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SUMMARY OF 1977 GEOTHERMAL DRILLING — WESTERN UNITED STATES

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During 1977 there were 52 wells drilled to explore for and develop geothermal resources in the states of California, Nevada, Idaho, Utah and New Mexico. By category, 26 were intended as development wells and 8 were stepouts to proven production. The remaining were 9 exploration, 3 injection and 2 observation wells, and 4 attempted recompletions or deepenings of previously existing wells. Of the 47 drilled for production, 25 appear to have found at least potentially commercial amounts of steam or hot water, 17 are suspended and 5 were abandoned. This is an indicated success rate of 53%, disregarding the future production possibilities from the presently suspended wells.

Table 1 summarizes the drilling activity by States and Table 2 by Operator. Included are all wells spudded during calendar year 1977. The total footage drilled was 374,129 feet, which represents a 15% decrease from the 437,752 feet drilled in 1976. The most active operators in 1977 were Union, Aminoil, Shell and Republic Geothermal, based on footage drilled.

CALIFORNIA

Imperial Valley

In the Imperial Valley (Figure 1) geothermal field development was continued in 1977 by the drilling of 7 new wells, plus a redrill, for a total footage drilled of 50,058 ft.

At East Mesa, Republic Geothermal obtained final approval in May of the first Federal Geothermal Loan Guaranty, in the amount of \$9.03 million dollars. Four wells were subsequently drilled and completed by Republic, increasing their total number of wells in the field to seven. The first of the 1977 production wells, 56-30, was spudded in May and drilled to 7520 ft. Immediately following, 16-30 (8000 ft.) and 78-30 (7442 ft.) were completed. Bottom hole temperatures are approximately 355°F. and flow rates exceed 33,000 B/D. Near

the end of the year, Republic's "East Mesa" 52-29 was drilled to a total depth of 4524 ft. as a field evaluation well and then converted to a peripheral injector. Republic Geothermal is presently conducting 30 day flow tests of their production wells, anticipating the construction and operation of a dual admission steam turbine-generator plant that will initially have an output of 10 Mw in early 1979, and a total 64 Mw gross (48 Mw net) output in early 1980.

Also at East Mesa, Magma drilled "US" #46-7 to 3095 ft. as an injection well located midway between their two deep production wells. The three Magma wells will be used in conjunction with an 11.2 Mw experimental dual binary cycle heat exchanger power plant that is now under construction.

At North Brawley, Union Oil Completed the "Cox" #1 to 9609 ft., followed by Chevron's "Rutherford" #1 (7930 ft.), bringing the total of 7 wells to be drilled in the field within the last 3 years. The North Brawley wells are reported to flow a 100,000 mg/l brine at rates up to 500,000 #/hr. Union applied to the County in November for permits to construct a 10 Mw power plant.

In the Westmorland field Republic Geothermal redrilled "Landers" #1 to recomplete it within the 5062-7000 ft. interval. This production well had been drilled the previous year, with a bottom hole temperature above 500°F. at 7705 ft. In September, Republic and MAPCO Geothermal jointly submitted an application for a \$21 million dollar Federal Geothermal Loan Guaranty to further the drilling and development at Westmorland.

Additional activities in the Valley were the McCulloch announcement of locations for a geothermal production and injection well pair at a new (undrilled) area south of Brawley, and the stated intent that both San Diego Gas and Electric and Southern California Edison are progressing toward each having a 50 Mw (nominal) geothermal power plant at Heber.

TEMPERATURE GRADIENT MAP
OF THE
IMPERIAL VALLEY
CALIFORNIA

SCALE IN MILES

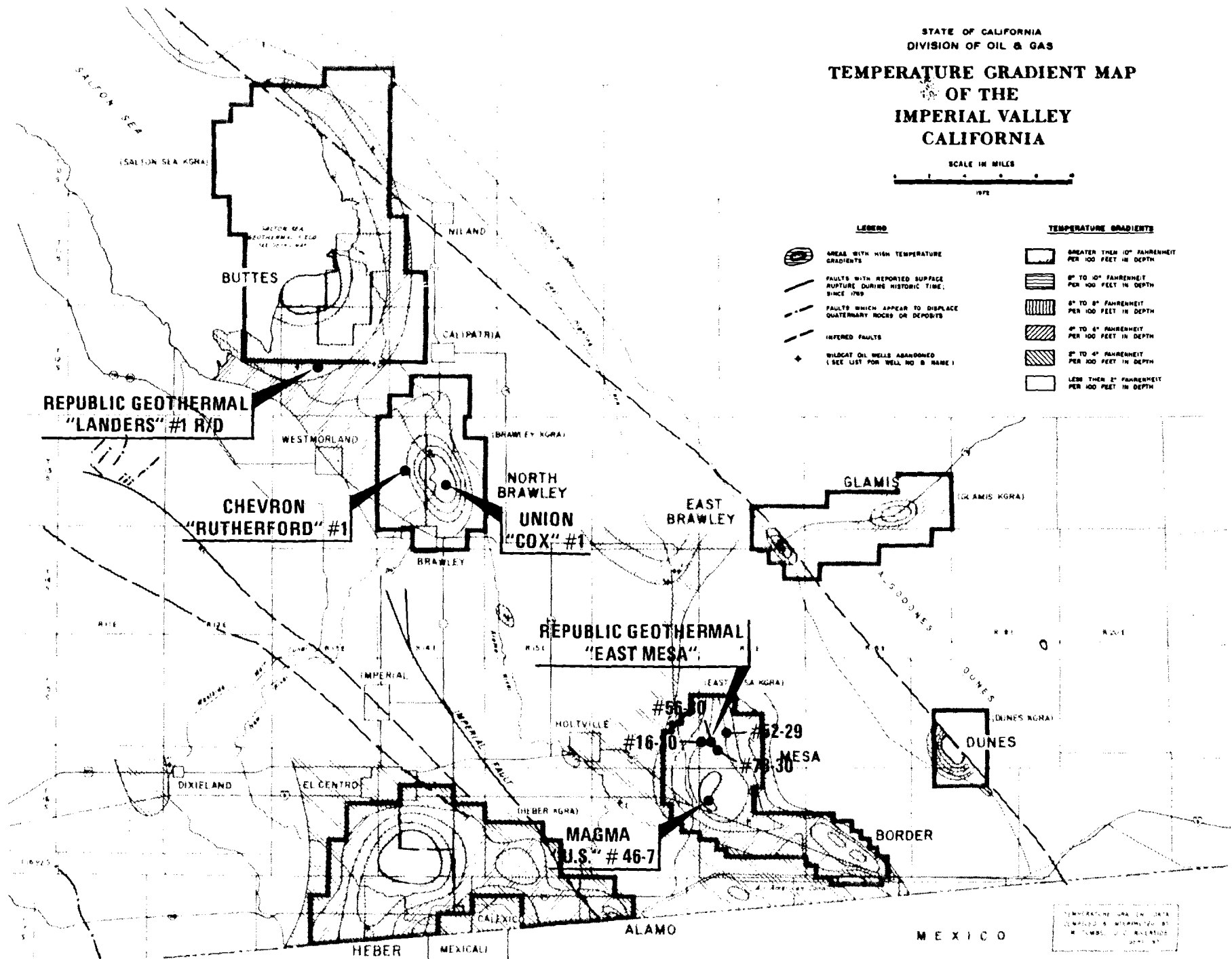


LEGEND

- AREAS WITH HIGH TEMPERATURE GRADIENTS
- FAULTS WITH REPORTED SURFACE RUPTURE DURING HISTORIC TIME, SINCE 1789
- FAULTS WHICH APPEAR TO DISPLACE QUATERNARY ROCKS OR DEPOSITS
- INFERRED FAULTS
- WILDCAT OIL WELLS ABANDONED (SEE LIST FOR WELL NO. & NAME)

TEMPERATURE GRADIENTS

- GREATER THAN 10° FAHRENHEIT PER 100 FEET IN DEPTH
- 8° TO 10° FAHRENHEIT PER 100 FEET IN DEPTH
- 6° TO 8° FAHRENHEIT PER 100 FEET IN DEPTH
- 4° TO 6° FAHRENHEIT PER 100 FEET IN DEPTH
- 2° TO 4° FAHRENHEIT PER 100 FEET IN DEPTH
- LESS THAN 2° FAHRENHEIT PER 100 FEET IN DEPTH



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Figure 1, 1977 Geothermal Wells, Imperial Valley, California

The Geysers

Thirty-two wells were drilled during 1977 in The Geysers region of Northern California, an increase of 5 over last year. The total footage drilled increased by 9% to 260,495 feet. Two extensions of production were made to the east and south. The overall success ratio was 59% (19 of 32), with 16 (76%) of the 21 intended new development wells being reported as commercial.

Union Oil Co. drilled 15 wells, all but one intended as development wells in The Geysers field (Figure 2). The "Sulphur Bank" #24 (7977 ft.) and both the "Ottoboni State 4596" #23 (9005 ft.) and #24 (6006 ft.) are successful make-up wells for the early units. The 110 Mw Unit-12 power plant is now scheduled for completion in 1979, and 5 new potential producers drilled for its use were the "LF State 4597" #25 (7400 ft.), #26 (7770 ft.), #27 (7640 ft.), the "DX State 4596" #25 (7509 ft.), and the "Cobb Mt. Hunting Club" #2 (9520 ft.). The "DX State 4596" #32, similarly intended, was abandoned after being first drilled to 10,111 ft., and then redrilled to 9113 ft. The "LFH State 4597" #2 (9264 ft.) and #3 (9067 ft.), located a mile northeast of Unit-12, were both suspended. The Union "GDC" #5, (8667 ft.) and the #6 (4777 ft.) were both successfully drilled and completed for Unit-14, another 110 Mw plant that is now also under construction. And in the southeastern corner of The Geysers field the Union "D & V" #1 was completed to only 5113 feet, with production reported to be excellent. Over 7 miles north of known production, Union drilled "Jorgensen" #1 as an exploratory well to 10,560 ft. near Thurston Lake (Figure 3). The well is suspended, after giving indications that a 400-500°F hot water resource of less than commercial deliverability was found.

Aminoil was the leader in attempting to extend the known limits of production of The Geysers field during 1977. Of the 8 wells drilled by Aminoil, 2 are new development wells, one is a development well redrill and 5 are significant step-outs from known productions (Figure 2). On the eastern edge of the field the "PDC" #1 was drilled to 7704 ft. as a successful stepout well located about a mile east of production. Aminoil was then unsuccessful when twice attempting to get commercial production an additional mile east. the "B-R" Unit #1 was drilled to 10,005 ft., twice redrilled, and then suspended, followed later in the year by the "Smith & Breazeale" #1 that was also suspended, after having established a new depth record of 11,141 ft. for wells drilled in The Geysers.

On the northwest side of The Geysers, the Aminoil "Squaw Creek" #1 was drilled a mile NNE of Aidlin #1, which was a successful stepout well drilled in 1976. The "Squaw Creek" #1 (redrill) was plugged and abandoned at 9075 ft., thereby providing some apparent definition to the field limits in that direction. The rig was then moved to drill "Aidlin" #2 at a location 2/3 of a mile northwest of "Aidline" #1, but it was suspended at 10,550 feet after having found only subcommercial amounts of steam. The 2 new development wells that Aminoil successfully drilled for Unit-13, a 135 Mw plant to be completed also in 1979, are the "MLM" #2 (7508 ft.) and the "Dillingham-Vought" #2 (4564 ft.). The nearby "McKinley" #5 was deepened from 8195 ft. to 8903 ft.

Meanwhile Shell was drilling 5 new wells and an attempted recompletion on their Federal land near the present southeastern edge of The Geysers. First, the "U.S. Geothermal" #24-2 (8030 ft.) was drilled as a successful infill development well located between production areas, followed immediately by the #24A-2 that was completed at 9082 ft. Then the #76-3 (A-1), Shell's first well drilled in 1975 to 8409 ft., was re-entered and redrilled from 2268 ft. to 8975 ft. and abandoned. The Shell #43-3 (F-8) was drilled next as a westerly stepout, reportedly resulting in an excellent producing well completed to only 5469 ft. Toward the end of the year Shell attempted to offset #11A-1 to the south, but the #38-1 was drilled and abandoned at 6967 ft., followed by the #38A-1 that was also abandoned after being initially drilled to 7333 ft. and then redrilled from 963 ft. to 9222 ft.

To the north, McCulloch completed the "Francisco" #2-5 (8910 ft.) as a confirmation well to last year's #1-5 discovery well, and they signed an agreement for the Department of Water Resources to build a 55 Mw plant nearby. McCulloch is presently attempting to extend their production about 1 mile further to the northeast with the "Newfield" #1-33. The well is now suspended at 4113 ft. waiting on drilling rig repairs.

Republic Geothermal drilled the "Bouscal" #1 at Howard Hot Springs (Figure 3), located about 5-1/2 miles east-northeast of established production. The well is presently being evaluated after drilling was suspended at 7376 feet. Bottom hole temperatures are within the 400-500°F range.

Coso

Coso Hot Springs is the third geothermal area in California drilled in 1977 (Figure 4). In the fall CER Corp., operating for the Navy, drilled the

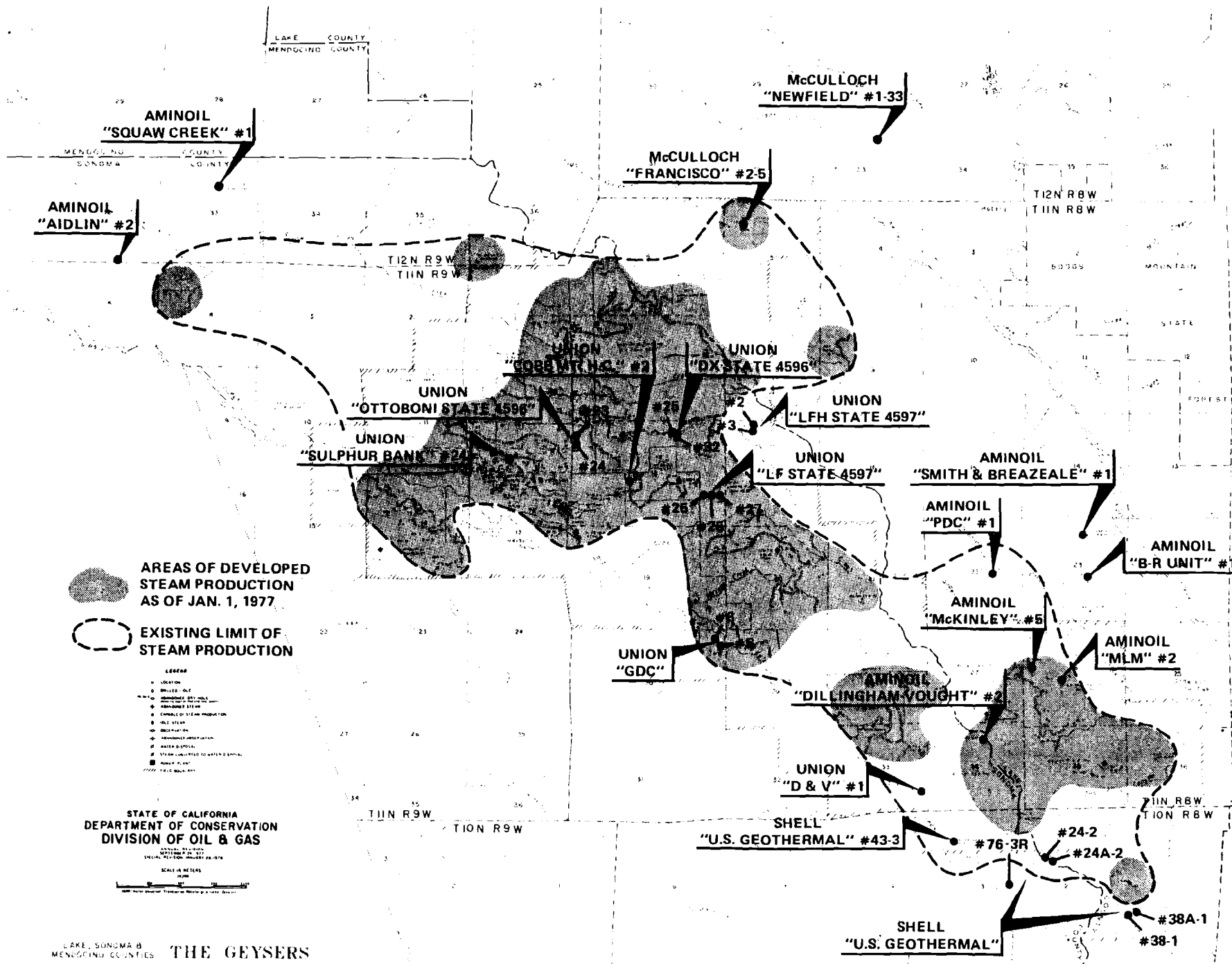


Figure 2, 1977 Geothermal Wells, The Geysers Field, California

"CGEH" #1 to 4845 ft. in granitic rock at a location near the center of a 15 sq. mile area of significant surface heat flow. Fractures located in the bottom 15 ft. of the well contain water of at least 362°F, and a wellhead temperature of 213°F was observed during a flow rate of 4500 B/D. The government has estimated the resource to be "of considerable magnitude, possibly 4,000 Mw".

NEVADA

During 1977, the Carson Sink region near Fallon continued to be explored with slim hole drilling. Occidental Geothermal drilled the "Federal" #72-33 as a 3000 ft. observation well at Lee Hot Springs, where waters of 172°F flow from an area surrounded by sinter deposits. Meanwhile, 8 miles west of Fallon, where Chevron had previously drilled a 4306 ft. test well in 1974, they returned in 1977 to drill "Soda Lake" #44-5 to 4975 ft. as a relatively nearby second observation well.

Phillips drilled "Campbell-E" #1 as the first well in the Rye Patch KGRA area, located 70 miles to the northeast of Fallon. The well found temperatures exceeding 325°F at 1853 feet, and drilling was suspended. Six locations for additional wells are now being permitted, with a deeper drilling assessment of the indicated resource scheduled for this year.

IDAHO

Phillips also drilled two geothermal wells in Idaho. The "Christenson A" #1 was drilled to 8001 feet at a location 2 miles south of Crane Creek KGRA. About 90 miles further south, the "Lawrence D" #1 (9340 ft.) is located within the Castle Creek KGRA area on private lands adjacent to a federal lease they successfully bid on in November, 1975. Neither well has been reported to be a commercial discovery, and both are now suspended.

In southeastern Idaho, at the Raft River Project area, the Idaho National Engineering Lab drilled the "RRGI" #4 to 2840 ft. with the original intent of using it as an interior injection-pressure maintenance well. After having flow tested the well and further assessed the reservoir, it now appears that it may be deepened to become a fourth producer, with the programmed injecting wells relocated peripherally. A 5 Mw demonstration power plant is now under construction.

UTAH

At the Roosevelt KGRA, Thermal drilled "Utah State" #24-36 (6107 ft.) as a stepout well located 1.5 miles northeast of proven production. The well did not encounter sufficient fractures or heat, and it was converted to an observation well. Nearby, Phillips has been conducting long-term production testing of #54-3, and a 1 Mw Sprinkle wellhead power plant is now being installed beside the well to run the injection pumps. Preliminary agreements were signed in December by Phillips, Utah Power and Light, and Rogers International for a 50 Mw power plant scheduled for operation in mid-1982. Independently, Thermal et al. and VTN Corp. are also working toward their having a 55 Mw plant in the Roosevelt area by 1982, having reportedly demonstrated a capacity of 12-14 Mw for a single well, #72-16.

In 1976 Union had to abort at 1151 ft. the drilling of their first well in the Cove Fort area due to lost circulation and hydrogen sulfide problems. After acquiring Department of Energy financial support, Union moved a rig back into Cove Fort in late 1977 and spudded "Cove Fort-Sulfurdale" #42-7. Local conditions have again proved troublesome, but this time drilling was suspended at 7735 ft. Test equipment is just now being moved in, although temperatures are reported to be less than anticipated.

Republic Geothermal drilled the first deep exploratory well in the Thermo Hot Springs area, located 30 miles southwest of Roosevelt. The "Escalante" #57-29 was drilled to 7288 ft. on federal land leased in a 1976 KGRA sale. Initial evaluation of the well indicates the natural flow rates are low, that temperatures of 350-400°F are present and that the fluid has a low salinity. Additional flow testing is presently being conducted. About 20 miles further south of Thermo, McCulloch drilled and suspended the "Jones" #1-8 at 5857 feet.

NEW MEXICO

In April, Los Alamos Scientific Laboratory began re-drilling "GT-2", a geothermal well originally drilled in granitic basement to 9607 ft. as part of the Government Hot Dry Rock resource assessment of the Valles Caldera. After having successfully fractured EE-1, an offset well, the intent was to directionally re-drill "GT-2" to intersect the same fracture and effect better fluid communication between the wells. The first re-

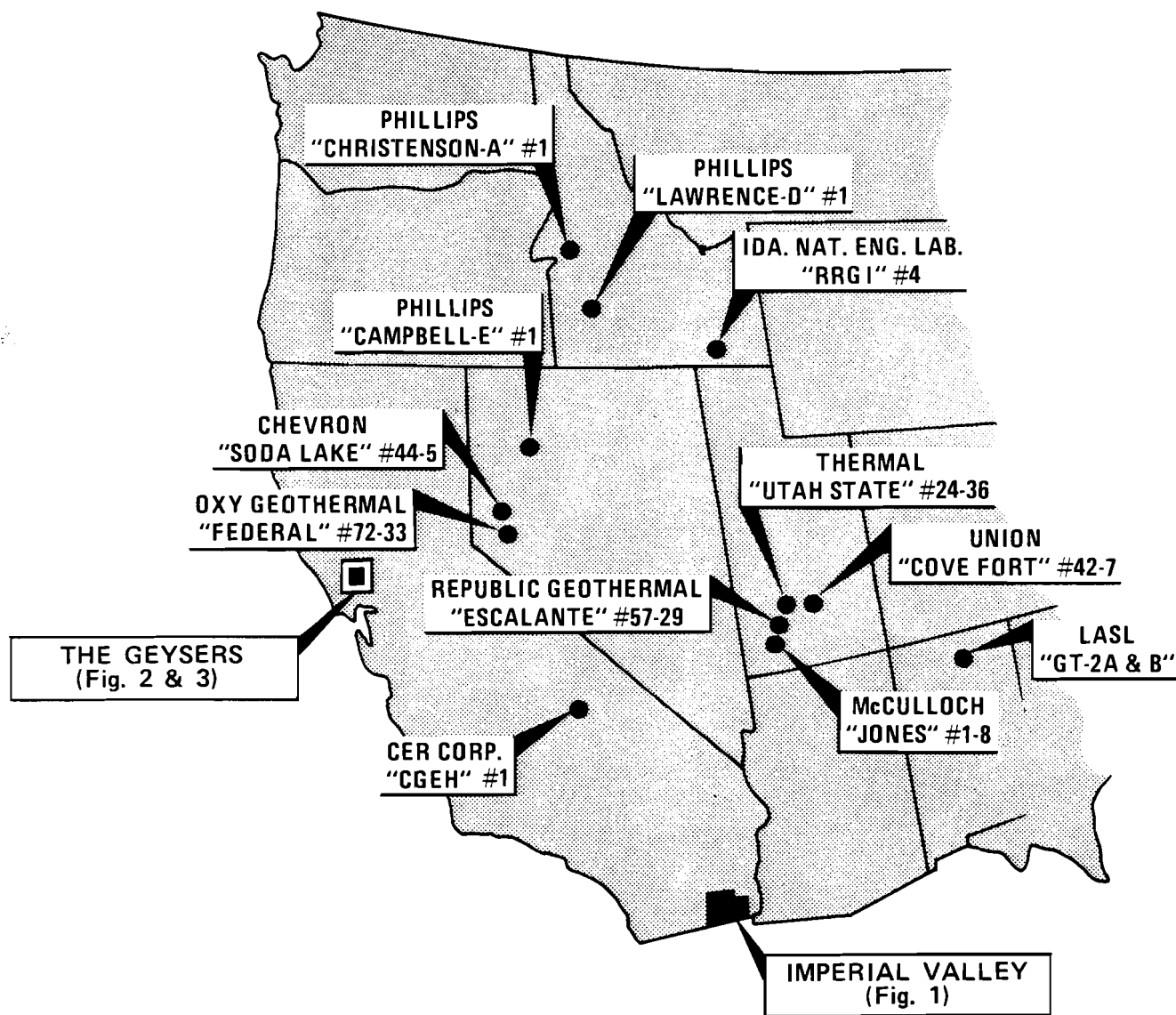


Figure 4, 1977 Geothermal Wells, Western United States

drill (GT-2A) to 9184 ft. was only partly successful, but the second redrill (GT-2B) to 8909 ft. is now sufficiently interconnected at a distance of 300 ft. from EE-1 so as to flow 6200 B/D. Bottom hole temperature is 345°F, and wellhead temperatures have been about 250°F. Two 10 Mw thermal heat exchangers are to be installed for testing.

In summary, the year 1977 was one of slightly reduced geothermal drilling activity as the operators concentrated primarily on development drilling for several new dry steam plants under construction at The Geysers, and elsewhere on the flow testing of new and existing production wells to determine the design characteristics of at least 9 hot water resource power plants, all intended to be built within the next 1 to 4 years.

TABLE #1 SUMMARY BY STATES, 1977 GEOTHERMAL DRILLING, WESTERN U.S.

| State, Region | Area | Operator | WELLS | | | | | FOOTAGE | |
|-----------------|-----------------------|---------------------|-------|-------|------|------|------|---------|---------|
| | | | PROD. | SUSP. | ABD. | INJ. | OBS. | (Feet) | |
| California | | | | | | | | | |
| Imperial Valley | East Mesa | Republic Geothermal | 4 | 3 | 0 | 0 | 1 | 0 | 27,486 |
| | | Magma | 1 | 0 | 0 | 0 | 1 | 0 | 3,095 |
| | Brawley | Union | 1 | 1 | 0 | 0 | 0 | 0 | 9,609 |
| | | Chevron | 1 | 0 | 1 | 0 | 0 | 0 | 7,930 |
| | Westmorland | Republic Geothermal | 1 | 1 | 0 | 0 | 0 | 0 | 1,938 |
| The Geysers | Main Geysers | Union | 13 | 10 | 2 | 1 | 0 | 0 | 107,731 |
| | | McCulloch | 1 | 1 | 0 | 0 | 0 | 0 | 8,910 |
| | Southeast Geysers | Shell | 6 | 3 | 0 | 3 | 0 | 0 | 50,849 |
| | | Aminoil | 6 | 4 | 2 | 0 | 0 | 0 | 45,878 |
| | | Union | 1 | 1 | 0 | 0 | 0 | 0 | 5,113 |
| | Northwest Geysers | Aminoil | 2 | 0 | 1 | 1 | 0 | 0 | 19,965 |
| | North Geysers | McCulloch | 1 | 0 | 1 | 0 | 0 | 0 | 4,113 |
| | Howard Hot Springs | Republic Geothermal | 1 | 0 | 1 | 0 | 0 | 0 | 7,376 |
| | Thurston Lake | Union | 1 | 0 | 1 | 0 | 0 | 0 | 10,560 |
| Inyo Co. | Coso Hot Springs | CER Corp. | 1 | 0 | 1 | 0 | 0 | 0 | 4,845 |
| NEVADA | | | | | | | | | |
| Carson Sink | Soda Lake | Chevron | 1 | 0 | 0 | 0 | 0 | 1 | 4,975 |
| | Allen Springs | Oxy Geothermal | 1 | 0 | 0 | 0 | 0 | 1 | 3,000 |
| Pershing Co. | Rye Patch | Phillips | 1 | 0 | 1 | 0 | 0 | 0 | 1,853 |
| Idaho | | | | | | | | | |
| Washington Co. | Crane Creek | Phillips | 1 | 0 | 1 | 0 | 0 | 0 | 8,001 |
| Owyhee Co. | Castle Creek | Phillips | 1 | 0 | 1 | 0 | 0 | 0 | 9,340 |
| Cassia Co. | Raft River | INEL | 1 | 0 | 0 | 0 | 1 | 0 | 2,840 |
| Utah | | | | | | | | | |
| Beaver Co. | Cove Fort | Union | 1 | 0 | 1 | 0 | 0 | 0 | 7,735 |
| | Roosevelt Hot Springs | Thermal | 1 | 0 | 1 | 0 | 0 | 0 | 6,107 |
| | Thermo Hot Springs | Republic Geothermal | 1 | 0 | 1 | 0 | 0 | 0 | 7,288 |
| Iron Co. | Lund | McCulloch | 1 | 0 | 1 | 0 | 0 | 0 | 5,857 |
| New Mexico | | | | | | | | | |
| Sandoval Co. | Los Alamos | LASL | 1 | 1 | 0 | 0 | 0 | 0 | 1,735 |
| TOTALS: | | | 52 | 25 | 17 | 5 | 3 | 2 | 374,129 |

BIOGRAPHIES:

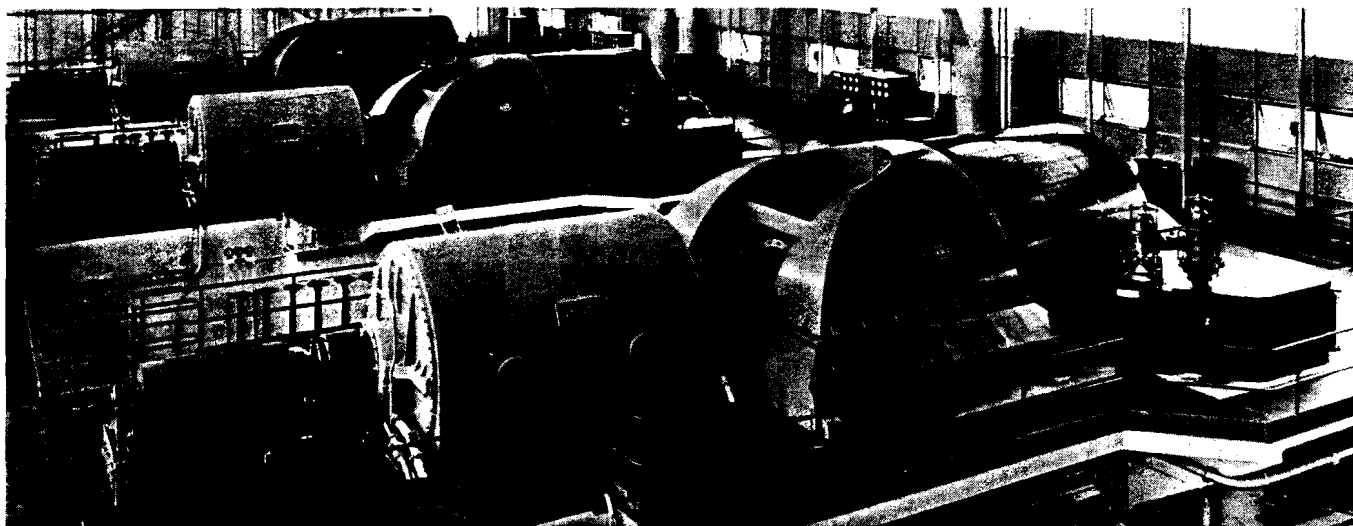
Dr. Smith, Vice President-Exploration, received his education as a geologist at Middlebury College and Indiana University. After spending a decade as an explorationist with Standard Oil Company of California, he has been with Republic

Geothermal for the past three years. Mr. Isselhardt received a M.A. (geology) at U.C. Berkeley and was active with Union Oil geothermal operations for five years before coming to Republic in 1976. Mr. Matlick, an exploration geologist-geochemist, joined Republic in 1975 after completing his M.S. in geology at Arizona State University.

TABLE #2 SUMMARY BY OPERATOR, 1977 GEOTHERMAL DRILLING, WESTERN U.S.

| Operator | Wells Drilled | Producibile | Suspended | Abandoned | Injection | Observation | Total Footage Drilled |
|---------------------|---------------|-------------|-----------|-----------|-----------|-------------|-----------------------|
| Union | 17 | 12 | 4 | 1 | 0 | 0 | 140,748 |
| Aminoil | 8 | 4 | 3 | 1 | 0 | 0 | 65,843 |
| Shell | 6 | 3 | 0 | 3 | 0 | 0 | 50,849 |
| Republic Geothermal | 7 | 4 | 2 | 0 | 1 | 0 | 44,088 |
| Phillips | 3 | 0 | 3 | 0 | 0 | 0 | 19,194 |
| McCulloch | 3 | 1 | 2 | 0 | 0 | 0 | 18,880 |
| Chevron | 2 | 0 | 1 | 0 | 0 | 1 | 12,905 |
| Thermal | 1 | 0 | 1 | 0 | 0 | 0 | 6,107 |
| CER Corp. | 1 | 0 | 1 | 0 | 0 | 0 | 4,845 |
| Magma | 1 | 0 | 0 | 0 | 1 | 0 | 3,095 |
| Oxy Geothermal | 1 | 0 | 0 | 0 | 0 | 1 | 3,000 |
| INEL | 1 | 0 | 0 | 0 | 1 | 0 | 2,840 |
| LASL | 1 | 1 | 0 | 0 | 0 | 0 | 1,735 |
| TOTALS: | 52 | 25 | 17 | 5 | 3 | 2 | 374,129 |

Geothermal power generation



The three 30 MW mixed pressure sets in Station 'B' Wairakei Power Station, New Zealand.

SETS AVAILABLE UP TO 55 MW

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