
NATURAL RESOURCES JOURNAL

Volume 6
Issue 4 *Fall 1966*

Fall 1966

Legal Problems of the Geothermal Industry

John W. Brooks Jr.

natural resources journal
Published four times a year by The University of New Mexico School of Law
VOL. 6 OCTOBER 1966 No. 4

LEGAL PROBLEMS OF THE GEOTHERMAL INDUSTRY

JOHN W. BROOKS, JR.*

Life leaps like a geyser for those who drill through the rocks of inertia.

—Alexis Carrell
1873-1944

I
GEOLOGY

A. History

Geothermal power literally means "earth-heat" power.[1] Normally, temperatures within the earth increase as depth increases; this thermal gradient, however, varies widely depending on factors such as volcanic activity and the thermal conductivity of the various rock strata.[2] The temperature difference between the earth's surface and its interior generally results in an upward flow of heat that is usually dissipated in small, often unnoticed, and commercially insignificant quantities; but hot springs, geysers, and other thermal manifestations indicate shallow-lying heat reservoirs which frequently are potential sources of power.[3]

Geothermal manifestations have been noted by man since the first century B.C. At that time, Lucretius Carus mentioned the fumaroles[4] of Larderello, Italy, in his poem "De Rerum Natura."

* Member of the California Bar.

1. Some scientists use the word "endogenous" to denote a power source from within the earth.

2. In regions having a normal geothermal gradient, a depth of nearly 10,000 feet is required to reach a temperature of 100° Centigrade.

3. N. H. Darton, Geothermal Data of the United States (U.S. Geological Survey Bull. No. 701, 1920).

4. A fumarole is a hole in or near a volcanic area from which vapor issues.

First to escape from its early core was the fiery ether
Through unperceptible outlets; it wafted away in its passage
Vast accumulations of heat
De Rerum Natura, Book V, at 19.

Nevertheless, surface thermal phenomena have been little more than geological curiosities until recently; the first commercial development did not occur until 1818, when the geothermal steam of the Larderello area was used as a source of heat in an effort to concentrate the boric acid which was found in solution in the boiling waters. The application of this earth-energy to the production of electric power awaited the twentieth century. In 1904, Prince Conti of Larderello succeeded in operating a geothermal steam-driven dynamo which lighted five electric lamps.[5] Eight years later, after a quarrel with the local power company, Conti installed his first steam turbine, with a 250 kilowatt (kw.) capacity.[6]

By the late 1930's the Larderello fumarole area, consisting roughly of one hundred square miles, was producing almost 100,000 kw. of electric power. The German retreat of 1944, coupled with numerous allied bombings, completely destroyed the steam plants. The plants later were rebuilt with United States aid, and currently there are eight stations at Larderello with a combined capacity exceeding 300,000 kw. In addition, boric acid, borax, carbon dioxide, boron carbide, and sulphur are manufactured from the non-condensable gases which are contained in the steam.[7]

Despite the success of Italian development, and notwithstanding its expansion following the war, little attention was given to geothermal development elsewhere except for the use of steam and hot water in geyser areas, in Iceland and in parts of the Soviet Union, for community heating purposes.[8] In 1950, however, a major project was initiated in New Zealand, at Wairakei, on the North Island. By 1958, 69,000 kw. were being produced by fifty wells located in an area approximately fifty miles long.[9]

Within recent years, international interest and activity have increased. World-wide industry, with its present great dependence

5. A. Mazzoni, *Societa Larderello in Italy Brings in World's Largest Steam Well*, Petroleum Engineer, Aug. 1952, p. A-47.

6. T. S. Lovering, *Some Problems in Geothermal Exploration*, The 1965 Jackling Lecture, in Mining Engineering, Sept. 1965, p. 95.

7. A. Kaufman, Geothermal Power: An Economic Evaluation 4 (Information Circ. No. 8230, U.S. Bureau of Mines 1964).

8. This utilization of natural heat originated about 1930; but the most important use is the Reykjavik Municipal Hot Water System in Iceland, constructed in 1943 and supplying 3,500 inhabitants. 3 Proceedings of Fifth World Power Congress (1956).

9. Haldane, Wood & Armstead, The Development of Geothermal Power Generation, Paper No. 21 C/1, Delivered to World Power Conference, Montreal, Canada, September 1958.

upon fossil fuels as sources of energy, and the doubling and redoubling of United States power requirements in the post-war years, have placed a heavy strain on these patently exhaustible resources throughout the world and have intensified the search for those which are essentially inexhaustible.

Geothermal energy was the subject of a conference[10] sponsored by the United Nations and held in Rome, in the spring of 1961. At this conference some eighty papers were presented by engineers and geologists in which the techniques and the economics of the use of geothermal steam as a source of electric power were considered. Other world meetings have followed.[11]

Geothermal fields have been discovered in Burma, Chile, El Salvador, Guatemala, Kenya, and Nicaragua; drilling has been undertaken in the West Indies; and two small pilot plants are being tested at Beppu and Hakone in Japan. Electric power is presently being produced from a 25,000 kw. plant in Hidalgo, Mexico;[12] and from a 5,000 kw. plant on the Kamchatka Peninsula of Russia.[13]

In the United States geothermal exploration has been concentrated in the Western States, notably in California. In that state, the first commercial geothermal power plant[14] became operative in 1960 at The Geysers, in Sonoma County, in an area in which hot springs and steam vents had supported a nationally known spa in the late 19th century.

The most spectacular discovery of geothermal energy in California, and perhaps in the world, has been made in the Salton Sea area of Imperial County, where, in 1958, a wildcat oil well returned drilling mud of such high temperatures[15] that its operators, finding it impossible to continue drilling with the equipment at their disposal, set casing and attempted to place the well on production in the shallower of two zones in which electrical logging had indi-

10. United Nations Conference on New Sources of Energy, Rome, 1961.

11. United Nations Conference for the Application of Science and Technology to the Benefit of the Less Developed Countries, Geneva, 1963; First African Electric Power Meeting, Addis Ababa, 1963.

12. Kaufman, *op. cit. supra* note 7, at 5.

13. *Hearings on S. 1674 Before the Subcommittee on Minerals, Materials, and Fuels of the Senate Committee on Interior and Insular Affairs*, 89th Cong., 1st Sess. 22 (1965).

14. 27,500 kw. of electricity is presently produced by Pacific Gas and Electric at The Geysers from steam wells developed by the Magma Power Company.

15. Mud-return system temperatures in the Salton Sea area have exceeded 115° Centigrade to date. Oil and Gas Journal, February 10, 1964, p. 63.

cated oil possibilities. The well produced no oil, but a strong flow of steam and brine appeared with temperature as high as 215° Centigrade at a depth of 3,370 feet. Deeper wells, subsequently drilled, have produced large volumes of steam and boiling brines, containing a high content of chemicals of significant commercial value. The mineral brine, however, appears to be a source of technological problems which, as yet, seem not to have been fully solved; although removal of the mineral content of the hot brine of the Salton Sea area has been successfully accomplished on a pilot-plant basis, large-scale development of steam for the production of electric power in that area has not yet begun.

Approximately 300,000 dollars is recently reported to have been invested near Mammoth, California, at Casa Diablo Hot Springs, where Magma Power Company has developed steam wells said to be capable of generating power in excess of 15,000 kw. A contract reportedly has been made with Southern California Edison Company for the erection of a power plant at Mammoth to utilize this energy.[16] The completion of such a plant would give California a geothermal power production of 42,500 kw.

In any consideration of the problems (technical, economic, and legal) which are involved in the production and use of geothermal energy, one is certainly struck, at the outset, with a sense of the unreal. It seems incredible that there should exist a virtually unlimited and practically inexhaustible reservoir of thermal energy, which has been a matter of common knowledge for more than 2,000 years without there having been made any serious attempt at commercial development until comparatively recent years. For reasons which will be discussed, it appears that the Western United States is now upon the threshold of such a development.

B. Theory of Occurrence

In the formation of the earth, there has developed within it a tremendous reservoir of heat, in an amount that only the elemental forces of nature could generate. While scientists are not in agreement as to the specific sources of the heat,[17] all agree that it exists, in the form of magma, or molten rock. As the earth cooled, the outer shell, with an estimated thickness of twenty miles, lost sufficient heat so that the outer magma began to crystallize into pri-

16. *Hearings on S. 1674, supra* note 13, at 39.

17. See B. Gutenberg, Physics of the Earth's Interior, (Academic Press 1959), in which it is suggested that the heat is the result of radioactive decay of the elements comprising the magma, particularly the granites.

mary rock. Loss of heat caused surface contractions leading to faulting and to fractured areas in the earth's shell. The inner magma, being thus relieved of pressure, assumed a state of fluidity and rose, either completely to the surface as volcanoes, or to relatively shallow depths near the surface, as magmatic intrusions into overlying sedimentary strata. Thus, according to geological theory, there were created the two basic types of geological areas from which geothermal power is produced: non-volcanic regions such as Larderello, which apparently overlie deep-seated bodies of magma; and shallower, volcanic areas such as Wairakei.[18] Examples of each type occur in the Western United States.

In non-volcanic regions, faulted sedimentary formations allow the circulation of underground fluids down to the "hot rocks"[19] with a consequent generation of convection currents. In volcanic areas, residual heat resulting from prior volcanic activity often remains in hot or molten rock near the surface. If a fault intersects this shallow heat reservoir, the heat is carried rapidly to the surface by ground water entering from areas adjacent to the volcanic body.

The movement of hot water toward the surface establishes a convective system in which heavier cold water moves downward to replace rising hot water. Within such a system, the hot water remains liquid at temperatures well above the normal boiling point, because of the hydrostatic pressure of the overlying water.[20] A well drilled into such a zone relieves the pressure, causing a drop in the boiling point, so that hot water flashes into steam enroute to the surface. So long as the withdrawal of steam does not exceed the rate at which ground water can be heated to the operating temperature by the heat source at depth, the system should furnish steam for power almost indefinitely.[21]

---

18. Kaufman, *op. cit. supra* note 7, at 2.

19. Magmatic intrusions. At Larderello the heat source is thought to be at about 8,000 feet and in excess of 1,600° Centigrade.

20. At the relatively shallow depth of 1,000 feet, water does not boil until above 200° Centigrade.

21. The heat of the earth's core (magma) is based upon a cooling gradient extending over a period of 2 billion years. One of the major problems in the development of geothermal fields is to ascertain the optimum production of steam with respect to the heating power of the underground heat source, and the supply of deep ground water.

Ideally, steam should not be used faster than the replacement of an equivalent amount of ground water heated to the requisite temperature. Ground water conditions are highly variable, and depend on local conditions; for a given aquifer there is an optimum spacing of wells and a maximum output per well that will allow indefinite replenishment of the aquifer by underflow. These optimum conditions are exceeded

C. *Exploration*

Presently, there are about ninety known areas in the United States where geothermal steam may be harnessed for power; all of them are in the Western States: California, Hawaii, Idaho, Nevada, and Oregon. The common occurrence of both recent volcanic activity and recent faulting appears to make California, in particular, a promising area for the development of geothermal power.

In the present stage of knowledge, the obvious place to look for geothermal fields is in regions of evident and unusual thermal activity—just as the initial search for oil was localized in areas in which oil and gas seeps appeared. All geothermal areas have anomalously high heat flows, and they frequently betray their presence on the surface.

The thermal area at The Geysers comprises approximately 3,200 acres, extending for about five miles along one side of a fault-line canyon. The thermal area at the Salton Sea is within one of the most profound fault systems on the North American Continent, being composed of the San Andreas, the San Jacinto, and the Elsinore Faults. Hot springs, mud-pots, pumice buttes, obsidian flows, local lava flows, and volcanoes characterize the entire Pacific Coastal fault area.

Where no surface thermal manifestations occur, an anomalous heat flow may be detected by drilling relatively shallow exloratory drill holes. The techniques of exploration for, and development of, geothermal power sources are essentially the same as for petroleum, insofar as shallow lying volcanic areas are concerned. Geological surveys, as well as geophysical work, such as electrical resistivity, gravimetric, magnetometric, seismological, and electromagnetic surveys, are helpful in determining the structure of the field, particularly the location of faults and fractures, stratigraphy, permeability of the strata, and the possible existence of an impermeable caprock to serve as a "pressure cap." Finally, small diameter thermal gradient holes may be drilled to evaluate the potential reserves, pressures, and temperatures.

---

nearly everywhere that ground water is tapped for agricultural, civic, or commercial use, and a large amount is taken from storage. In effect, it is "mined"; in the production of geothermal power steam also can mined.

If, however, a geothermal area produced no more steam or hot water than were supplied by recharge, and at a rate that allowed it to heat to the required temperature, a geothermal field could have a life measured in millenia. Lovering, *supra* note 6, at 97.

While some of the above shallow exploratory methods will be useful in identifying the deeper-lying magmatic convection-current fields, it appears that a field outline and an estimate of power reserves, available in shallow volcanic fields by means of thermal gradients, will be more difficult to obtain. Studies[22] indicate, however, that if geothermal drilling is based solely on nearby surface evidence of abnormal heat-flow, a success-ratio of one successful hole to fifty unproductive holes may be anticipated; given adequate exploration, the ratio may be expected to drop to one to twenty.

II

ECONOMICS

A. United States Energy Market

In the report of the Paley Commission[23] in 1952, it was estimated that twice the amount of energy which was used by the United States in 1950 would be required in 1975. The Commission was of the opinion that the total energy resources of the United States would be adequate for this anticipated increased demand provided, however, among other things, that new reserves could be developed, and that vast low grade resources of energy which then were not economic, could be brought into practical use through technological advance. The predictions of the Paley Commission, however, fell short of the mark. Even by 1960, our consumption of electricity alone had more than doubled. In 1964, the Federal Power Commission, using 1960 as the base year, predicted that the total electric energy requirements of the United States would double by 1970; would increase 166 per cent by 1975; and that the increase would rise to 330 per cent by 1980.[24]

As a result of the general relationship of industry, population, and electricity, the demand for energy is regional; it is strongly related to industrial and population centers. Thus, the economic role of geothermal power must be analyzed on a regional basis, a fact happily accommodated by the existence, in the Western States, of this country's greatest known geothermal potential, for it has been estimated that Western State power needs will be 45 per cent greater than those of the remaining areas of the United States by 1980.[25]

22. Facca & TenDam, Geothermal Power Economics 33 (rev. ed. 1964).

23. President's Materials Policy Commission (Library of Congress No. 330.973 U585).

24. FPC, National Power Survey, 1964, Table 17.

25. FPC, Release 11, at 289, Jan. 30, 1962.

Moreover, even greater *interchangeability* of energy supplies is close at hand; electric energy is a relatively fluid commodity, and improvements in the art of transmission and the increased efficiency of power systems are making it possible to shift power from areas of surplus into deficit regions to a much greater extent than formerly possible.[26]

Presently, electric energy within the Western States is produced almost wholly by hydroplants and steam plants;[27] the trend, however, is to steam generation. This undoubtedly reflects the exhaustion of suitable hydropower sites, and the trend toward fuel-generated power probably will become even more pronounced in the future.[28] While, in recent years, the efficiency of steam boilers has been improved, so that 11 per cent less oil per kilowatt-hour (kw.-hr.) was required in 1961 than in 1956, the cost of oil, per million B.t.u.'s produced, has increased approximately 25 per cent in the same period.[29] Moreover, the increased efficiency of new "fuel" power production units seems to be reaching a point of diminishing returns: additional capital outlays which will be necessitated in order to achieve greater efficiency soon may outweigh the saving in operating costs. Thus, it appears probable that the future tendency will be toward technological improvements in areas other than that of thermal efficiency. It is likely, moreover, that any such improvements will be applicable to all power sources impartially: to earth heat as well as to processed fuel.

There is, obviously, a burgeoning market for energy in the entire United States, particularly in the West; it is here that geothermal power production likely will first develop, should it prove, as presently indicated, to be directly competitive in cost with fossil fuel installations.

B. Production Costs

The experience so far gained in the exploration and production of geothermal energy, together with the very considerable progress

26. Currently, California and Nevada import small quantities of electricity from the surrounding states, and export electricity to Mexico. The other Western States are primarily surplus areas exporting to the surrounding states. Kaufman, *op. cit. supra* note 7, at 17.

27. *Ibid.* In 1961, hydro units comprised 57% of generating capacity, steamplants were responsible for 42%, and the remaining 1% came from atomic energy, gas turbines, and internal combustion sources.

28. FPC, National Power Survey, 1964, at 75, 117. It is estimated that only 27% of output in the Western States will come from hydro units by 1980; fuel generated output will increase six-fold.

29. Kaufman, *op. cit. supra* note 7, at 17.

which has been made in the theoretical understanding of the special problems involved, already has largely reduced the cost of producing geothermal energy. Drilling for, and production of, geothermal steam has a great deal in common with oil and gas operations. However, the geothermal hole may be larger; and the high temperatures encountered require use of different drilling materials.[30] Problems also are encountered with drilling fluids, because of the high hole temperature (up to 425° Centigrade), and a conversion to sodium surfactant mud or compressed air or the installation of mud-cooling facilities normally is required below 3,000 feet in order to keep the mud fluid.

Blowout problems have occurred at The Geysers, but special concrete well-head collars and more extensive grouting of the surrounding ground should eliminate such problems in the future.

The most elaborate cost estimates made to date have been compiled by Facca and TenDam,[31] Italian geophysicists who have collated materials from Larderello, Wairakei, and The Geysers. Starting with only surface manifestations of thermal activity, a complete geothermal exploration, from preliminary surveys through the drilling of six to eight exploratory wells, has been estimated to cost between 872,000 dollars and 1.05 million dollars.[32] Geothermal exploration therefore involves a considerable expenditure, but probably less than the average exenditure considered necessary in the petroleum industry for the discovery of a medium sized oil field.

Facca and TenDam define a commercial geothermal field as one capable of producing 500 million kw.-hrs. per year. This would require approximately thirty average steam wells.[33] A cost of approximately thirty dollars[34] per foot was assumed, based upon

30. E. T. Anderson, *How the World's Hottest Hole Was Drilled,* Petroleum Management, Oct. 1961, p. 81.

31. Facca & TenDam, *op. cit. supra* note 22.

32. *Id.* at 39, Table 27. Facca and TenDam assume that a geothermally promising area cannot be abandoned before at least six to eight exploratory wells have been drilled. Thus, within the limit of twenty dry holes (see text accompanying note 22 *supra*) three areas of interest can be investigated with at least three times the cited cost.

33. Projections for wells at the Salton Sea indicate that this 500 million kw.-hrs. per year goal (a 70 megawatt electric plant) could be supplied with as few as seven wells. Kane, Geothermic Consultants Study, Sept. 1963. (Geothermic Consultants, Box 119, Virginia City, Nevada.)

34. A leading California geothermal pioneer estimated that drilling costs in "hardrock" areas were approximately forty to fifty dollars per foot. See *Hearings on S. 1674, supra* note 13, at 30. Well depths at the Salton Sea have exceeded 5,000 feet; at The Geysers well depths vary from 400 to 1,200 feet.

shallow (1,600 feet) wells, giving a total field cost for thirty wells of 1.5 million dollars.

Considering only the cost of operation, electric energy produced from geothermal steam appears to be economically competitive with power produced from conventional suorces. Facca and TenDam have calculated the generating costs per kw.-hr. net output for various types of power plants as follows (in mills): geothermal, 2.36; conventional, 4.56; nuclear, 5.42 (decreasing, however, to near 2.1 by 1980); and hydroelectric, 3.0.[35]

The only geothermal steam field being operated commercially in the United States today is powering two turbines which produce 27,500 kw. of electricity for the Pacific Gas and Electric Company; this steam is coming from shallow wells at The Geysers, producing approximately 500,000 pounds of steam per hour, which is conducted through a quarter-mile-long, twenty-four-inch diameter insulated pipe, to the generating plant. Pacific Gas and Electric pays for the steam at the rate of two and one-half mills per kw.-hr. of electric power generated, delivered to its transmission lines.

Conversely, the capital cost per kw. may be considerably higher than that for a conventional plant. This results from the heavy investment required to discover, produce, and transport the steam, and from the shorter amortization period currently assumed for geothermal wells.[36] Should it be determined that geothermal steam qualifies for a tax depletion allowance, the computed cost of plants would be lowered.[37]

---

35. It should be noted, however, that the technology of geothermal steam is much less advanced than nuclear technology, and that progress will likely be made in reducing the cost of generating geothermal electricity to less than two mills per kw.-hr. for large installations. Facca & TenDam, *op. cit. supra* note 22, at 30.

36. The useful life of a geothermal steam well is difficult to predict. It varies with the type of producing formation, the mineral content of the brine, and the type of well installation.

Facca and TenDam have projected a well amortization period of ten years, although an occasional well at Larderello has sustained production for over twenty years. No information is so far available about wells in the United States.

Geothermal steam plants are variously amortized from ten to twenty years with the latter figure being more commonly accepted. Conventional thermal plants are generally estimated to have a useful life of approximately thirty years.

Economics of scale, however, can reduce the capital costs so far as the power production plant is concerned. The Federal Power Commission reported (1960) that conventional plants with a capacity of less than 19,000 kw. cost an average of 235 dollars per kw., whereas plants capable of producing 500,000 kw. or more had an average capital cost of 123 dollars per kw. See Kaufman, *op. cit. supra* note 7, at 11.

37. *Hearings on S. 1674, supra* note 13, at 2. See note 21 and accompanying text *supra*.

It is apparent that geothermal steam represents, or that it can be made to represent, a relatively inexpensive primary source of power. In instances where the hot water or steam is too corrosive to be fed directly to a generating turbine, a heat exchanger can be used.[38] Geothermal power might also be useful as a supplement to conventional electric generating facilities, either as a source of peaking power, or to firm up blocks of hydroelectric power.[39]

An additional source of revenue for geothermal operations may exist through the recovery of minerals in solution in the steam-brine. At Larderello, various boron compounds are produced as by-products.[40] The Salton Sea area wells apparently are capable of flowing 500,000 pounds of brine per hour with a twenty per cent mineral content.[41] The brine is extremely rich in potash, with commercially profitable amounts of aluminum, iron oxide, and common salt.[42] After processing costs are deducted, income from the sale of iron, aluminum, and salt alone is estimated at 600 dollars daily.[43] On the other hand, if the mineral matter is not recoverable, or should its recovery prove not to be commercially feasible, a method might be devised, as has been suggested by some engineers, by which the thermal energy can be utilized, while leaving the minerals in the formation.

III

LAW OF THE GEOTHERMAL INDUSTRY

A. Acquisition of Geothermal Rights

Thus far, virtually all geothermal exploration in the United States has been conducted on private lands. Present knowledge of geothermal occurrences indicate, however, that a substantial proportion of this resource exists under federally-owned lands in the Western United States.

38. This is done at Larderello, Italy.

39. It may also be useful, where the hot water is not suitable for power generation, as a preheater for water that is to be fed to conventional boilers. This would reduce the fuel requirements of conventional units and might result in substantial operating economies.

40. See text accompanying note 7 *supra*.

41. Oil and Gas Journal, Feb. 10, 1964, p. 62. Other engineers' reports have fixed the mineral content of the brine as high as twenty-nine per cent.

42. Calcium chloride, lithium, and manganese also appear to be commercially extractable.

43. Interview With R. W. Cypher, geologist for California Geothermal Co. and pioneer developer of Salton Sea geothermal area in Long Beach, California on December 29, 1965 and March 20, 1966.

The minimal utilization of geothermal resources on federal lands is mainly attributable to the absence of definite legal guidelines under which private development might proceed. So far, those geothermal explorations which have been initiated upon public lands have been under the provisions of the Mineral Location Law of 1872,[44] or the Mineral Leasing Act of 1920.[45]

The Mineral Location Law of 1872 reaffirmed the Government's policy of opening federal lands, valuable primarily for their minerals, to exploration and purchase.[46] After discovery of a valuable mineral deposit, a lode or placer claim could be located entitling the locator, who diligently pursued his find, to protection against interference with his possession. The locator is given the right to remove all minerals discovered, even though he should elect not to secure a patent in fee simple from the Government. Placer claims located by a single individual and based upon a single discovery are limited in area to twenty acres.

The Mineral Leasing Act of 1920, on the other hand, is a permit and leasing system designed to promote development of certain[47] minerals by private capital, while leaving title to the land and unproduced minerals in the United States. This is in obvious contrast to the mining location laws by which the locator may ultimately obtain fee title to the lands and then devote them to any use he desires, whether of a mineral or a non-mineral character.[48]

The Mineral Leasing Act system provides compensation to the Government by way of rentals and royalties payable by the lessee. Moreover, the act permits the lessee to "hold" lands without interference by other claimants for a period adequate for exploration and development of the mineral deposits. The maximum acreage which may be held under a single lease varies upward from 640 acres.

Those geothermal developers who entered public land relying upon the Mineral Location Act of 1872 were faced with at least one primary uncertainty. The uncertainty arose from the proviso that only "valuable mineral deposits" be opened to exploration and

44. Act of May 10, 1872, 17 Stat. 91, 30 U.S.C. § 23 (1964).

45. Act of February 25, 1920, 41 Stat. 437, 30 U.S.C. § 181 (1964).

46. The subsequent sketch of the Mineral Location Law of 1872 and the Mineral Leasing Act of 1920 follows 1 American Law of Mining, Titles I and II (Rocky Mountain Mineral Law Foundation ed. 1964).

47. Coal, phosphate, sodium, potassium, sulphur, oil, oil shale, gas, and potash are leasable.

48. See Act of May 10, 1872, 17 Stat. 94, 30 U.S.C. §§ 29, 37 (1964).

purchase.[49] This requirement entails a consideration as to whether geothermal steam is a "mineral." The 1872 law does not define "minerals"; federal regulations purport to do so.

> Whatever is recognized as a mineral by the standard authorities, whether metallic or other substance, when found in public lands in quantity and quality sufficient to render the lands valuable on account thereof, is treated as coming within the purview of the mining laws.[50]

A judicial test often[51] applied is that the mineral character of land under the 1872 law is established when it is shown to contain such a substance that: (1) is recognized as mineral according to its chemical composition by the standard authorities, *or* (2) is classified as a mineral product in trade or commerce, *or* (3) is such a substance as would justify a prudent man in expending labor and capital in the effort to obtain it.[52]

If it were to be determined that geothermal steam was a mineral for location purposes, despite the fact that it is not one of the "hard" minerals generally thought to have been encompassed by the 1872 law, it would be subject to location under placer laws and hence, extractable without charge. However, for the same reasons that led to public dissatisfaction with placer oil locations,[53] it is difficult to see governmental acquiescence in geothermal steam locations.

On the other hand, steam *does* bear similarities to the Mineral Leasing Act minerals, particularly oil—the resource is available only at great depth and after a great expenditure of money. Both sorts of claims, therefore, require legal protection prior to actual discovery of the "mineral." Moreover, in most instances[54] the acreage limitations under the Mineral Leasing Act are better adapted for geothermal development than the acreage available under the Mineral Location Law. As a probable consequence of these similarities, the

49. See Act of May 10, 1872, 17 Stat. 91, 30 U.S.C. § 22 (1964).

50. 43 C.F.R. § 3400.2 (1966).

51. 1 American Law of Mining, *op. cit. supra* note 46, at § 2.4.

52. 1 Lindley, Mines § 98, at 174-75 (3d ed. 1914).

53. The Mineral Leasing Act of 1920 was preceded by two decades of dissatisfaction with the unrestricted exploitation of oil lands of the West. See United States v. Midwest Oil Co., 236 U.S. 459, 466-67 (1915) (fear was expressed that soon the United States would be reduced to purchasing what it had practically given away).

54. The amount of land required to support an economically feasible geothermal steam development depends, *inter alia*, on the type of heat reservoir present, problems of mineral brine disposal, and the need for construction of power generation facilities at the well site. See text accompanying note 98 *infra*.

Mineral Leasing Act was briefly considered as an appropriate vehicle for the leasing of geothermal resources.[55]

It was originally[56] the position of the Department of the Interior that "steam is a gas by conversion of water. Water . . . although it is a mineral substance or material has never been deemed to be a mineral subject to location . . . . [It] is clearly a mineral material [and] may be sold under the Materials Act of . . . 1947."[57]

The Materials Act authorizes the severance from and disposition of certain[58] mineral resources on the public lands, with title to the lands being retained by the United States. "Adequate" compensation must be received by the Government under this act; moreover, if the "appraised value" of the materials exceeds 1,000 dollars, provision must be made for *public bidding*. It seems readily apparent that this "scientific" position was the natural result of the government's unwillingness to let the economic benefits of geothermal resources slip away under the Mineral Location Act of 1872.

Seven months later the Department of the Interior issued its only formal legal opinion on the classification of geothermal steam, and for reasons which are not altogether clear, changed its mind:

> Upon reconsideration of this question we believe that geothermal steam is not subject to disposition by this Department as a 'mineral material' under the Materials Act. * * * [W]e conclude that geothermal steam is developed from hot springs systems and that the greatly dominant component in these systems is meteoric water. . . .[59]

The Government's position was that an amendment to the Mineral and Hot Springs Act[60] would be necessary to authorize it to lease these "geothermal springs" for electric power.

---

55. S. 883, 88th Cong., 1st Sess. (1963).

56. Letter From Theodore F. Stevens, Solicitor, U.S. Dep't of the Interior, to J. W. Aidlin, Magma Power Co., Los Angeles, California, Jan. 19, 1961.

57. Act of July 21, 1947, 61 Stat. 681, 30 U.S.C. § 601 (1964).

58. In addition to vegetative materials such as yucca, manzanita, mesquite, cactus, timber, or other forest products, the Government was authorized to dispose of "common varieties" of sand, stone, gravel, pumice, pumicite, cinders, clay, and *other* materials of similar character.

59. *Hearings on S. 883 Before the Subcommittee on Minerals, Materials, and Fuels of the Senate Committee on Interior and Insular Affairs*, 88th Cong., 1st Sess. 70 (1963).

60. Act of March 3, 1925, 43 Stat. 1133, 43 U.S.C. § 971 (1964). This act provides for the leasing of land near or adjacent to "mineral, medicinal or other springs" for the erection of bath-houses, hotels, or other improvements for the accommodation of the public.

B. *The Question of State Water Rights*

1. The Legal Framework

Lying behind the emergence of the Mineral and Hot Springs Act on the geothermal stage was, apparently, the realization by the Government that the water which is a necessary constituent of geothermal steam might be subject to the regulation and control of the states under their applicable water laws.

The Desert Land Act of 1877[61] authorized the reclamation of desert lands on the public domain in certain[62] states. Furthermore, the act provided for the acquisition from the United States of *rights to use* all *surplus* unappropriated non-navigable waters on the public lands, by appropriation *in accordance with local laws and customs*. The Supreme Court has held in a series of cases that the provision above "effected a severence of all waters upon the public domain, not theretofore appropriated, from the land itself."[63]

One consequence of such a "severance" would appear to be that a federal geothermal steam lessee would have only a "naked right" to such steam until he also complied with the applicable state laws regulating water rights. Before analyzing the further consequences of such state regulation, an outline of the Government's "reaction" to this possibility, leading to its assertion of power under the Mineral and Hot Springs Act, will be helpful.

In the *Pelton Dam* decision,[64] the Court ruled that the severance of water rights from land, accomplished by the Desert Land Act, pertained only to "public lands," and not to lands that had been "reserved" by the United States.[65] Thus, once public land is re-

61. Act of March 3, 1877, 19 Stat. 377, 43 U.S.C. § 321 (1964). This act was an arid land adaptation of Congress' land disposition and settlement policy. See California Oregon Power Co. v. Beaver Portland Cement Co., 295 U.S. 142 (1935). The act was devised as a way by which both title to land and the use of water could be acquired, so that lands in the designated desert land states could be settled, conditioned upon reclamation by irrigation.

62. Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, and Wyoming. Act of March 3, 1877, 19 Stat. 377, 43 U.S.C. § 323 (1964).

63. California Oregon Power Co. v. Beaver Portland Cement Co., 295 U.S. 142, 162 (1935). See Nebraska v. Wyoming, 325 U.S. 589, 612 (1945); Ickes v. Fox, 300 U.S. 82, 95 (1937).

64. FPC v. Oregon, 349 U.S. 435 (1955). The Court held that when the United States reserves a dam site, it can grant a license to use non-navigable waters on the federal reservation without the consent of the state.

65. This distinction is between lands "unqualifiedly subject to sale and disposition" (public lands) and "lands that have been appropriated to some other purpose" (reserved lands). See, *e.g.*, United States v. O'Donnell, 303 U.S. 501, 510 (1938).

served by the federal government, no further[66] rights to the waters thereupon can be obtained under state law which will not be subject to a *superior* water right in the federal government. Much federal land has been reserved this way under the general authority of the Pickett Act[67] whereby the President has the discretion to withdraw from sale or entry and reserve for "public purposes" any of the public lands of the United States.

In 1930 President Hoover, acting under the authority of the Pickett Act, withdrew "every smallest legal subdivision of the public land surveys . . . [containing] a hot spring, or a spring the waters of which possess curative properties . . . ."[68] The springs withdrawn under this Executive Order were those capable of producing sufficient water daily to be valuable for general public use and benefit,[69] and such surrounding lands were to be leaseable under the Mineral and Hot Springs Act of 1925.[70] In this manner, apparently, the specter of state regulation of geothermal steam resources was to be avoided.

The Government's opinion that geothermal steam wells are hot springs seems to be open to dispute, both scientifically and legally. The Department of the Interior Solicitor's Opinion[71] rests, in part, upon the assertion that geothermal steam is a product of "meteoric water,"[72] a subject upon which geologists currently are divided.[73] The more obvious problems with the Government's position is that the withdrawal order of 1930[74] speaks of *springs,* not of underlying and *untapped* ground water; yet the Department of the Interior opinion clearly must interpret the withdrawal order as including all lands upon which a "hole may be drilled to underlying deposits of geothermal steam, no matter how far down, just as long as the steam is capable of being brought to the surface in its fluid form in

66. Water rights perfected *prior* to the reservation, however, would remain undisturbed.

67. Act of June 25, 1910, 36 Stat. 847, 43 U.S.C. § 141 (1964).

68. Exec. Order No. 5389 (1930).

69. See 43 C.F.R. §§ 2321.1-2(b) (1966).

70. 43 Stat. 1133 (1925), 43 U.S.C. § 971 (1964).

71. *Hearings on S. 883, supra* note 59, at 70.

72. *Ibid.* Water that previously existed as atmospheric moisture.

73. If geothermal wells produce from connate water (water deposited simultaneously with the depositing of solid sediments) or even magmatic water (water derived from cooling igneous magma), then it would be reasonable to hold that such "waters" are mineral in the true sense and perhaps not an appropriate subject for disposition under the Mineral and Hot Springs Act.

74. Exec. Order No. 5389 (1930).

quantities sufficient for public use or benefit as bath or spa water."[75]

Less violence would be done to the language of the Executive Withdrawal Order if its operation were restricted to those lands upon which hot springs, or springs with curative properties, are visible on the surface, rather than stretching the language to include man-made wells. However, to do so leaves much land that may be valuable for geothermal steam purposes *unreserved,* and therefore possibly subject to state water regulations.

2. The ground water problem

Several basic problems should be noted at the outset of an analysis of the "water rights" question. Certainly a primary one is whether the problem should be classified as one concerning water *at all;* or whether one classification holds any promise of being useful across the board.

The basic resources involved is *thermal energy within the earth.* That this energy is carried to the surface in the form of hot water, brine, or steam, there to be utilized as a source of electrical power, or, that energy expended, the brine stored, awaiting extraction of minerals, is important only insofar as the "water" carrier is used up.[76] If the ground water reservoir is not depleted,[77] the reasons for characterizing the problem as one of "water rights" lose most of their force.

Second, to the extent that geothermal steam may be a product of magmatic or connate waters,[78] it would not appear to be amenable to state control as a "water right," but rather be subject to the plenary power of the federal government in its capacity as fee owner of the minerals.[79]

---

75. *Hearings on S. 883, supra* note 59, at 29. It was further noted that by a prior Executive Order of April 17, 1926, lands containing springs (presumably *cold* ones) and water holes had been reserved for public use; it was stated, however, that it is improbable that the withdrawal applied to lands upon which machines could *drill* a water well to the water table. *Ibid.*

76. See note 21 *supra.*

77. It presently appears possible to use a *heat exchanger* production method by which either fresh water from an external source is constantly recirculated through the heat source at depth, or the hot brine is reinjected into the ground after exchanging its heat on the surface. In either of these methods it is probable that only a minimum of "make-up water" would be required.

It is also conceivable that a *direct generation* principle could be developed, so that electrical energy could be produced at the bottom of the well hole, thereby precluding entirely the need for a water carrier.

78. See note 73 *supra.*

79. Further complicating the problem is that present knowledge of geothermal occurences indicates that the percentage of the water attributable to each of these

Assuming, however, that some depletion of available water is probable, there is, nevertheless, still some question about the applicability of the "severance" phenomenon of the Desert Land Act to geothermal steam because geothermal steam *is derived from ground water,*[80] as opposed to surface waters. The terms of the Desert Land Act include "all surplus water over and above . . . actual appropriation and use" in irrigation "together with the water of all lakes, rivers, *and other sources of water supply upon the public lands and not navigable.*"[81]

In *State ex rel. Bliss v. Dority,*[82] the New Mexico Supreme Court held the above quoted language of the Desert Land Act to be applicable to "artisian basins," despite the phrase *"upon* the public lands." The court noted that Congress intended in the Desert Land Act "to cover *all* water that could be used and appropriated for beneficial use *under the laws of the State where the land is located,"* and that waters in an artesian basin were subject to appropriation under New Mexico law.[83] This is not to say, however, that the term "artesian waters" is coextensive with "ground waters";[84] but it does indicate that the Desert Land Act may be interpreted as having severed more than surface waters. Insofar as the water laws of the other Western States make any forms of ground water subject to appropriation, then the production of geothermal steam from federal lands, drawing upon those forms of ground water, may be subject to state control and regulation.

On the other hand, if the Desert Land Act were to be found inapplicable to those waters from which geothermal steam is produced, then presumably such waters would "belong"[85] to the owner

---

sources may vary from place to place depending on whether, for example, the heat source is an old volcanic one or a present magmatic intrusion; and whether it is overlain by metamorphic rocks or by sedimentary depositions. Interview With R. W. Cypher, *supra* note 43.

80. Geothermal waters do not become steam until the pressure of the overlying formation is relieved. As the naturally heated waters immediately adjacent to the heat source are used up (as the vehicle carrying thermal energy to the surface), replenishment of the aquifer takes place by underflow and depletes the surrounding storage of ground water. See note 21 *supra.*

81. Act of March 3, 1877, 19 Stat. 377, 43 U.S.C. § 321 (1964). (Emphasis added.)

82. 55 N.M. 12, 225 P.2d 1007 (1950), *appeal dismissed,* 341 U.S. 924 (1951).

83. 55 N.M. at 23, 225 P.2d at 1014. (Emphasis added.)

84. See W. A. Hutchins, Selected Problems of Water Rights in the West (Misc. Pub. No. 418, U.S. Dep't of Agriculture 1942). There, ground water is divided into (1) "definite underground streams," (2) "percolating waters," and (3) "artesian waters."

85. See F. Trelease, *Government Ownership and Trusteeship of Water,* 45 Calif. L. Rev. 638 (1957). Dean Trelease maintains that "ownership" by a sovereign power

of the land; here, the owner would be the United States as proprietor of the public lands. Under this analysis geothermal resources would be leaseable without the necessity of making an application to the state to appropriate the required water. It would, moreover, obviate the necessity of relying upon "reservation" of geothermal lands by the Executive Withdrawal Order of 1930.

It should be noted that even though the federal government might have full proprietary powers[86] over some forms of ground water underlying the public lands, those powers may be *correlative* to the rights of the state, if, for instance, both are taking ground water from the same basin.[87] Moreover, were injury to adjacent private landowners to develop from depletion of the common basin by geothermal steam production, state water law would appear to be the appropriate system in which to settle the dispute.[88]

There is some feeling, however, that geothermal resources should not be subject to any state water laws at all, presumably on the rationale that the federal interest in developing this source of power justifies the assertion of federal authority in derogation of state law. That the power to ignore state water laws exists in the federal government seems no longer to be a subject of dispute.[89] However, it seems appropriate to draw some analogies between the federal oil and gas leasing program, and the pending proposals for geothermal steam. Physically, federal and non-federal lands, overlying a common ground water basin are like federal and non-federal lands overlying a common pool of oil or gas federal statute[90] and federal lease agreements[91] recognize the latter problem in realistic efforts to deal with it. Federal oil and gas leases provide that "the rate of production . . . shall be subject to control in the public

is a meaningless term, because the incidents of such ownership differ so widely from those of private ownership.

86. U.S. Const. art. IV, § 3. For a full explication of what the Government believes this power entails with respect to water rights, see *Hearings on Federal-State Water Rights Before the Senate Committee on Interior and Insular Affairs*, 87th Cong., 1st Sess. 16 (1961).

87. Ground water laws are based upon a recognition that an underground basin is a common source of supply to many overlying water users, and that its safe yield is measurable in finite quantities. See C. Corker, *Water Rights and Federalism*, 45 Calif. L. Rev. 604, 622 (1957).

88. *Ibid.*

89. See Note, 60 Colum. L. Rev. 967 (1960).

90. 60 Stat. 952 (1946), as amended, 30 U.S.C. § 226(g) (1964), authorizes the Secretary of the Interior to negotiate compensatory royalty agreements with adjacent landowners.

91. Bureau of Land Management Form No. 4-1158, *Offer To Lease and Lease for Oil and Gas* § 4 (6th ed. 1957).

interest . . . taking into consideration, among other things, . . . state laws and regulations issued thereunder . . . ."[92] While provisions have been made in pending geothermal steam legislation[93] for unitization of federally leased lands, and for control of the rate of production under such plans, it is not clear that any consideration has been given to any form of production control vis-à-vis other users of a common ground water basin *who do not happen also to be geothermal steam producers.* It is suggested that some recognition be given to this problem, and legislative provisions made for its resolution, *regardless* of whether it is ultimately decided that the initial *right to use* ground water underlying federal lands is or is not subject to state regulation and control under the Desert Land Act.

C. Legislation

It is difficult to assess whether or not the Government's fear that the Western States might have a claim to regulation of ground water underlying the public domain is, in fact, well founded. Its change of position, however, as to the manner of permissible disposition of geothermal steam, coupled with the urgings of an impatient geothermal industry, have given impetus to several proposals of legislation in the Senate.

Senate bill 883[94] (S. 883) proposed to treat geothermal steam as a Mineral Leasing Act mineral, on the rationale that terms and conditions under the Mineral Leasing Act were "comparatively well-defined" and had a "fairly definite meaning."[95] The demise of S. 883 was foreshadowed just as surely, however, in a report[96] from the Department of the Interior four weeks prior to the hearings on the bill. The Department indicated that it could find no justification for conferring geothermal rights upon holders of existing oil and gas leases, thereby giving them a windfall.

Moreover, objection was made by the Government to the wholesale adoption of Mineral Leasing Act provisions, particularly those which would allow geothermal lessees to hold a combined acreage of 246,080 acres[97] in any one state. It was feared that so large a maximum might allow preemption by one individual of all the geo-

92. *Ibid.*
93. S. 1674, as amended, 89th Cong., 1st Sess. § 10 (1965).
94. S. 883, 88th Cong., 1st Sess. (1963).
95. *Hearings on S. 883, supra* note 59, at 4.
96. *Id.* at 108.
97. 74 Stat. 781 (1960), 30 U.S.C. § 184 (d) (1964).

thermal potential within one state. A substitute bill, its framework independent of the Mineral Leasing Act, was concurrently submitted by the Department. Among its salient features was the vesting of total discretion in the Secretary of the Interior regarding *all* lease terms and regulations.

The subsequent hearings were substantially more than a public wake for S. 883; the record is filled with forthright presentations of the views of the industry and of the Government—diverse among representatives of the former, each interested in maintaining those interests he felt he had perfected under prior placer claims,[98] potassium prospecting applications,[99] or oil and gas leases;[100] unitary on the part of the Government, unabashedly interested in a grant of authority to obtain the greatest possible return for the Government from the leasing of its lands.

In 1965, hearings were heard on a new bill, Senate bill 1674 (S. 1674.[101] S. 1674 reflected the combined efforts of industry[102] and the Department of the Interior:[103] each had submitted draft bills at the close of the Senate hearings on S. 883. S. 1674 passed the Senate on September 7, 1965, in a slightly amended form. It conferred specific authority on the Secretary of the Interior to issue leases for geothermal development, independent of any existing legislation. S. 1674 approached the problems of state water control more equivocally: "Nothing in this Act shall constitute an express or implied claim or denial on the part of the federal government as to exemption from State water laws."[104]

On September 8, 1965, S. 1674, as amended, went to the House Interior and Insular Affairs Committee, where its supporters undoubtedly will again lock horns with the Department of the Interior. As a prelude to a discussion of some of the more important problems resolved in S. 1674, as amended, it would appear valuable to reconsider briefly some of the respective basic interests of the federal government and of private industry which, naturally, have generated their proposals. Necessarily interwoven are questions of the role of Congress: how specific should be the ultimate provisions;

98. *Hearings on S. 883, supra* note 59, at 31.

99. *Id.* at 37.

100. *Id.* at 15.

101. A Bill To Authorize the Secretary of the Interior To Make Disposition of Geothermal Steam and Associated Geothermal Resources, and for Other Purposes. S. 1674, 89th Cong., 1st Sess. (1965).

102. *Hearings on S. 883, supra* note 59, at 152, 155.

103. *Id.* at 106.

104. S. 1674, 89th Cong., 1st Sess. § 20 (1965).

and how much power in determining lease provisions ought to be delgated to the discretion of the Secretary of the Interior?

Economic standards in geothermal steam legislation are of vital importance to the entrepreneur; for, in such a nascent industry, risks are high and unascertained. Conversely, because of that same dearth of geological and economic information, the Government is chary of tying itself to fixed provisions which prove to be so favorable to the risk-taker that the Government goes relatively unrewarded for making available its land. It is natural, therefore, that private interests and the Government have come forward with quite different proposals for rental and royalty terms of geothermal steam leases.[105] Nor is the disagreement totally economic. The Government's interests are fostered by provisions allowing for the maximum exercise of judgment and discretion by the Secretary of the Interior. This sort of interest is exemplified by the Government's proposal to remove from the control of the steam developer, and to vest in the Secretary, the right to decide whether, in fact, valuable by-products of a steam well can be "reasonably produced."[106]

Additionally, steam developers are interested in encompassing within any legislation as much federal land as possible, not only because so much geothermal potential underlies federal lands, but because the acquisition of additional lands later would undoubtedly prove more "expensive" should initial development be more than marginally successful. Such may be an alternative, albeit more sanguine, explanation for the Government's reluctance to include parks and wildlife areas[107] in the present bill.

The general objective, nevertheless, is to encourage geothermal steam development by private industry, while protecting the public interest during the time that these natural energy deposits are being brought to full utilization. It is well to keep this background in mind while analyzing the provisions of the proposed legislation.

1. Competitive Bidding and Priorities

The geothermal steam lease provision which probably has gener-

105. *Compare* S. 1674, 89th Cong., 1st Sess. § 12 (1965), *with* § 12 of the 1965 Dep't of the Interior draft bill in *Hearings on S. 1674 Before the Subcommittee on Minerals, Materials, and Fuels of the Senate Committee on Interior and Insular Affairs*, 89th Cong., 1st Sess. 10 (1965).

106. *Compare* S. 1674, 89th Cong., 1st Sess. § 8 (1965), *with* § 9 of the 1965 Dep't of the Interior draft bill § 9 *supra* note 105.

107. *Compare* S. 1674, 89th Cong., 1st Sess. §§ 1, 4 (1965), *with* the 1965 Dep't of the Interior draft bill, *supra* note 105, at §§ 2, 4.

ated the most discussion depends on whether the leases should be granted to the first qualified applicant or should be issued after competitive bidding.

The position of the Government is that adherence to competitive leasing for all geothermal resources will protect the public interest by providing a "wholly objective standard . . . [of] the fair market value of the right to explore . . . ."[108]

Counter-arguments of industry were not wholly responsive: basically, it was pointed out that there have been geothermal steam pioneers who have spent substantial amounts in research and exploration who should not be subjected to the hazards of losing their interests to other more conservative companies who happened also to be more affluent.

This rationale, however, would support more than one resolution. The Government argued that there are many areas where the potentialities of geothermal development are obvious, exploratory risks minimal, and thus that there is no justification for awarding a lease to a particular individual based solely on the "fortuitous circumstances" of his having filed the first application. It was feared that an avalanche of applications would result, many of which would be held, without actual development, only for their speculative value. In an attempt at compromise, apparently unacceded to by the Government, the concept of a "known geologic structure"[109] was borrowed from the Mineral Leasing Act of 1920; as to geothermal steam leases in such structures, competitive bidding was to be the rule.

This solution was not entirely satisfactory even to the more affluent industry members because they generally sided with the smaller exploratory pioneers in demanding the inclusion of a system of priorities or preferences as to future leases for those who had previously held a colorable interest under Mining or Lease Act claims. A precedent for this proposal appeared in the granting of preferences in leases to the holders of claims, under the General Mining Law of 1872, for oil and gas at the time of the enactment of the

108. *Hearings on S. 1674, supra* note 105, at 15.

109. There is still considerable doubt concerning the ability of present geological methods to pinpoint the extent of a geothermal field. *Compare* Facca & TenDam, Geothermal Power Economics 103 (rev. ed. 1964), *with Hearings on S. 883 Before the Subcommittee on Minerals, Materials, and Fuels of the Senate Committee on Interior and Insular Affairs*, 88th Cong., 1st Sess. 106 (1963). The concept of a known geologic structure was supported, however, by representatives of the larger private companies who could more easily accept the burden of competitive bidding.

Mineral Leasing Act of 1920.[110] A period of time, ranging variously from 120 days to two years was suggested, during which former claimants should have the right to convert their prior claims to geothermal leases covering the same land.

The Department of the Interior, however, was adamant;[111] they based their objections to preference privileges upon the assertion that a lessee under the Mineral Leasing Act "had received full value for the rentals paid," and that there was no ground for inquiring into the reason behind such a lease offer (although the Government acknowledged that some of the leases were probably taken with an eye to geothermal resources, rather than oil and gas); preference based upon prior placer claims was similarly rejected because such claims already might "ripen into full fee ownership"; and, therefore, to grant a preference right would be, in each case, to confer an "uncompensated privilege" upon the claimant. It seems clear, however, that the present industry proposals as to *conversion* privileges do not in fact confer an additional privilege upon the holders of prior claims, for such claims must be surrendered in order to exchange the priority established under them for a geothermal lease.[112]

S. 1674, as amended, effected a combination of these proposals in what appears to be a fair and practicable form:

> * * *
>
> Sec. 11. Subject to (a) and (b) hereof, if lands to be leased under this Act are within any known geological structure of a geothermal resources field, they shall be leased to the highest bidder by competitive bidding under regulations to be formulated by the Secretary of the Interior. If the lands to be leased are not within a known geological structure of a geothermal resources field, the qualified person first mailing application for the lease shall be entitled to a lease of such lands without competitive bidding. Notwithstanding the foregoing, any time within 180 days following the effective date of this Act:
>
> (a) with respect to all lands which on January 1, 1965, were subject to valid leases or permits issued under the Mineral Leasing Act of February 25, 1920, as amended . . . , or to valid mining claims filed on or prior to January 1, 1965, the lessees, or permittees or claimants who are qualified to hold geothermal leases shall have

110. 41 Stat. 451 (1920), 30 U.S.C. § 193 (1959).

111. *See Hearings on S. 883, supra* note 109, at 107, in which it is stated that the Department of the Interior takes "strong exception" to the granting of preferences.

112. *Hearings on S. 1674, supra* note 105, at 59.

> the right to convert such leases, or permits or claims to geothermal leases covering the same lands; and
>
> (b) with respect to all lands which were, on January 1, 1965, the subject of applications for leases or permits under the above Acts, the applicants may convert their applications for geothermal leases having priorities dating from the time of filing of such applications under such Acts.[113]

The only question seems to be the problem of ascertaining what is a "known geological structure." Facca and TenDam[114] indicate that present geological theory permits clear definition of structural and stratigraphic objectives, and that, given that reference, problems of outlining a field are no more difficult than in oil exploration.[115]

2. The Problem of Prior Valid Mineral Leases

Under both the 1965 draft proposal of the Department of the Interior, and sections 6 and 7 of S. 1674 (*prior* to its amendment) persons holding leases, claims, or permits for other minerals on lands subsequently coming under geothermal steam leases were apparently dependent upon the beneficence of the steam lease holder: section 6 of S. 1674 formerly provided that operations under any other leases or other uses could not interfere with operations for geothermal steam; section 7 required "substantial beneficial use" of such minerals as might be contained in the geothermal brines produced as a "by-product" of steam.

Section 6 obviously would have inhibited normal expansion of mining operations of other sorts than geothermal, on the same land, whether commenced under leases granted *before or after* the steam lease; this apparent oversight was corrected by granting similar and reciprocal rights to holders of other sorts of leases:

> nor shall operations under leases issued pursuant to the provisions of this Act unreasonably interfere with or endanger operations under any lease, claim, or permit issued pursuant to the provisions of any other Act.[116]

113. S. 1674, as amended, 89th Cong., 1st Sess. § 11, in 111 Cong. Rec. 22067 (1965).

114. Facca & TenDam, *op. cit. supra* note 109, at 33.

115. It should be noted here that "known geologic structure" as used in the Mineral Leasing Act of 1920 does not refer to *actual* productivity, but rather only to that part of a geologic structure which, on the basis of structural considerations, appears *favorable* to oil and gas accumulations. L. E. Hoffman, Oil & Gas Leasing on the Public Domain 194 (F. H. Gower 1957).

116. S. 1674, as amended, § 6, in 111 Cong. Rec. 22068 (1965).

Section 7 was potentially more ominous;[117] if for instance, geothermal leases were to be granted on lands already covered by a valid potassium prospecting permit, the beneficial use provision apparently would have "obligated" the geothermal energy producer to mine potassium as well, if it appeared as a geothermal brine by-product. The damage to the prior potassium permittee is obvious, even though the permittee and the geothermal resources developer would be producing from different "mines." This inequity was attacked by amending section 7 to include:

> in no case shall the use or production of such byproducts be permitted other than by the holder of the preexisting leases, claims, and permits whenever the same or similar byproducts are being produced on the same land under other leases, claims, or permits granted previously.[118]

Changing the language, however, did not entirely solve the problem. Geothermal steam and its "associated geothermal resources" come out of the well simultaneously. If potassium were *present* in the steam-producing formation, it might prove impossible to refrain from producing it. Dividing the effluent, potassium to the permittee, the remaining brine minerals to the geothermal developer, may be technically feasible; it raises, however, problems of paying for such processing—a contingency with which the permittee may be financially unable to cope.

A possible solution as to *future* leases is to give title to all minerals which are produced as an inseparable part of the geothermal process to the geothermal lessee; this does not, of course, solve this potential problem for those persons holding production expectations under prior mineral leases.

Another question which may prove troublesome, and which appears to be inadequately treated under either the Senate or the Department of the Interior bill, also involves the section concerning beneficial use. Even absent the potential conflict with a prior mineral permittee noted above, it is possible that "substantial beneficial use of production" of minerals may be contrary to the interests of the geothermal steam developer. This, admittedly, depends upon what "uses" satisfy the requirements. The high capital cost of erecting a chemical extraction plant might prove an uneconomic burden to a

117. See text accompanying note 41 *supra.*

118. S. 1674, as amended, § 7, in 111 Cong. Rec. 22068 (1965).

developer who intended only to sell energy for electric power. If the "ponding" of the effluent, and an offer to sell the brine residue at the well site satisfies "beneficial use," this may be an alternative. But it may well be an impractable alternative in well locations where no adequate areas for the extensive[119] ponding required exists, as for example, parks and wildlife areas.

In areas with inadequate room for ponding mineral brine, the technological answer to disposal of the effluent may be to return it to the formation, there to be "stored" until its extraction and "beneficial use" is economically feasible. Reinjection wells may be suited to this purpose.[120] It is uncertain, however, whether this form of "non-production" would be accepted by the Secretary under his discretion to waive the requirement of beneficial use for "reasons satisfactory to him."[121]

3. Excluded Lands

From the beginning of the hearings on geothermal steam, the Government has urged the exclusion of national park areas, wildlife refuges, and Indian-owned lands.[122] The exclusion of the first two is based upon the asserted incompatibility of geothermal steam development with the purposes for which the lands were dedicated;[123] the exclusion of Indian-owned lands is predicated upon the fact that such lands are essentially privately owned[124] and should continue to be governed by the Act of August 9, 1955.[125]

Private industry appears to have limited its attack, however, to an argument for the inclusion of those wildlife refuges administered by the Secretary of the Interior. Under existing law,[126] the Department of the Interior has the authority to lease such lands for eco-

119. At the Salton Sea ponding areas, approximately 160 acres are presently being used in the fractional crystallization of the brine.

120. In some geothermal areas this problem is minimal because the steam produced is dry and very nearly mineral-free. Such a situation is found at The Geysers. Some of the Salton Sea geothermal developers, however, have already encountered this disposal problem owing to the extremely high mineral content of the brine.

121. 1965 Dep't of the Interior draft bill § 8, in *Hearings on S. 1674, supra* note 105, at 10; S. 1674, as amended, § 7, in 111 Cong. Rec. 22068 (1965).

122. *Hearings on S. 883, supra* note 109, at 9; 1965 Dep't of the Interior draft bill, § 4, in *Hearings on S. 1674, supra* note 105, at 10.

123. *Hearings on S. 1674, supra* note 105, at 7.

124. *Ibid.*

125. 69 Stat. 539 (1955), 25 U.S.C. § 415 (1964), which gives leasing rights to restricted Indian lands to the Indian owners, subject to certain restrictions upon lease terms.

126. Migratory Bird Conservation Act, 49 Stat. 383 (1935), 16 U.S.C. § 715 (1964).

nomic development, including, presumably, the harnessing of geothermal power. And, pursuant to regulations[127] issued by the Secretary, such economic development may be permitted even though it does not further the purposes for which the lands are devoted: the test lies in the determination as to whether development will further the public interest. It is suggested that a steam project, minimally interfering with wildlife conservation, could, in some areas, greatly serve the public interest by producing needed power at low cost. The test is one of social desirability, and it would seem that it should not be abandoned under a blanket exclusion.[128]

S. 1674 now provides for leases on *all* lands administered by the Department of the Interior,[129] as well as for United States Forest Service lands.

4. Term, Acreage, and Royalty Provisions

S. 1674 as amended, provides for a primary lease term of fifteen years,[130] and so long thereafter as geothermal steam or energy is produced in commercial quantities. The government draft bill calls for a ten-year primary term, with a secondary term not to exceed ninety years. The Department of the Interior apparently

127. 50 C.F.R. § 29.3 (1961).

128. In this regard a favorite anecdote of Senator Gruening (Alaska), Chairman of the Senate Subcommittee holding hearings on geothermal steam, concerns the Kenai National Moose Range. It was reserved (without hearings) in 1940; requests for permission to conduct oil exploration were turned down repeatedly on the assertion of conservationists that such activity would destroy the moose. The permission, Senator Gruening relates, was ultimately granted, however, and apparently moose have multipilied so fast that the season has had to be lengthened in order to prevent them from running out of browse. See, *e.g., Hearings on S. 1674, supra* note 105, at 23.

129. The 1965 Department of the Interior draft bill § 2 contains a provision that leases upon lands withdrawn in aid of functions of the Department may be issued under such terms as the Secretary shall prescribe to "insure adequate utilization of the lands for the purpose for which they were withdrawn." *Hearings on S. 1674, supra* note 105, at 10.

It is interesting to note that this provision, eminently reasonable on its face, provides potential comic relief to the power technology of geothermal development: this provision presumably would apply to those geothermal lands which the Department maintains were withdrawn as "curative hot springs." See Exec. Order No. 5389 (1930). The Hot Springs Act of 1925 provides for the erection of bathhouses and hotels on lands so withdrawn and subsequently leased. See 43 Stat. 1133 (1925), 43 U.S.C. § 971 (1964). A geothermal developer might, therefore, have to assure the Department that his development will not interfere with, nor preempt choice locations for future bathhouses for tourists desiring to "take the cure" in the 600° Farenheit steam.

130. A "drilling operations" clause is available to extend the primary terms for an additional five years. S. 1674, as amended, § 8, in 111 Cong. Rec. 22068 (1965).

is concerned that geothermal steam, unlike oil and gas, may be an inexhaustible resource, and therefore, a terminal date must be inserted in the lease itself. However, the extent of the secondary term would appear to be less crucial to the entrepreneur than the primary; inasmuch as geothermal energy, unlike oil, cannot be transported over any great distance, development facilities must be constructed at the well-site. This is a time consuming and expensive process, the feasibility of which may depend upon assurances from the operator that the then unexplored lease potential is worth such an investment. It is suggested that a primary term of as much as twenty years prior to production is not inappropriate.

Amended S. 1674 provides for a lease acreage minium of 640 acres and a maxium of 2,560. Moreover, in any one state, lessees may not hold more than 51,200 acres in federal leases.[131] The Government urges that these limits be reduced, *inter alia,* to a 640 acre *maximum.* The governmental rationale may be that a reduced lease size will permit smaller operators to compete effectively; or it may be based upon their understanding as to what area would constitute an economic unit.[132] The latter understanding may have been acquired from testimony,[133] concerning geothermal producing areas in Northern California, which, in fact, may be the exception rather than the rule; contradictory testimony was offered by industry spokesmen in reference to the Salton Sea geothermal area. It was said that in that area an acreage maximum of as much as three or four townships might be appropriate.[134] In any event, it is apparent that less is known about the geology, engineering, and economics of geothermal production than is known concerning oil and gas production; for this reason alone it seems desirable that a geothermal energy developer be given control over at least as large a parcel of land as given to oil explorers.

Federal and private interests may have found their greatest accommodation in the legislative provisions for rentals and royalties.[135] The Government bill provided for a minimum 10 per cent royalty on steam, and *not less than* 5 per cent on minerals extracted, with a minimum royalty of two dollars per acre in lieu of rental. The Senate version asked for 10 per cent of the steam *actually sold or utilized,* and 5 per cent of the minerals, with a

131. S. 1674, as amended, § 9, in 111 Cong. Rec. 22068 (1965).
132. *Hearings on S. 1674, supra* note 105, at 8.
133. *Hearings on S. 883, supra* note 109, at 34.
134. *Id.* at 58.
135. S. 1674, as amended, § 12, in 111 Cong. Rec. 22069 (1965).

royalty of one dollar per acre in lieu of rental. Rental requested by the Government was one dollar per acre for the first five years, and two dollars per acre thereafter until production. The Senate bill provided for fifty cents per acre rental *without escalation.*

The element of risk seen to be undertaken by developers apparently outweighed the Government's contention that a royalty on "steam sold or utilized only," as opposed to one on gross steam derived from production, would "tend to encourage the waste of natural resources to no economic purpose to the detriment of conservation."[136] The amended version of S. 1674 which passed the Senate *added* "actually sold or utilized" as a condition to the royalty provisions for *minerals* as well.

Conversely, some recognition was given to the Government's objective of remaining free from the burden of geothermal speculators with no intention or ability actually to develop the lease because the amended bill incorporated the Government's higher annual rent provision of one dollar per acre, even though it failed to incorporate the requested escalation clause.[137] Moreover, the Government's proposal for two dollars per acre minimum royalty in lieu of rental was adopted over the industry proposal of one dollar per acre.

A difference which apparently could not be reconciled concerned the Government's proposal that royalties in steam *utilized but not sold* should be determined by comparison with equivalent energy from the lowest cost alternative power source.[138] Industry objected that such a provision failed entirely to appreciate the point of geothermal energy—its low cost. It was pointed out that alternative sources of power would always be more expensive,[139] and that it would be illogical and artificial to fix the value of geothermal energy thereby. The Senate bill, as amended, provides that the value of geothermal steam *used but not sold* shall be determined by the Secretary of the Interior, who shall take into consideration the cost of exploration and production, as well as the economic value of the resource in terms of its *ultimate* utilization.[140] Impre-

136. *Hearings on S. 1674, supra* note 105, at 5. This contention is not consistent with the theory that steam may be an inexhaustible resource asserted by the Government in connection with lease term provisions. *Id.* at 14.

137. S. 1674, as amended, § 12(c)-(d), in 111 Cong. Rec. 22069 (1965).

138. 1965 Dep't of the Interior draft bill § 12(b), in *Hearings on S. 1674, supra* note 105, at 11.

139. It has been forecast that the only economically competitive power supply would be hydroelectric energy in the area immediately adjacent to the Grand Coulee Dam. See *Hearings on S. 883, supra* note 109, at 40.

cise as this is, it is no more imprecise than the rule that governs the Secretary's power to review the value of oil and gas for determining government royalty.[141]

5. Lease Readjustments

The Government has repeatedly urged the adoption of a provision for readjustment of lease terms and conditions every five years.[142] It appears to be the view of the Department of the Interior that if the lessee is unhappy with the altered terms, he either remains unhappy or he should terminate the lease. Inasmuch as the development of geothermal energy admittedly will necessitate large-scale investments and long term power contracts covering the depreciable life of the installations, fluctuation of terms at the discretion of the Secretary might prove to be an effective bar to financing. It is not clear, however, that the representatives of the geothermal industry object to readjustment insofar as *associated geothermal resources* are concerned.[143] Nevertheless, the Government's proposal has been rejected in its entirety by the Senate's amended version of S. 1674.

CONCLUSION

S. 1674, as amended, appears to provide a practicable framework within which geothermal exploration and development on federally owned lands can proceed. Some further legislation may be required at the state level in order to resolve the uncertainties attending the possible application of state water law to geothermal resources, but the foreseeable electrical energy demand of the Western United States makes the development of a low-cost power resource desirable, and the natural coincidence that most geothermal areas appear to underlie federal lands makes expeditious passage of such a federal leasing program necessary to that end.[144]

140. S. 1674 as amended, § 12(e), in 111 Cong. Rec. 22069 (1965).

141. 43 C.F.R. § 3125.3(d) (1966), which provides that the Secretary may "establish reasonable values . . . due consideration being given to the highest price paid for . . . production of like quality in the same field, to the price received by the lessee, to posted prices and to other relevant matters."

142. 1963 Dep't of the Interior draft bill § 14 in *Hearings on S. 883, supra* note 109, at 106; 1965 Dep't of the Interior draft Bill § 13 in *Hearings on S. 1674, supra* note 105, at 4.

143. *Compare Hearings on S. 883, supra* note 109, at 141, *with Hearings on S. 1674, supra* note 105, at 63. The more recent position indicates that readjustments are opposed as to *any* lease term or condition.

144. On October 21, 1966, the House of Representatives sent back to the Senate an amended S. 1674, which appears to have an excellent opportunity for passage, without further changes, at the beginning of the next Congress. See 112 Cong. Rec. 27221-26, 27396-97 (1966).