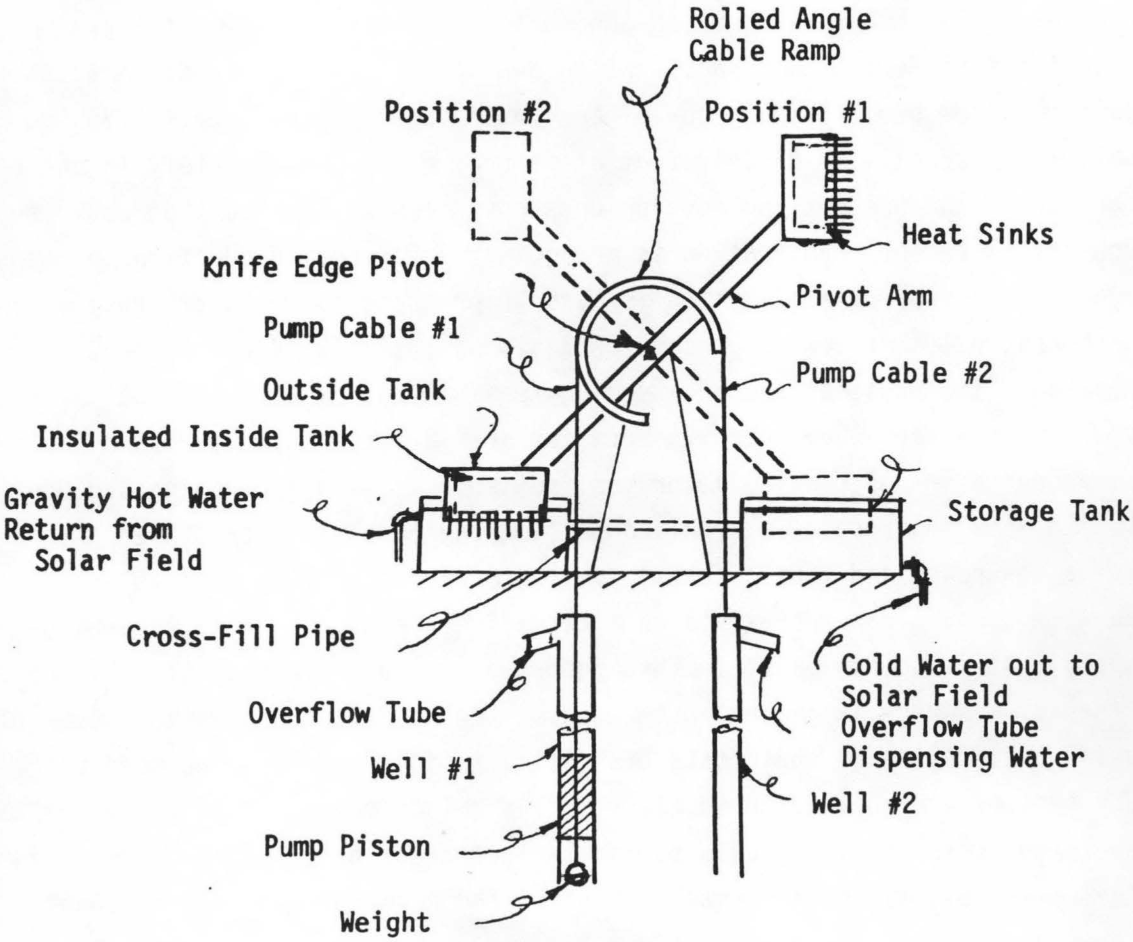


Figure 11. Dual-Stroke Low Temperature Pumping System for Irrigation Use.

Source: Modified from Honeywell, Inc.

## Fossil Fuel Steam Plants and Internal Combustion Engine-driven Pumps

At present there is no fossil fuel steam plant in Idaho except for a small gas turbine installation at Ketchum, and a small diesel power plant at Salmon. In a physical sense, a steam power plant requires a heat source for steam turbines. This is usually supplied by burning of coal, natural gas, or crude oil. Figure 12 shows in schematic form the arrangement for a typical fossil fuel steam plant. At an average efficiency of 38%, a steam plant requires per kilowatt hour of energy produced approximately 0.75 lbs of coal, 1 cup of oil, or 9 cubic feet of natural gas. Unfortunately in the State of Idaho up to the present, no developments have been discovered that would supply such fossil fuels. Exploration is now going on for coal production in Teton County and petroleum exploration is also in progress in the overthrust areas of northeastern Idaho. Under present conditions, fosil fuels would need to be imported. The physical and engineering feasibility for a fossil fuel plant to serve as an alternative energy source for irrigation pumping in Idaho implies a transportation of coal, oil, or gas from sources such as Wyoming and Montana.

In some instances, internal combustion engines have been linked with irrigation pumps and thus a fossil fuel form of resource is used as an energy source. This represents an alternative energy source to the energy supply that is now in use. In this report a minimal reference to this as an alternative source is presented because of the need to conserve this type of fuel and the evidence that costs are rising rapidly and more and more users of such systems are converting to electrically driven pumps. This trend can change depending on the cost of fuels particularly that of natural gas. Fossil fuel steam power plants and internal combustion engines represent non-renewable energy sources.

## Nuclear Plants

Initial production of electrical energy from atomic reactors using heat from nuclear fission occurred in Idaho but to date no commercial production has occurred. The basic process depends on the splitting of the nucleus of an atom into two approximately equal parts whose combined mass is less than the original nucleus. This disappearing mass converts to energy. Man-made fission usually uses uranium 235 and the fission process is started by bombarding the uranium nucleus with neutrons. The excaping neutrons then strike other nuclei

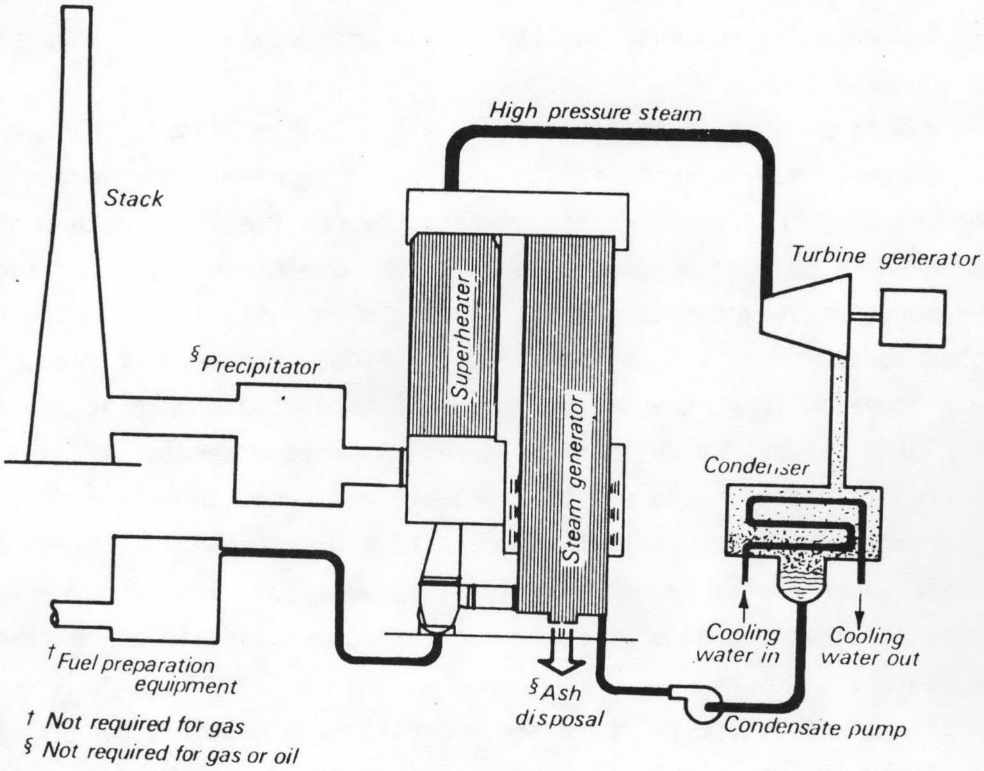


Figure 12. Schematic diagram of typical fossil fuel power system

Source: Seattle City Light,
Engineering Division
&
Cone-Heiden

and sustain a chain reaction. The fission energy of one ounce of uranium fuel pellets ($UO_2$) is the equivalent to the chemical energy of 100 tons of coal.

The system is very complicated and can be best illustrated by two figures. Figure 13 is a diagram of the uranium fuel processing and Figure 14 the energy production plant utilizing an atomic reactor. Three types of reactors are presently used for production: (1) boiling water reactors (BWR), (2) pressurized water reactor (PWR), and (3) high temperature gas-coaled reactor (HTGR). Only a single cycle BWR type of system is here illustrated in Figure 13. Usually for economic reasons, nuclear plants are developed in sizes of at least 1000 MW.

In addition to the conventional PWR and HTGR type fission nuclear reactor plants, there is now experimental technology that permits development of fast breeder reactors that would greatly extend the non-renewable nature of the uranium used in nuclear power plants. As the name breeder reactor suggests, the reactors, while generating heat, produce more fissible plutonium PU-239 than they consume. This is not perpetual motion. The breeder reactors do not create plutonium; they convert uranium U-238 to plutonium and at the same time "burn" plutonium fuel in the central core. A breeder reactor makes it possible to be more efficient in the use of the basic resource, in this case uranium. A breeder reactor utilizes up to 60 percent of the heat energy content of uranium ore, while water cooled reactors utilize approximately 1 to 2 percent. Thus it is obvious that a breeder reactor nuclear power plant is a non-renewable energy source.

Nuclear fusion type reactors are hoped to be a possible energy alternative of the future. However, to date the technology to harness the energy release of fast neutrons has not been perfected. It is expected abundant sea water can be used as the source of the basic resource of tritium and deuterium. Some scientists have predicted a breakthrough in technology by the year 2000. At this time it is still an unproven mode of production of electrical energy. Even this, though, is a non-renewable approach to energy production.

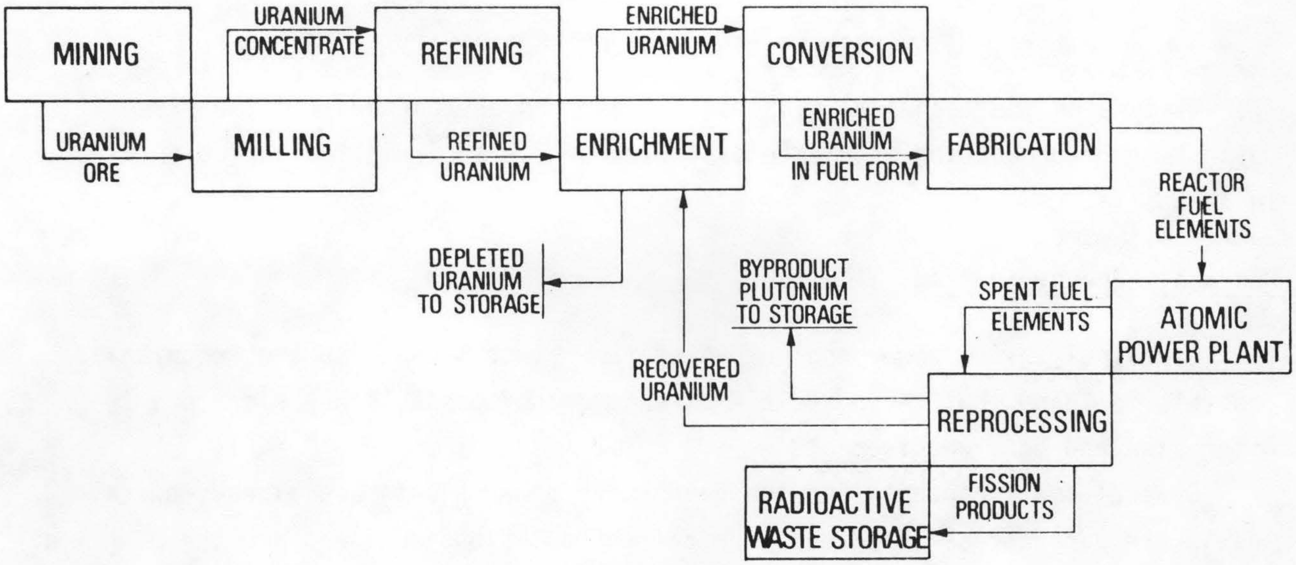


Figure 13. Flow diagram of nuclear fuel processing system.

Source: Seattle City Light,
Engineering Division
& Cone-Heiden

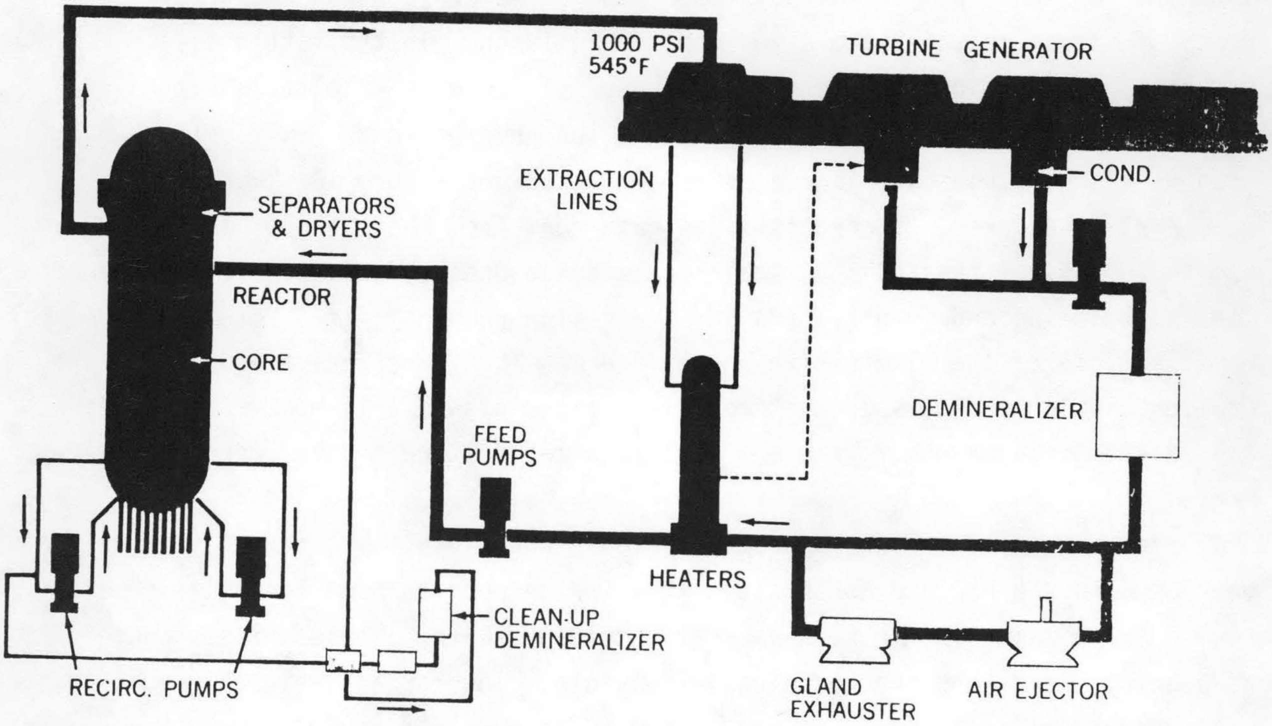


Figure 14. Schematic diagram of nuclear steam power plant.

Source: Seattle City Light,
Engineering Division
& Cone-Heiden

# ASSESSMENT OF TECHNICAL FEASIBILITY

Discussing the technical feasibility has been approached from the viewpoint that of production should be suitable for use in irrigated agriculture in Idaho.

## Renewable Energy Sources

Certaintly hydro power and pumped storage power production are technically feasible in Idaho, but there are a finite number of possible new sites due to water flow and head requirements.

Several small capacity and low head hydro power plants are already operating in irrigated areas of Idaho. Typical installations in Idaho are the plants of the city of Idaho Falls and the Lower and Upper Salmon plants of the Idaho Power Company in the Hagerman Valley. Feasibility to serve as an alternative energy source, though, implies that there is additional resource sufficient to meet irrigation pumping needs. The present survey by the Idaho Water Resources Research Institute is trying to answer that very question. An example of how this is being assessed stream by stream is shown on the summary sheets for two such studies, one in the canal system of the Boise Project and one of a reach of stream in the Snake River near Buhl, Idaho. In the latter case, potential energy might theoretically be used to serve as an alternative energy source for present or future irrigation pumping in the Twin Falls area. These examples are indicated as Figure 15 and Figure 16.

Preliminary results certainly indicate that from the standpoint of physical and technological feasibility, small scale hydro does offer a possible means of meeting existing and future loads for irrigation pumping. It is probably the most feasible of the alternative energy sources for Idaho irrigated agriculture. Caution should be expressed that new small sized plants will need tied in with the existing transmission grid and meet required voltage and frequency requirements.

A pumped storage power operation at only one hydro installation site has been developed in the Pacific Northwest. This is the pump-turbine installation at Coulee Dam pumping from Lake Roosevelt into Banks Lake. These units are useful as peaking plants and are technically feasible. Insofar as irrigation pumping will contribute to future peak loads, pumped storage hydro will serve as a suitable energy alternative. Several studies have been completed on preliminary engineering planning of such type of installations. The Idaho Power Company has studied

CANAL SYSTEM Boise Project

SITE # 2-Electric Drop

I. LOCATION

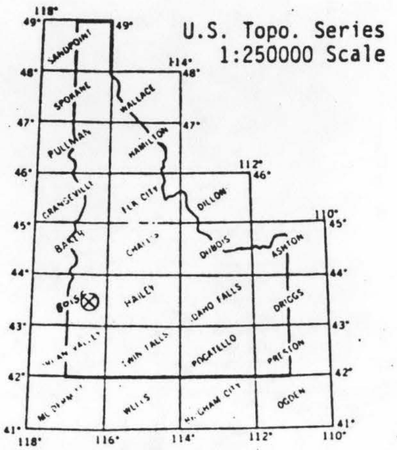
| | | |
|---|---|---|
| a. | State | Idaho |
| b. | County | Ada |
| c. | Section, Range, Township | 33, R1W, T24S |
| d. | Longitude, Latitude | 116°23'W, 43°28'N |
| e. | District Name | Boise-Kuna Irrigation Dist. |
| f. | Canal Name/s | Mora, Waldvolgel |

II. WATER RIGHTS

| | | |
|---|---|---|
| a. | Type | Flow & Storage |
| b. | Ownership | Irrigation District |

III. HYDROLOGIC AND HYDRAULIC CHARACTERISTICS

| | | | |
|---|---|---|---|
| a. | Elevation of Forebay | 2730 | Ft. MSL |
| b. | Available Head | 36 | Ft. |

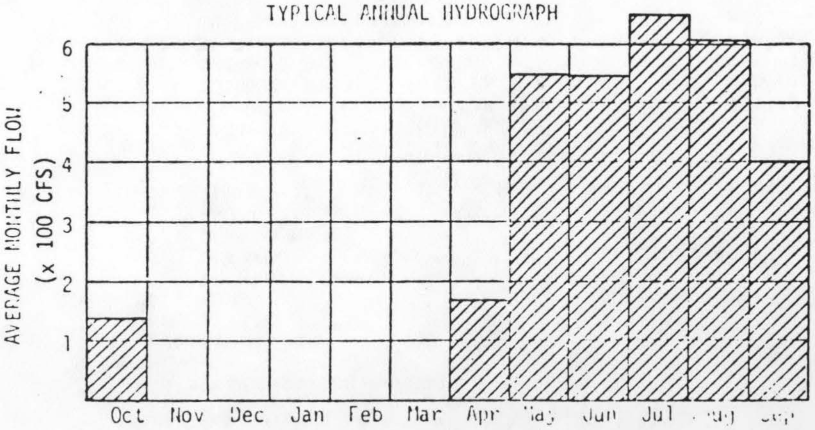


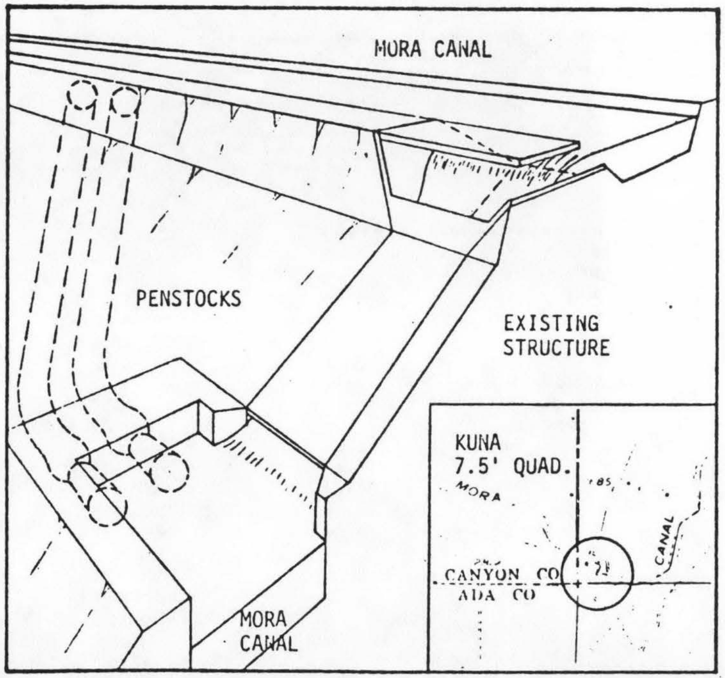
Location Map

FLOW DURATION AND POWER VALUES

| Exceedance Percentage | Discharge CFS | Plant Size MW | Annual Power Output GWh | Load Factor |
|---|---|---|---|---|
| 95 | 0 | 0 | 0 | ---- |
| 80 | 0 | 0 | 0 | ---- |
| 50 | 150 | 0.41 | 2.35 | 0.47 |
| 30 | 540 | 1.48 | 6.10 | 0.43 |
| 10 | 620 | 1.70 | 6.48 | 0.40 |

TYPICAL ANNUAL HYDROGRAPH





PICTORIAL DIAGRAM

Figure 15. Low-head hydro power site data on the Boise Project Canal System.

```
 REACH NUMBER 03500240CC0000R0030

 I  LOCATION
    A.  STATE                           IDAHO
    B.  COUNTY                          GOODING, JERCME, TWIN FALLS
    C.  TOWNSHIP, RANGE                 T 9S R16E
    D.  LATITUDE, LONGITUDE             42 37  114 35
    E.  STREAM NAME                     SNAKE RIVER
    F.  MAJOR BASIN NAME                SNAKE RIVER
    G.  RIVER MILE                     596.6 TO 618.0

 II HYDROLOGIC AND HYDRAULIC CHARACTERISTICS
    A.  UPSTREAM ELEVATICN OF REACH              3370 FT. MSL
    B.  DOWNSTREAM ELEVATION OF REACH            2955 FT. MSL
    C.  TOTAL AVAILABLE HEAD IN REACH             415 FT.
    D.  AVERAGE SLOPE IN REACH                   19.4 FT./MI.
    E.  DRAINAGE AREA ABOVE REACH MCUTH         25936 SQ.MI.
    F.  INFLOW CLASSIFICATION                     REGULATED

III REACH FLOW DURATION AND THEORETICAL POTENTIAL
    ENERGY CHARACTERISTICS

 EXCEEDANCE               THEORETICAL  ANNUAL ENERGY  PLANT
 PERCENTAGE   DISCHARGE   PLANT SIZE     AVAILABLE    FACTOR
                 CFS          MW            GWH
     95          1192        41.92        365.76       1.00
     80          1419        49.91        426.95       0.98
     50          1778        62.53        498.84       0.91
     30          3317       116.66        688.50       0.67
     10          7517       264.37        947.29       0.41

 IV TYPICAL ANNUAL HYDROGRAPH

         6⊥     AVERAGE ANNUAL FLOW = 3324 CFS
  A T     I
  V O     I
  G      5⊥
    A     I
  M V     I
R O G    4⊥
A N       I
T T A     I
I H N    3⊥
O L N     I
  Y U     I
O   A    2⊥
F F L     I                        ****
  L       I        ****
  O F    1⊥            ************    ****
  W L     I********                        ****
    O     I                                    ************
    W    0⊥------------------------------------------------
           OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
```

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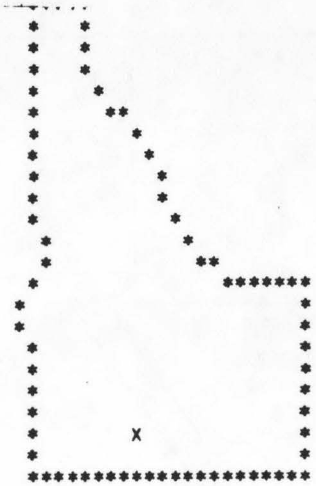
LOCATION MAPS

U.S. TOPO SERIES
  1:250000
   SCALE

 MAP NAME
 TWIN FALLS
```



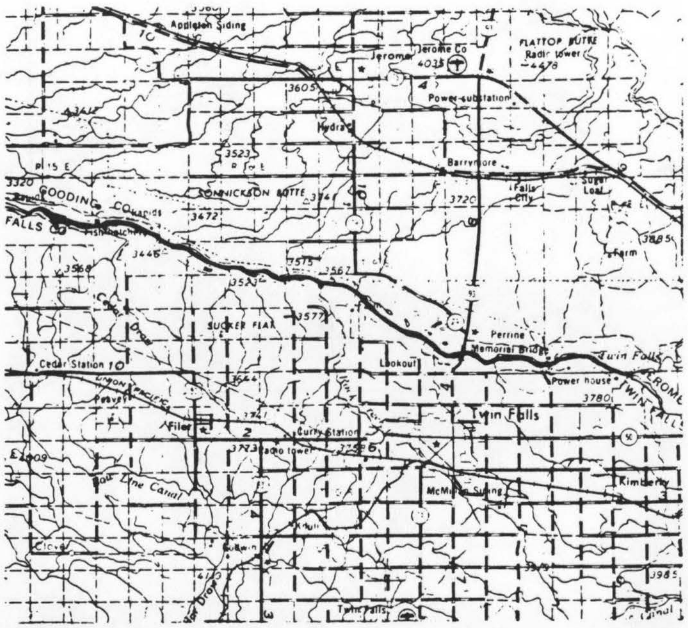


Figure 16. Hydro energy potential and characteristics in Snake River reach near Buhl, Idaho.

Source: Heitz, et. al, IWRRI

development in the Hells Canyon Reservoir area, as has Coupe (1977). The Corps of Engineers (1976) has completed a survey of the Columbia River system including most of the rivers in Idaho. The sites identified for potential in Idaho are shown in the map of Figure 17. Particularly favorable sites are those marked by a star and include Barbers Flat near Oxbow Reservoir, Cuprum near Hells Canyon Reservoir, Whiskey Creek near Dworshak Reservoir, and Flat Creek near Hells Canyon Reservoir. Another site discussed for a combination of wind power and pumped storage is the Little Camas Reservoir and Anderson Ranch Reservoir on the South fork of the Boise River (U.S. Bureau of Reclamation, 1977). Pumped storage is an alternate energy resource, but it will not really meet the total continuous energy demands. Assuredly additional such systems will be built in the Pacific Northwest, and ultimately pumped storage will be necessary and beneficial in meeting energy requirements in Idaho. Present peaking load increases are being met by installing additional turbines in existing large hydro plants in the Columbia River system like the Third Power Plant of Coulee Dam.

Studies of possibilities for biomass steam power plants by Johnson, Simmons and Peterson (1977) give a good summation of the technical and physical feasibility of utilizing biomass steam power plants as an alternative source for supplying energy for irrigation pumping. Three maps in Figure 18 show the suitability of providing energy from (1) wood mill residues and forest residues, (2) municipal wastes, and (3) fuel plantations. In the first case it can be seen that essentially all wood residues and forest residue are great distances from the irrigation areas that especially need an alternative energy source. In the second case five sites that might support solid waste energy recovery facilities are considered only marginal for a steam plant. The third case of development of a fuel plantation is considered to be possible only in one area. Animal wastes likewise are not concentrated enough to encourage development. Thus the present technological feasibility of biomass steam power plants providing electrical energy is very limited in the irrigated areas of Idaho.

Geothermal steam power plants are already in production. An experimental production system, using low temperature hot water with a binary heat exchange

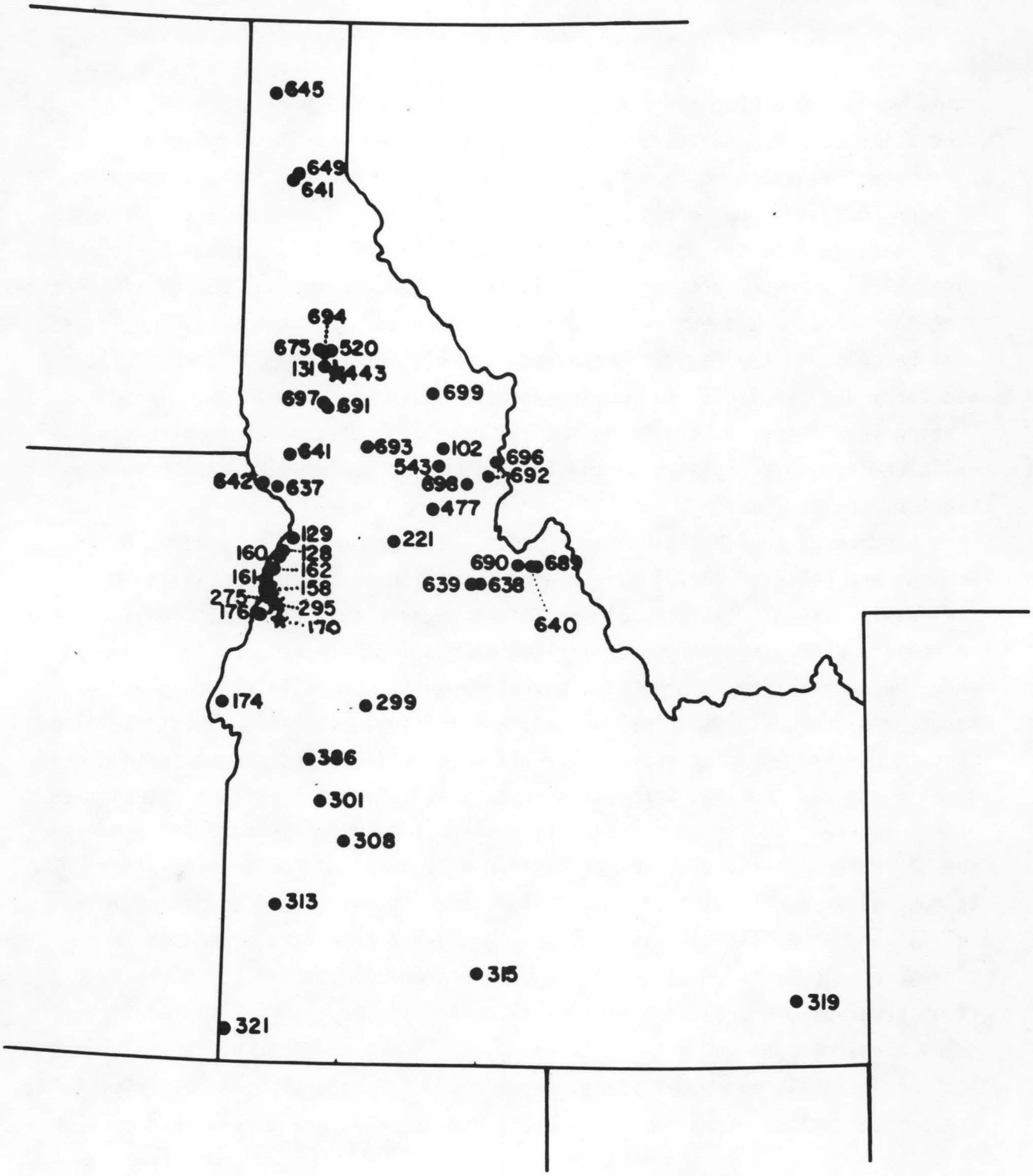


Figure 17. Map of potential pumped storage sites in Idaho.

Source: U.S. Corps of Engineers

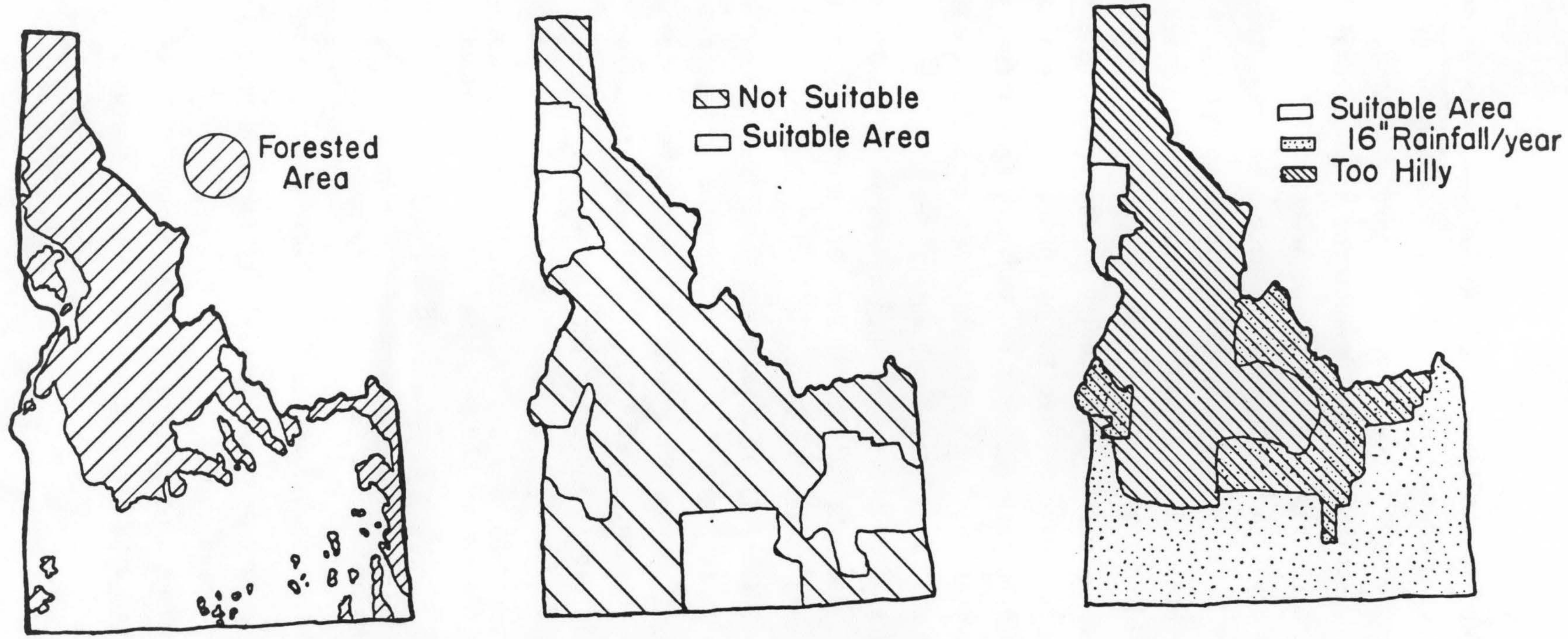


Figure 18. Maps of areas suitable for providing biomass for energy production.

Source: Johnson, Simmons, & Peterson

system, is nearing reality in Idaho's Raft River area. The extent of renewable hot water for continuing production is still an unproven factor in the technical feasibility of geothermal electrical supply systems.

Technological feasibility of the development of geothermal steam power plants is somewhat uncertain at this time due to the newness of techniques that are being proposed. No dry steam geothermal resource areas have been discovered to date in Idaho. Thus a binary steam system would be necessary at any known geothermal resource area. Eight known geothermal resource areas (KGRA) have been identified in Idaho that would have significance in connection with irrigation pumping. These are shown and labeled appropriately on a map Figure 19. Miller and Warnick, 1978 have defined the hydrology of these areas. Restraints here would be similar to those defined for ordinary fossil fuel steam plants. A further restraint that should be noted is a water quality control restraint imposed by the fact that most geothermal waters are highly mineralized and disposal of the wastes from processing such waters would be a serious concern. Hopefully the wastes could be reinjected into the deep zones of the underground aquifers which are used to tap the heat.

The technical feasibility of developing electrical energy from wind driven power plants is restrained by the requirement to have areas where winds are of magnitude and of sustained enough nature to make it economically feasible Studies by Peterson, Hewson, et al (1978), indicate information that defines the restraints. This report indicates the following in Idaho.

> *"Upper Snake*
>
> *In the spring and fall, marginal to moderate potential exists over the ridges while during the summer the potential is low to marginal.*
>
> *Central Snake*
>
> *Marginal to moderate wind power potential can be expected over the exposed ridges during spring and fall. The wind power potential in the elevated areas of the sub region during the summer is low to marginal. The wind power potential is low in the Snake River Valley throughout the year."*

This indicates a very marginal feasibility for wind power production to meet irrigation pumping needs.

In some cases where wind density is great enough it is technically possible to pump water with direct connected pumping system and avoid the ex-

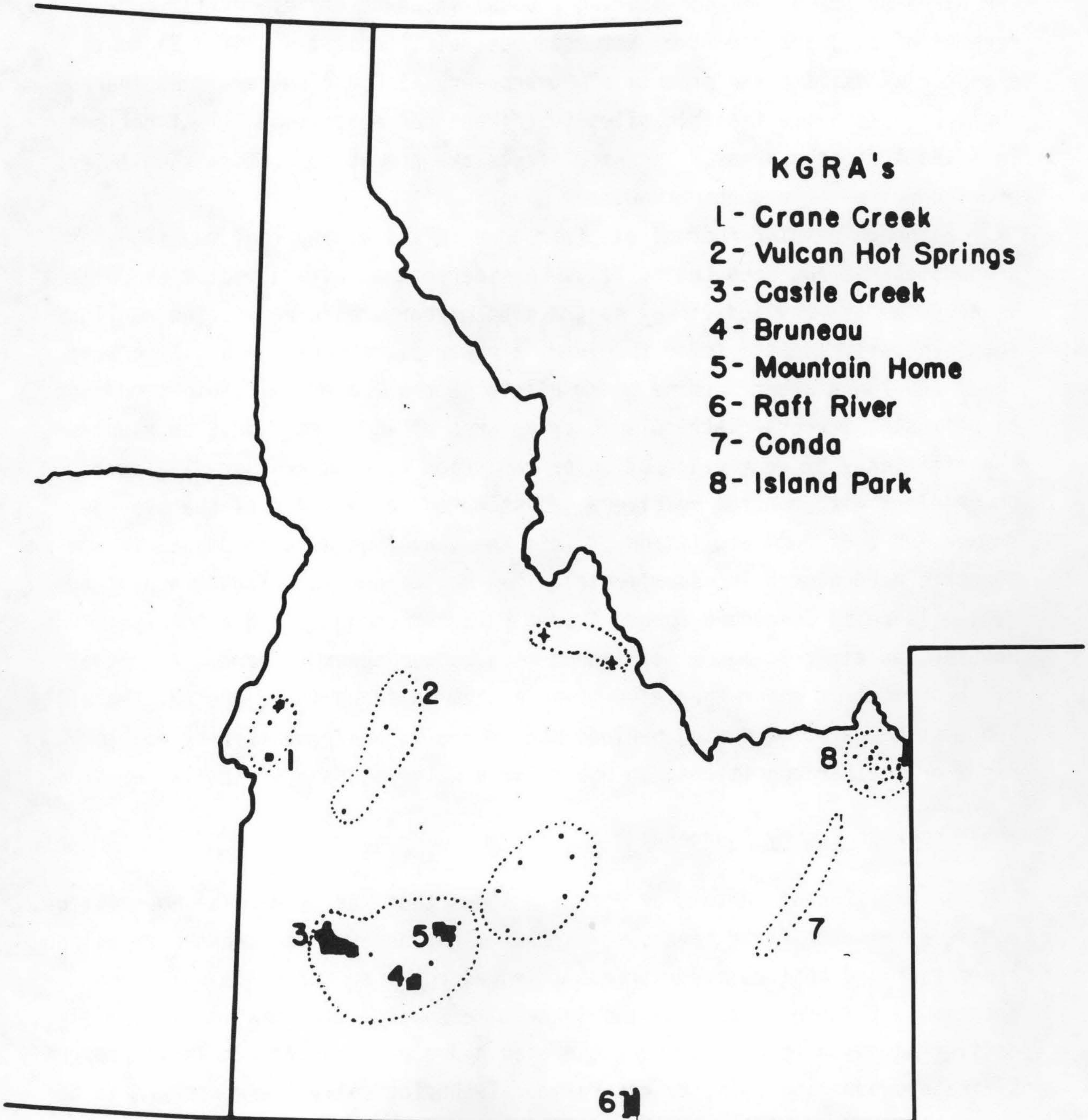


Figure 19. Known geothermal resource areas in Idaho.

pense of generators. Typical available power from such a system where wind density is 1/2 P $V^3$ is 200 watts/square meter (a value somewhat common for parts of Idaho) and considering a usual value of efficiency for conversion of 34%, the report by Peterson, et. al., indicates that a 25 foot diameter windmill could produce 12 horsepower. Indications are that there would be only a few feasible sites for direct connected windmill locations in Idaho irrigated areas. Technical tests are needed to confirm the limits of wind driven power production.

Although a solar-thermal-electric power plant of any real magnitude or production has not been built, it is considered that with a radiation collection system of many individual suntracking mirrors, each reflecting sunlight on a centrally located tower receiver, a power plant could be built to heat steam and run a steam turbine power plant. For a 100 MW unit, eight modules of heliostat mirrors distributed over an area of 405 acres would be required. The efficiency of conversion of solar radiation to a solar-thermal-electric power plant with central receivers is estimated to be 5.7 % of the average summer input of 3000 Btu/$ft^2$/day. This then involves a steam plant with an electric generator. In experiments in New Mexico and in Arizona, a pumping system is being developed to use a pump directly connected to a turbine. However, an electric motor is planned as a backup power support. A schematic of the system of solar-thermal-pumping system is shown in Figure 20. Normally for system operation during periods when there is non-productivity due to night or weather conditions, an energy or a water storage system is required.

## Non-Renewable Energy Sources

An analysis of the map of Figure 2 shows that for commercial importation, public or private firms have systems that might be expanded and transmission lines that are available for transmitting energy into the state. The one problem is that in cases like the Bonneville Power Administration system of delivering power from government operated hydro power units, there is presently a finite production capacity restraint. Technologically there appears to be no problems of providing an alternative to existing electrical energy importation into the system of transmission lines.

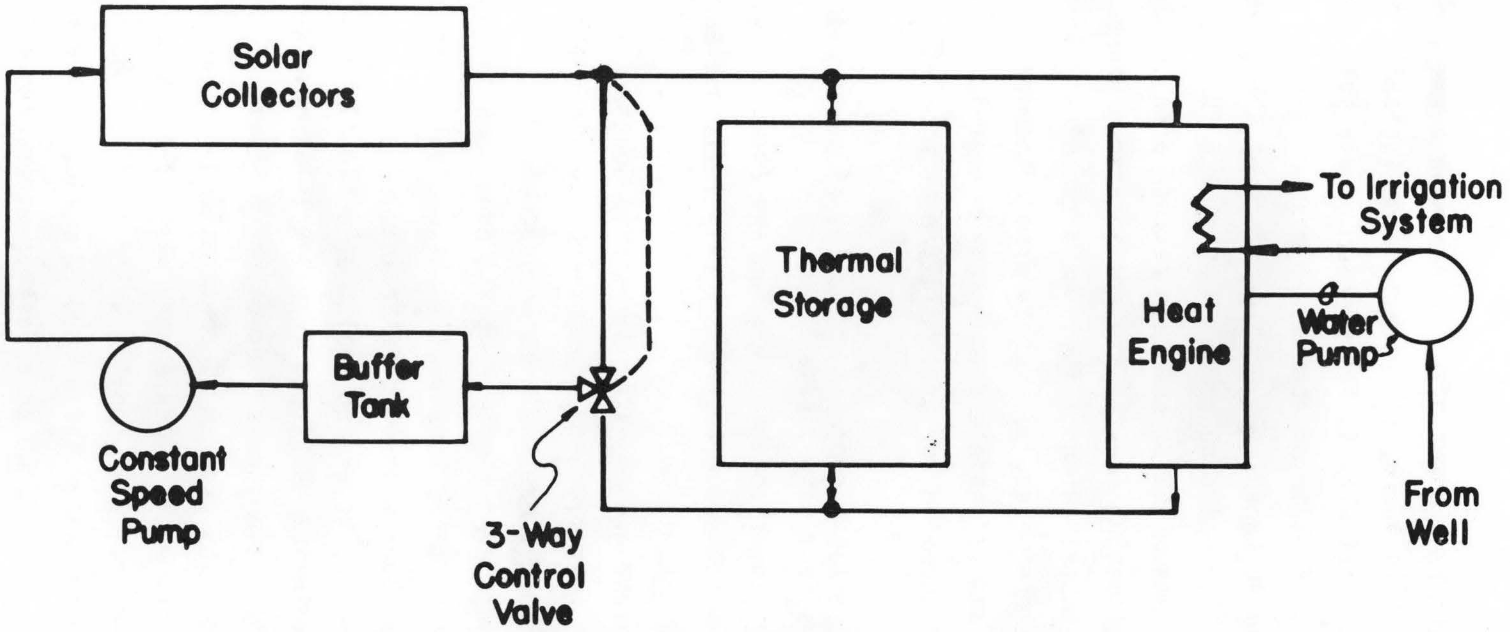


Figure 20. Schematic of solar engine system for pumping.

Although no fossil fuel power plants other than a small peaking plant at Ketchum have been built in Idaho, it appears technologically feasible to construct such units. A difficulty is the problem of air pollution in certain areas. Availability of fuel in an economical manner is a technological problem that will need to be faced. An earlier study by the author has defined areas most acceptable for building steam power plants (Warnick, 1976).

Nuclear power plants might be built in certain areas of Idaho. Limiting the technical and engineering feasibility are locations where it is considered unsafe to build such installations. Their main technical limitations would be (1) safety from earthquakes, (2) safety from contamination of a major water supply aquifer and (3) safety from location near large population centers. The criteria normally accepted for feasibility near population centers is as follows:

> "for safety and social acceptability, sites of power plants should be at least 4 miles from city limits."

A seismic risk map for Idaho and parts of Montana shows a region classified as major damage area which would technologically limit nuclear power plant development in Idaho.

The vast Snake River ground water aquifer in Southern Idaho has been considered a resource that might be contaminated by a nuclear power plant accident and, even though there are presently atomic reactors operating over the aquifer, it is considered unwise to build over such an aquifer. Figure 21 gives a map of the areas where construction of nuclear power plants would be restricted due to the above mentioned restraints.

Another technological restraint would be availability of water for cooling purposes. Studies by (Heitz 1975) and (Warnick 1976) have defined these limits for Idaho. These publications give maps defining limits of technological feasibility. In almost any program of constructing nuclear power plants, the economics of development would dictate very large plant sizes, probably at least 1000 MW in capacity. Thus cooling water supplies would be a technological restraint. Cooling water for a 1000 MW nuclear power with cooling waters would require about 18,000 acre feet of water conservatively used per a year.

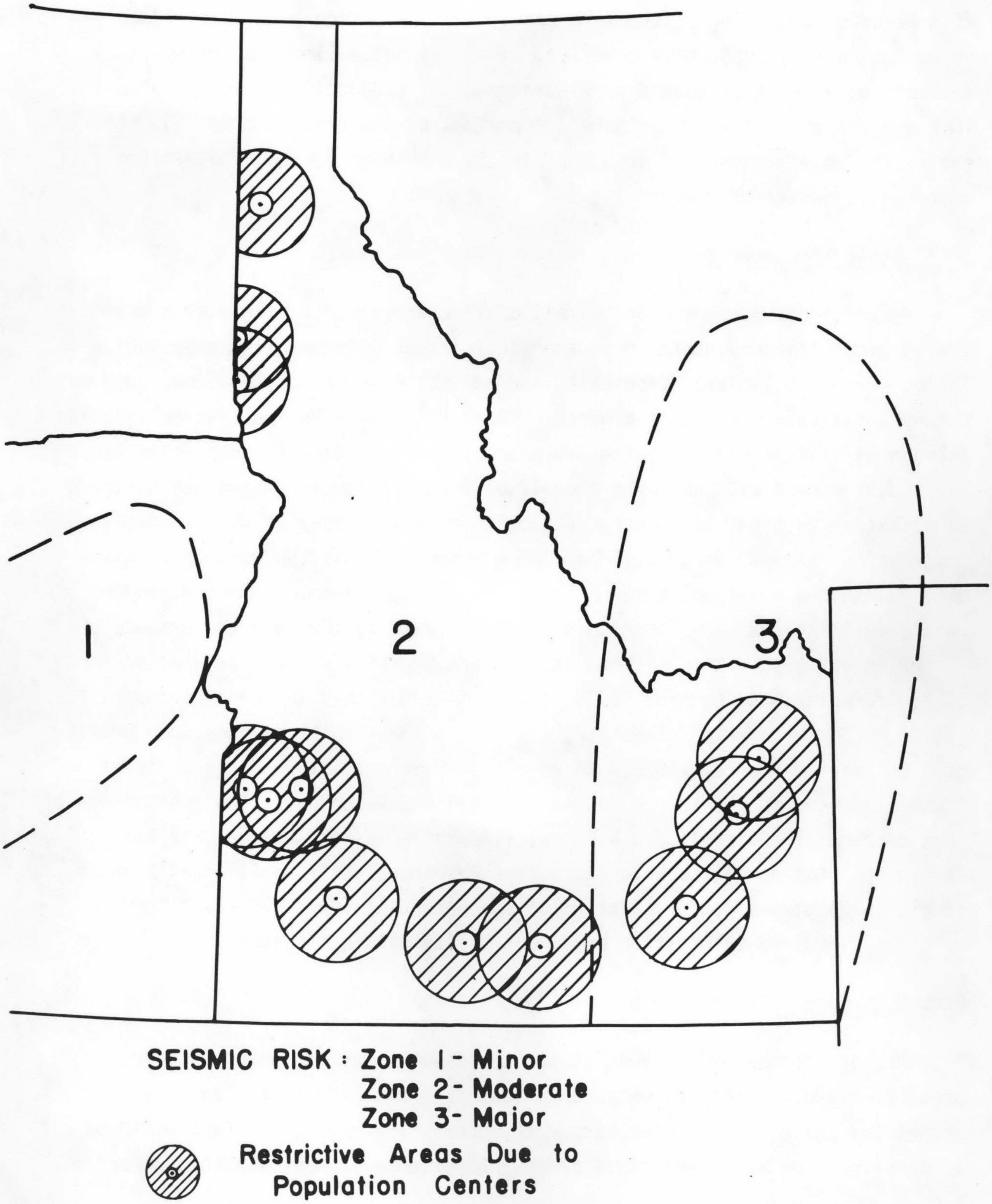


Figure 21. Map of infeasible areas for nuclear power plant development.

# ASSESSMENT OF SOCIAL AND POLITICAL ACCEPTABILITY

An appraisal of social and political acceptability of the nine identified means of supplying alternative energy for irrigation pumping in Idaho is at best a very subjective exercise. There is not a clear cut means of determining in advance when a particular mode of production is acceptable. This evaluation is the writer's best appraisal at the present time. Justification for an expression of acceptability is presented for each enumerated alternative source of energy.

## Small Scale Hydropower:

Recent indications are that small scale hydroelectric plants as a mode for energy production may be the most acceptable as an alternative energy source in Idaho. From a political standpoint, the present Governor of Idaho has come out rather positively for such a program. However, until site specific designation is made it is difficult to judge how socially and politically acceptable hydropower development will be. The Idaho Public Utilities Commission has instructed utilities to give this energy production mode an appraisal when submitting information for new energy sitings. Development at existing dams that do not have full hydro development seems to have much acceptance. Numerous studies have been initiated both in the public and private sector, and the private sector is going to action. These studies are typified by such studies as those of Tudor Engineering Company (1976, 1978), International Engineers Company, Inc. (1978), U.S. Bureau of Reclamation, (1978) and the studies of the Idaho Department of Water Resources (1978). A recent seminar held at the University of Idaho evidenced much interest in low head hydro development. The proceedings of that conference (Gladwell and Warnick, 1978) give insight to the problems. The recent studies of the Water Resources Research Institute (Gladwell, Heitz, et al, 1979) give a good evaluation of the potential for small-scale hydro potential and some information on acceptability within the state.

## Pumped Storage

Pumped storage hydro power plants represent a way of enhancing energy production systems that is untried in Idaho, so that it is hard to judge social and political acceptability. It appears that pumped storage would be in very isolated and specialized areas. Experience in Moscow with a proposed study of a pumped-storage potential site adjacent to Lower Granite Dam on the Snake River near Pullman, Washington, showed that public reaction can be very negative. Public reaction actually terminated a feasibility study by the Walla Walla District of the U.S. Corps of Engineers. Locating the operating reservoir or reservoirs will have a very important bearing on acceptability and this gets down to site specific situations. Sites adjacent to Oxbow Reservoir on the Snake River in Idaho appear to have no strong opposition at the present time.

## Biomass

In consideration of biomass stream power plants, much interest has been expressed from the public in using solid wastes and mill wastes for production of energy. The northern part of the state of Idaho has sponsored programs to encourage this as an alternative energy source. There appears to be very little to prevent this energy production form from being socially and politically acceptable. The only deterent might be that the use of that energy for producing steam for space heating and process heating would prevent use for production of electrical energy for pumping energy because it could more fully use the heat energy.

## Geothermal Steam Plants

Progress and plans for development of a pilot geothermal power plant in the Raft River area of southern Idaho indicate that this mode of power production has social and political acceptability. The only fear might be problems of contamination of ground water supplies presently in use. Because of no real experience with this mode of production in the U.S. except in the Geyser area of California, there is limited possibility of judging its acceptability.

## Wind Power Plants

The acceptability of small individual direct connected wind power units appears to be very low. Windmills for pumping of even domestic water have practically been discontinued in Idaho. However, there appears to be no strong opposition to development of energy from wind power by larger and more modern plants.

## Solar-Thermal Power Plants

Because of the fact that solar thermal power plants are such a new approach, it is almost impossible to project social and political feasibility. The fact that extensive areas of land would be needed for solar collectors makes it somewhat unpopular. However, near the irrigated areas of Idaho there are lands available that might be relegated to that use with a minimum loss in resources values.

## Commercial Importation

Non-renewable energy source alternatives furnishing irrigation pumping energy in the future from commercial importation appears to be a declining and unpopular possibility because of the following reasons:

1. Each of the private utilities that might do the supplying such as Washington Water Power, Pacific Power and Light, Utah Power and Light, Co., and Montana Power Co. are having difficulty meeting their own demands in their operating areas.
2. The Bonneville Power Administration has indicated it will have difficulty continuing to supply certain energy expected loads. However, a thrust for establishing a new policy for sale and marketing of power from federally constructed projects may improve conditions for power users in Idaho.
3. A policy enunciated by the Idaho Water Resources Board and accepted by the Idaho legislature appears to not favor importation. This is contained in following statement from the Objectives, Part I of State Water Plan (Idaho Water Resource Board, 1974):

> *"Idaho Water Resource Board adopted as a planning objective a reduction reliance upon imported electric power. To achieve this objective, the state water resource policy is to promote and encourage those projects and programs which provide for development of new electrical energy and more efficient use of existing energy sources."*

With this above assessment it more factual than subjective to note that recent action in the State appears to favor developing as a power source a steam plant cooperatively with a utility in Nevada at the Valmy site near Winnemucca, Nevada.

## Fossil Fuel Steam Plants

Attitude toward construction of a fossil fuel steam power plant in Idaho has indicated there is a rather negative reaction. Referendum votes in counties involved were against such a program in the case of Idaho Power's proposed Orchard plant near Boise. The former governor of the state came out in opposition to that planned development and it was finally turned down by the Idaho Public Utilities Commission. Since that action the Idaho Power Company has applied for a permit to construct a coal fired plant at sites further to the east in the vicinity of Bliss. These proceedings of the Idaho Public Utilities Commission appear to be for a slow and cautious approach.

The State Legislature has for several sessions tried to pass new energy plant siting legislation, but the bills have never proceeded to action stage. Lack of a more definitive statute for purposes of energy plant siting appears to act as a deterent to the social and political acceptability of fossil fuel steam plant development. To say then there is social and political acceptability for fossil fuel steam power plants is being overly optomistic.

## Nuclear Steam Plants

Although licensing and construction of nuclear power plants is proceeding in the state of Washington, there appears to be no support for development of nuclear power plants in Idaho. It seems strange that the citizenry of Idaho has come to accept the experimental nuclear reactor and nuclear safety program of the Idaho National Engineering Laboratory but do not show interest in development of nuclear power plants. A definite deterent to this is the extremely long lead time necessary to reach production status and the lack of utilities within the state of Idaho that have real experience with operating and managing nuclear power plants. Recent trouble in Pennsylvania with nuclear power makes this less and less attractive in Idaho.

## ASSESSMENT OF COST OF ENERGY ALTERNATIVES

This part of the study gives indications of what the cost of various alternative sources of energy will be under Idaho conditions, and more especially in the irrigated areas of Idaho.

### Renewable Energy Source Alternatives

Recent engineering studies by consulting firms, the state water resources agency and federal agencies have been reviewed to obtain indications of the cost of developing small scale hydro in the state or installing turbines in existing dams. Table 1 below gives estimated costs of power capacity and energy production on several of the most promising hydro developments that have been proposed in recent years.

TABLE 1 Representive Cost Information on New Hydropower Developments in Idaho

| Project | Year of Estimate | Capacity Cost $/kw | Energy Cost mills/kwh |
|---|---|---|---|
| Mora Drop | 1978 | 939 | 22.2 to 27.3 |
| Lucky Peak | 1978 | 707 | 22 |
| Palisades Addition | 1978 | 559 | 20.5 |
| Twin Falls Lowline Drop | 1977 | 1202 | |
| Anderson Ranch Addition | 1979 | 267 | 36-38 |
| Barber Dam | 1976 | 1047 | 18.4 to 20.7 |
| IPC Payette River Plants | 1978 | 861 | 40.2 |

Capacity costs are the capital investment costs for energy production facility including land, equipment and construction costs.

Studies by the Corps of Engineers (1976) on pumped storage indicate that the cost of power in 1975 prices would range from $151/kw to $279/kw and energy 10.6 between 21.5 mills/kwh. It should be remembered this is for huge plants of greater than 1000 MW capacity that are strictly operated for meeting peak loads. Because of the nature of peaking operations in energy production with pumped storage, a caution should be expressed that comparisons are difficult to make with other values reported in this study. Pumped storage plants can not be used to furnish continuous energy for sustained irrigation pumping loads.

Biomass steam power plants are just now being proposed for the Pacific Northwest in larger capacity. Johnson, Simmons, and Peterson (1977) indicate for a municipal type biomass steam plant the cost of energy would be 28-35 mills/kwh. It should be pointed out that indications are that because of the lack of biomass in any concentrated amounts in irrigated regions of Idaho, the cost would be higher than this and would require fuel plantations that would compete for the scarce water which is being developed by the irrigation pumping.

Personal communication from E.G. and G. Idaho, Inc. provides information on the cost of geothermal energy as estimated in 1979. Figure 22 gives a curve of expected costs depending on temperature of the geothermal water and different rates of delivery of that hot water. This shows that costs are likely to be in the range of 40-50 mills/kwh.

A curve from the Northwest Energy Policy Project of 1976 shows that energy cost of wind power varies with mean wind speed. Figure 23 is a reproduction from Johnson, Simmons, and Peterson (1977). It is not likely many irrigated areas will have mean wind velocities of greater than 12 mph so that the cost of wind power for use in irrigation is likely to exceed 70 mills/kwh. However, in isolated areas the use of wind powered electric generators may be a way to operate without having to extend long transmission lines or haul fuel for considerable distance.

Johnson, Simmons, and Peterson in 1977 indicate the land area in the Pacific Northwest that would be needed for heliostat collector areas is approximately 2 1/2 times that required in the Southwest. They estimate for 1977 prices the cost to be about 55 mills/kwh for solar-thermal-electric plant energy. They likewise indicate that cost of solar cell supplied energy would be 704 mills/kwh. Conversations with those working on a solar pumping project in Arizona indicate the costs are going to be higher than conventional fossil fuel supplied energy, and that the technology is still in the experimental stages.

## Non-Renewable Energy Source Alternatives

The action of Idaho Power Company to resort to importation of fossil fuel supplied energy produced in a new plant at Valmy, Nevada, indicates this is a viable alternative energy source. Company officials indicate the estimated cost of this energy will be 32 mills/kwh or slightly more at the busar or production facility so there is a likelyhood that delivered to Idaho irrigation

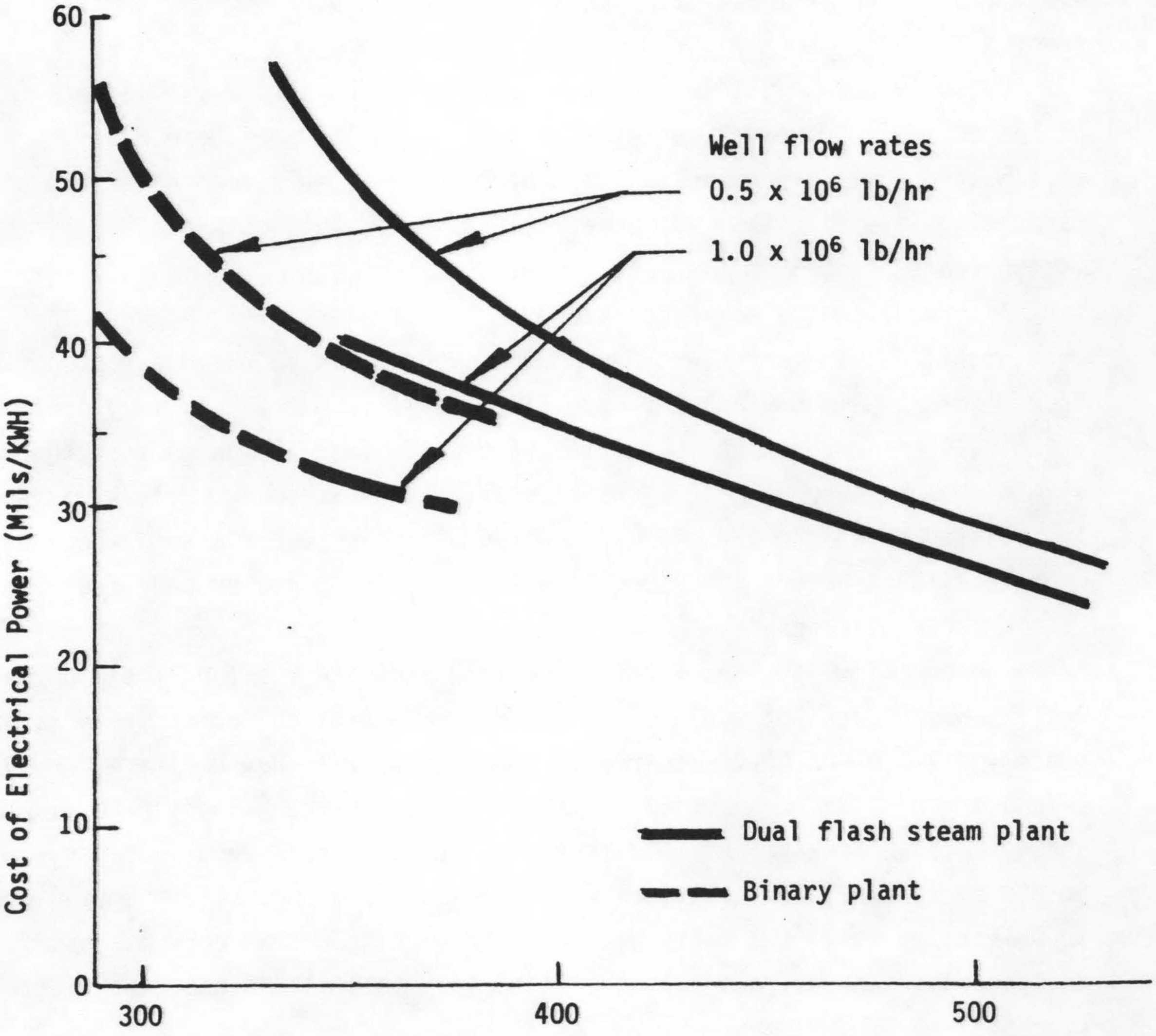


Figure 22. Estimated cost of geothermal power.

Source: E.G. & G., Idaho, Inc.

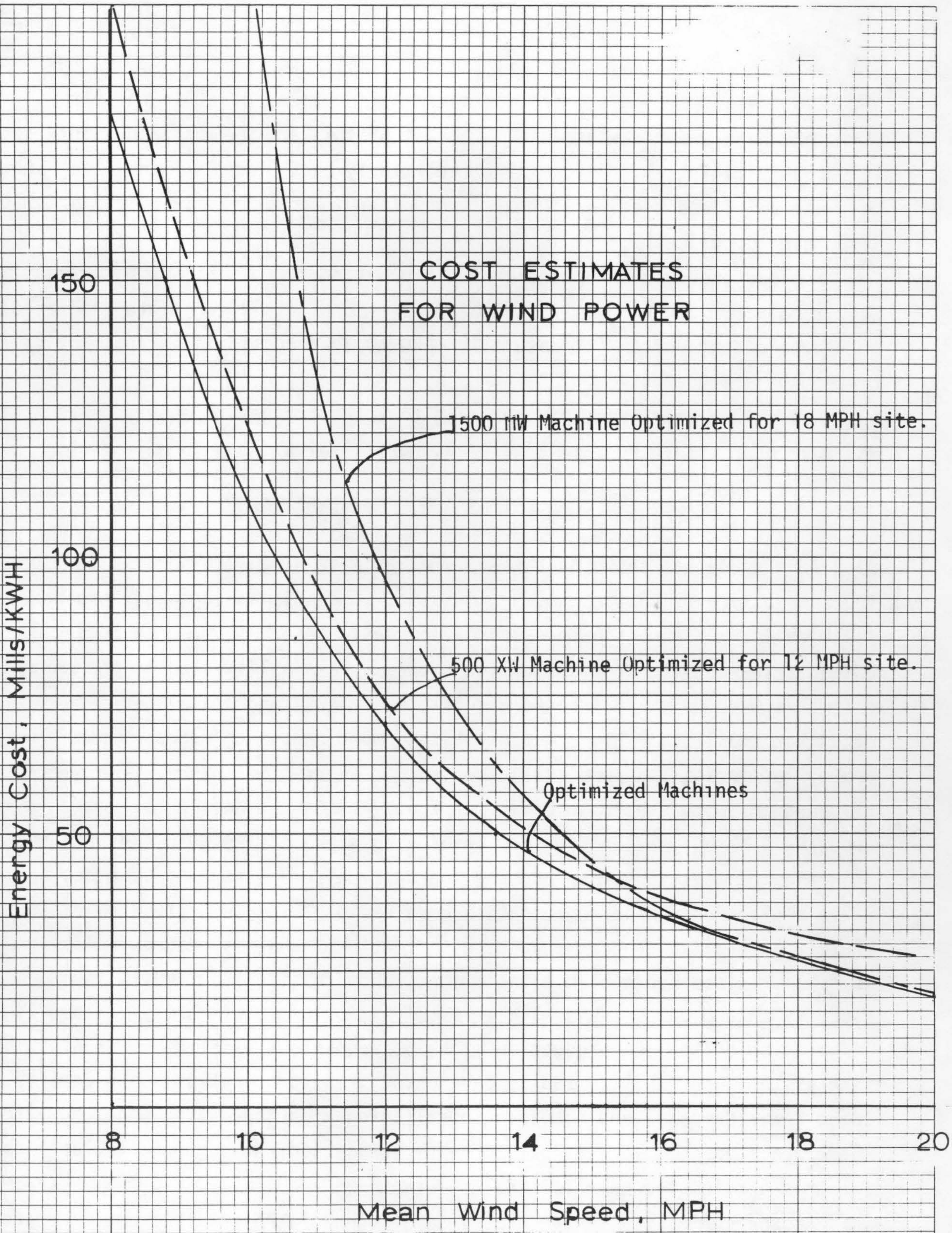


Figure 23. Cost estimates for wind power.

Source: Johnson, Simmons, & Peterson

use the cost of this new power will be 33-35 mills/kwh.

Exploratory siting studies for a coal-fired power plant in the vicinity of Bliss has been under discussion. The cost of this energy would certainly be at least 30-35 mills/kwh. Information reported by E. G. and G. Idaho, Inc. shows coal and oil fired electrical power production to cost from 39-60 mills/kwh under 1979 level of prices.

Nuclear energy cost according to information from E. G. and G. Idaho, Inc. will range from 28 to 50 mills/kwh at 1979 prices. This is before the recent nuclear accident which will naturally make nuclear costs higher just to increase the safeguards.

All this appears very discouraging to Idaho irrigation energy users who have been obtaining retail power at normally less than 20 mills/kwh.

## CONCLUSIONS AND RECOMMENDATIONS

This study has shown that there are at least nine alternatives for obtaining energy for irrigation pumping in Idaho. Emphasis in the study has been on the viability of non-renewable.energy sources. No one source can be singled out as answering the problems of the future. Feasibility studies and cost estimates made by various consulting firms, federal and state agencies indicate that small-scale hydro represents the most promising means of supplying energy for irrigation pumping in the near or short-time future. The question has been posed by the Idaho Office of Energy as to the desirability of choosing a demonstration site for developing a project to help expedite the answering of questions in producing energy from such a source. The new Idaho Falls replacement power represents a good example of a demonstration plant that is already to proceed towards construction. What is needed is more effort in smaller sized hydro plants that might range in size from 100 kw to 500 kw capacity that might serve a single large farm or group of farms. Needed is information on how the production might be fed into a existing power distribution system, whether this can be done under present operations of a utility like Idaho Power Company, and how such installation might operation under a system where the load is only seasonal to serve irrigation pumping. Suitable sites for this are located near Twin Falls, Idaho.

Another demonstration or experimental type of project that would be productive would be a development for study of passage of fish through turbines, especially small-scale low head facilities. Ideal sites to study this exist at two or three locations in the stretch of the Snake River from Twin Falls to Hagerman.

Another demonstration related to this might be a demonstration on one of the tributary streams like Rock Creek that flows through Twin Falls to develop information on the feasibility of desilting water that comes from irrigation return flow by trapping the water in small reservoirs developed for the power installation. This improvement in water quality might accrue to much advantage to those using the water to raise fish.

Pumped storage power plants are not yet needed and feasible in Idaho. A wise action here will be to preserve options at the feasible sites so that when peaking power are required development can be made without disrupting the environment and the economic system of power generation.

Biomass steam power electric power plants in the vicinity of irrigated areas in Idaho do not appear to offer much promise at the present time. It appears, that in general, municipal biomass refuse and wood wastes would be more economical use of the waste resource. The area irrigated around Rathdrum Prairie in northern Idaho, however, might benefit from a biomass steam power plant. The irrigation load in that area is rather small however.

Geothermal power plants are in the infancy of development, especially those using lower temperature geothermal waters. The pilot plant under development in the Raft River area Idaho represents a good demonstration effort for Idaho.

Wind power does not at present offer great encouragement from the economics viewpoint but a difficulty now facing planners is a knowledge of wind velocity conditions in Idaho. A specific recommendation is later made for this renewable alternative energy source.

Solar energy power plants for electrical energy production in Idaho appear to be a distant possibility but at present it would appear wise to follow the development work in Arizona and New Mexico before any demonstration efforts are made in Idaho. Contact with the University of Arizona indicates millions of dollars have gone into the single farm installation being developed near Coolidge, Arizona. A very major break-through in cost of production of direct energy conversion like photo voltaics may change this appraisal.

The non-renewable energy alternatives appear to be developing as fast as economics will justify. The only caution given here is that the present action of Idaho Power Company of developing an importation source is going counter to a policy put forth by the Idaho Water Resource Board and later ratified by the Idaho Legislature. That policy repeated here and underlined for the pertinent point (Idaho Water Resource Board 1974) state:

> *"The Idaho Water Resource Board adopts as a planning objective, a reduction in the reliance upon imported electric power. To achieve this objective, the state water resource policy is to promote and encourage those projects and programs which provide for development of new electrical energy and more efficient use of existing energy sources."*

Development of a large energy park using a combination of nuclear power, geothermal power and pumped storage power to meet expanding loads in the future has been mentioned. The area near Barber Flats in western Idaho was mentioned by Coupe 1977, for this type of development. Perhaps a serious look at this needs to be made, and if so, it needs a very thorough study with as much inovative thought as can be marshalled to study the problem. Two major recommendations are made:

1. That immediate attention be given to fostering as much encouragement to small scale hydro development in the form of intensive feasibility studies by all entities including small developers, irrigation districts, private utilities and government agencies. This should be guided by the potentials revealed by the studies now being completed by the Idaho Water Resources Research Institute. This, should not be done without full regard for the environmental impact of such development. A feasibility level study should be undertaken for a demonstration project of small-scale hydro in size range between 100 kw to 500 kw, that is directly related to an irrigation user near the hydro site and that might entail use of utility companys distribution lines.

2. That a program of studying wind velocities be instituted to more fully measure the potential for developing wind power as an alternative. This should be coupled with the development of a reasonably scaled demonstration project utilizing the best technology presently available. The type of unit now under study at Moses Lake airport represents that type of technology that might be used.

As further consideration there should be developed in the policy program of the state government a plan to continue to follow these various alternatives to be sure how conservation measures are impacting the various loads and production. Evidence indicates past pricing of power from programs like the Bonneville Power Administration has not encouraged some of the renewable energy sources. Like the small hydro plants that have been discontinued in places like the Star Valley Wyoming plants.

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