

20th ANNIVERSARY OF GEO-HEAT CENTER

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Geo-Heat Center

INTRODUCTION

The beginning of the Geo-Heat Center (GHC) can be traced to an international conference held on geothermal energy at the Oregon Institute of Technology (OIT) campus during October of 1974. The meeting was organized to review nonelectric, multipurpose uses of geothermal energy in Hungary, Iceland, New Zealand, the United States and Russia (U.S.S.R). As a result of the conference and interest in the need to exchange and disseminate information on low-to moderate-temperature resources and their utilization, the Geo-Heat Center (first known as the Geo-Heat Utilization Center) was established in 1975. Initial funding was provided by the Pacific Northwest Regional Commission (PNRC), a branch of the Executive Department of the Governors of the states of Oregon, Washington and Idaho. A sum of \$3,000 was granted to distribute information to participants of the October 1974 international conference. The proceedings

were published in a volume titled "Multipurpose Use of Geothermal Energy-Proceedings of the International Conference on Geothermal Energy for Industrial, Agricultural, and Commercial/Residential Uses." The primary functions of the Center were to disseminate information to potential users of geothermal resources, perform applied research on the utilization of low-temperature resources, and to publish a quarterly newsletter on the progress and development of direct-use geothermal energy in the United States and other countries.

Over the years a number of people were employed by the Center on a full time basis or for special projects. Many of these individuals started their careers in geothermal with the Center and are still involved with geothermal energy today. We recognize and thank the following persons, who have been associated with the GHC, for their contributions:



Figure 1. Speakers at the 1974 International Conference on Geothermal Energy for Industrial, Agricultural and Commercial-Residential Uses include from front left: B. Ogle, Alaska; E. Storey, Klamath Falls; J. Barnea, New York; R. Bowen, Portland; T. Boldizsar, Hungary; C. Lieb, Klamath Falls; M. Linton, New Zealand; W. Brewer, Washington; K. Hall, Washington DC; R.D. Wilson, New Zealand; J. Howard, Lawrence Livermore Labs.; D. Storey, Klamath Falls; E. Wehlage, California; P. Lienau, GHC; J. Zoega, Iceland; and J. Lund, GHC. Not in the picture were: B. Lindal, Iceland; W. Burrows, New Zealand; G. Culver, GHC; L. Svanevik, GHC; T. McCall, Governor of Oregon; W.D. Purvine, OIT; S. Eisenstat, Washington, DC.; D. Pitts, Washington DC; J. Schatz, Salem; and A. Ullman, U.S. House of Representatives.

GEO-HEAT CENTER EMPLOYEES FROM 1975 to 1995

	<u>GHC Position</u>	<u>Current Position</u>
Paul J. Lienau	Director 1975-present	Director
Gene Culver	Assoc. Dir. 1975-1994	Retired
John Lund	Research Assoc. 1975-present	Research Assoc.
Kevin Rafferty	Research Assoc. 1980-1994	Assoc. Dir.
Tonya Boyd	Research Assist. 1994-present	Research Assist.
Lars Svanevik	Research Assoc. 1974-1995	Research Assoc.
Charles Higbee	Research Assoc. 1977-1988	Retired
Gene Ryan	Research Assoc. 1979-1983	Retired
Don Karr	Research Assoc. 1976-1982	Retired
Bill Johnson	Research Assoc. 1976-1983	Retired
Kenan Smith	Research Assist. 1980-1981	?
Jay Silva	Research Assoc. 1980-1987	Retired
Saul Laskin	Research Assoc. 1976-19	Prof. in South Carolina
Wayne Phillips	Research Assoc. 1980	Retired
Robert Koeppen	Research Assoc. 1977-1979	USGS
Debra Justus	Research Assist. 1978-1982	International Energy Agency
R. Gordon Bloomquist	Research Assoc. 1978-1980	Washington State Energy Office
Neil Bascescu	Research Assist. 1978-1980	?
Stuart Simpson	Research Assist. 1979-1980	Washington State Energy Office
Keith Brown	Research Assist. 1978-1980	?
Richard James	Research Assist. 1978-1980	?
David McClain	Research Assist. 1978-1979	California Energy Company
Donald Markle	Research Assist. 1978-1980	North Carolina Energy Off
Leah Street	Research Assist. 1979-1980	DOE Idaho
Ann Fornes	Research Assist. 1979-1985	?
Roger Riveness	Research Assist. 1980-1982	K. Falls S. Sub. Sanitary Dist.
Mark Dellinger	Research Assist. 1980-1982	Lake Co. Sanitary Dist.
Ardelle Godfrey	Secretary 1975-1976	Nurse at MWMC
Colleen Fry	Secretary 1977-1981	Secretary - Salem, OR
Sandy Buckner	Secretary 1979-1981	?
Cindy Nellipowitz	Secretary 1981-1988	Legal Secretary
Joyce Pryor	Secretary 1981-1989	Retired
Penney Lewis	Secretary 1985-1989	Secretary-Unemployment Office
Kathleen Moore	Secretary 1988-1989	?
Donna Gibson	Secretary 1988-present	GHC Secretary
 <u>International Affiliates</u>		
Derek Freeston	1981	New Zealand
Thorbjorn Karlsson	1984-1985	Iceland
Wanda Wang	1984-1985	China
Weimen Li	1984-1985	China
Mingze Shi	1984-1985	China
Herman Guillen	1987	Philippines
Mike Dunstall	1989-1990	New Zealand



Figure 2. Staff members of Direct Applications Operations Research Planning include: G. Bloomquist, Washington; D. Justus, Oregon; N. Bascescu, Washington; S. Simpson, Washington; K. Brown, Montana; D. Markle, Alaska; D. McClain, Idaho; L. Street, Idaho; R. James, Wyoming; R. Koeppen, GHC; and D. Karr, GHC.

Since 1975, the GHC has been involved in a number of studies and projects, funded by a variety of sources but primarily from the Department of Energy, to meet its goals. A summary of these projects and activities are recounted below:

SUMMARY OF GHC PROJECTS

The following table is a listing of the geothermal projects completed from 1974 to 1995.

	<u>Date Completed</u>	<u>Funding Source</u>
1. Klamath Falls Hot Water Well Study	1974	US AEC
2. Corrosion of Downhole Heat Exchangers	1975	US DOE
3. Geo-Heat Quarterly Bulletin	1976	PNRC
4. Use of Geothermal Energy for Aquaculture	1976	Sea Grant
5. Feasibility and Design of a Geothermal Heating District in Klamath Falls	1976	Klamath Co.
6. Study of the Use of Geothermal Waters for Greenhouse Heating	1977	State of OR
7. Geo-Heat Quarterly Bulletin	1977	PNRC
8. Investigation of the Geology and Hydrology of the Klamath Falls KGRA	1977	USGS
9. Study of the Use of Geothermal Energy for Agribusiness Purposes in the Klamath and Snake River Basins	1977	US DOE
10. Downhole Heat Exchanger Performance	1978	US DOE
11. Geo-Heat Quarterly Bulletin	1978	PNRC/ODOE

12. Direct Applications Operations Research Planning (site data base)	1978	US DOE
13. Use of Geothermal Energy for Aquaculture (Phase I)	1977	PNRC
14. Use of Geothermal Energy for Aquaculture (Phase II)	1978	PNRC
15. Geothermal Heating Systems for Greenhouses	1980	PNRC
16. TA for Commercial Utilization of Geothermal Energy (Phase I)	1979	US DOE
17. Direct Utilization of Geothermal Energy: Development of 4 Educational Reports	1980	US DOE
18. Direct Use Geothermal Potential Within the BPA Marketing Area	1980	BPA
19. Use of Geothermal Energy for Aquaculture (Phase III)	1980	PNRC
20. Technical Assistance (Phase II) and Quarterly Bulletin	1980	US DOE
21. Technical Assistance (Phase III)	1980	US DOE
22. Market Development and Regional Coordination of Geothermal Energy for Region X	1980	US DOE
23. Technical Assistant (Phase IV)	1982	US DOE
24. Lakeview, OR, Electrical Generation Project WOOD Review (Jack Wood)	1982	
25. Technology Transfer and Information Dissemination for Regions IX & X	1983	US DOE
26. California Technical Assistance	1983	CEC
27. Oregon TA for Local Governments	1983	ODOE
28. Ashland, Oregon's Geothermal Resource Plan Document	1983	BPA
29. Compendium of Wellhead Generators	1983	EPRI

30.	Klamath Falls Aquifer Test	1984	US DOE
31.	Binary Power Plant Research	1986	ODOE
32.	Technology Transfer	1984	US DOE
33.	Biomass Conversion for Washington Dept. of Corrections Facilities	1984	WSEO
34.	Lake Elsinore, California District Heating Project	1984	City of L.E.
35.	Paso Robles, California District Heating Project	1984	City of P.R.
36.	Geothermal Technology Transfer	1985	US DOE
37.	Technical Assistance for California (Subcontract to BGI)	1985	CEC
38.	Information Dissemination & Technology Transfer	1986	US DOE
39.	City of Klamath Falls	1986	City of K.F.
40.	Technical Assistance for California (Subcontract to Envirosphere)	1987	CEC
41.	Information Dissemination & Technology Transfer	1987	US DOE
42.	Specialized Training for Philippines	1987	UN
43.	TA for California (Sub to Envirosphere)	1988	CEC
44.	TA for California	1989	CEC
45.	TA for California	1990	CEC
46.	Geothermal R & D Assistance	1990	US DOE
47.	TA for California	1991	CEC
48.	Geothermal Direct-Heat Utilization Assistance	1991	US DOE
49.	Geothermal Direct-Heat Utilization Assistance	1992	US DOE
50.	TA for California	1992	CEC
51.	Low-Temp Assessment	1993	EG&G
52.	Geothermal Direct-Heat Utilization Assistance	1993	US DOE
53.	TA for California	1993	CEC
54.	Low-Temp Assessment	1994	EG&G
55.	Geothermal Direct-Heat Utilization Assistance	1994	US DOE

Information on some of the major projects are briefly summarized below.

1974 Klamath Falls Hot Water Well Study. During the summer of 1974, a study was made of approximately 75 geothermal wells in Klamath Falls. Data on temperature, well depth, downhole heat exchanger use, heating system characteristics, water chemistry and corrosion problems were gathered. In addition, an economic study and analysis was made on the capital and operation cost of owning a geothermal well and associated heating systems. These costs were then compared with alternate energy forms. Detailed maps were prepared for the area showing contour of well depth and temperature. This was the first comprehensive study and documentation of geothermal direct use in Klamath Falls. The work was funded by Lawrence Livermore Laboratory. A report was presented at the 2nd UN Geothermal Symposium in San Francisco in 1975.

1975-1995 Geo-Heat Center Quarterly Bulletin. The Geo-Heat Center Bulletin has been the main and continuous source of information on direct use projects both domestic and internationally that have been disseminated by the Center. Starting with a modest blue print on yellow paper, 6-page, Vol. 1, No. 1 in May of 1975, it has grown into a colorful professional publication of 20 to 40 pages. This is the 59th issue of the Quarterly Bulletin. A total of 294 articles have been published, including ones from 22 foreign countries.

1976-1980 Use of Geothermal Energy for Aquaculture. During 1975, an aquaculture project raising large freshwater Malaysian prawns (*Macro brachium rosenbergii*) in geothermal effluent from the campus geothermal heating system was initiated. The project started with ten (4 x 4 ft) indoor tanks raising 1,000 post-larval prawns. During the summer of 1976 outdoor ponds were constructed to demonstrate commercial feasibility by evaluating the best methodology for intensive aquaculture through PNRC funding. The ponds were stocked with 48,000 post-larval stage prawns. These were successfully raised, showing substantial growth rates and low mortality rates. Other aquaculture experimentation included raising 20,000 fingerling trout with growth rates of more than three times that experienced in the hatchery. A final aspect of the project in 1980, involved raising tropical fish which showed high survival rates and exceedingly fast growth rates. Funding for the project ended in September, 1981.

1977-1980 Geothermal Heating Systems for Greenhouses. Construction of 30 x 60 ft greenhouse was initiated on the OIT campus during September of 1977. The facility was designed as a demonstration project of cascading geothermal applications using the effluent from the OIT campus geothermal heating system as its heat source. Efficiency and cost analysis studies were performed by students and faculty at OIT. Experimental use of the greenhouse was also shared by Oregon State University's (OSU) agricultural experimental station. Alternate heating systems using various flows and temperatures were investigated. The final design included use of unit heaters and finned tube radiators installed around the perimeter of the structure. Following completion of the study, responsibility for maintenance was transferred to the OIT physical plant to raise flowers and decorative plants for campus beautification. The structure was torn down in 1982 due to the construction of Purvine Hall at the site.

1977-1978 Study of the Use of Geothermal Energy for Agribusiness Purposes in the Klamath and Snake River Basins. Resource assessment and methods of geothermal energy direct utilization for existing and prospective food processing plants were determine. Ore-Ida Foods, Inc. and Amalgamated Sugar Company in the Snake River Basin were evaluated. In the Klamath Basin, Western Polymer Corp. (potato starch extraction) and three prospective industries--vegetable dehydration, alfalfa drying, and greenhouses were analyzed for utilization of geothermal fluids. Existing geologic knowledge was integrated to indicate locations, depth, quality and estimated productivity of the geothermal reservoirs. Energy-economic needs along with cost and energy saving associated with field development, delivery systems, in-plant applications, and fluid disposal were calculated for interested industrial representatives.

1977-1978 Study to Develop More Efficient Downhole Heat Exchangers. A contract was awarded to the GHC and Oregon State University Mechanical Engineering Dept. by ERDA to

provide an experimental and analytical research program to evaluate and improve the design of DHE's for direct applications of geothermal energy. During the study progress was achieved in (1) characterizing flows in wells with perforated casings and DHE's installed, (2) determination of energy extraction rates for short multi-tube DHE's in wells, (3) improve and substantiate models of heat transfer within the well including the mixing of aquifer and well waters, (4) development of new flow measuring techniques, and (5) economic analysis comparisons of DHE's and surface heat exchanger systems.

1977-1980 Direct Applications Operations Research Planning. The Geo-Heat Center, in cooperation with state energy offices, developed status reports for geothermal development in the states of Alaska, Idaho, Montana, Oregon, Washington and Wyoming. State-by-state institutional analyses are included that address major obstacles to geothermal development. The collective goal of these studies was to summarize, on a site specific basis, the various factors affecting development. Information includes: resource data, site geologic descriptions, reservoir characteristics, environmental characteristics, leasing and development status, institutional factors, population and market potential that could be used by geothermal developers as an aid to planning and commercialization.

1979-1995 Technical Assistance for Commercial Utilization of Geothermal Energy (Phase I). In August, 1978, a grant was awarded to the GHC by the Division of Geothermal Energy of the USDOE to provide technical assistance for development and commercial utilization of geothermal energy for space/process heating, aquaculture, and agriculture. The assistance applied to the states of Alaska, Washington, Oregon, California, Hawaii, Arizona, and Nevada. The program provided on-site investigations, limited resource evaluation studies, help in matching resources with applications, preliminary cost and economic analysis, information on institutional factors, help in materials and component selection, conceptual geothermal system designs, and consultation with engineers or designers involved in final design. Until 1983, up to 100 hours could be applied to projects, resulting in about 75 completed feasibility studies. Renewed USDOE grants continue to provide these services, limited to 8 hours per project, to potential users.

1980 Direct Utilization of Geothermal Energy: Development of 4 Educational Reports. During February of 1979, a three-day workshop was held at Diamond Lake Lodge, just North of Klamath Falls. The purpose of the workshop was to develop four educational reports on the "Direct Utilization of Geothermal Energy." These included a technical version ("A Technical Handbook") of 250 pages published by the Geothermal Resources Council as Special Report No. 7., a non-technical version ("A Laymans' Guide") of 97 pages published by GRC as Special Report No. 8, a series of articles for newspaper release, and a pricing parameter report. Each

Working group had from five to eight people participating in outlining and writing the initial draft at Diamond Lake. The workshop was funded by a DOE grant and administered jointly by the Geo-Heat Center and the Geothermal Resources Council.

1983-1995 California Technical Assistance. The California Energy Commission provides annual funding to private and public entities for geothermal energy projects. Practically all aspects of geothermal planning; technology research, development and demonstration; resource development; technology commercialization; and impact mitigation are eligible for funding. All projects must have a hardware component (e.g., well drilling; resource assessments; small-scale electricity production; direct-use systems; or testing or demonstration of innovative geothermal assessment techniques, components or systems). The GHC, through, a subcontract provides Technical Assistance to help resolve technical problems relating to a planned or ongoing project. For Fiscal Year 1995-96, \$5.7 million is available for project funding. To receive an application packet, call (916) 654-5129 or write California Energy Commission, Geothermal Program, 1516 9th Street MS-43, Sacramento, CA 95814-5512.

1983-1984 Klamath Falls Aquifer Test. This research evaluated the geothermal potential of the shallow hot water aquifer at Klamath Falls. Funded by a grant from the USDOE, the work included tracer studies by Stanford University, a pumping and injection test by Lawrence Berkeley Laboratories, temperature studies and collection of aquifer discharge and use data by the GHC, and sampling for chemical analysis by USGS. This effort, believed to be the most extensive testing of a direct-use aquifer, provided scientific data to be used to evaluate alternatives for district heating by the city of Klamath Falls and other users of the resource, to assess potential impacts of possible alternatives, and to aid in the evaluation of other fault-controlled geothermal systems.

1986 Binary Power Plant Performance. Three nominal 24-hour tests under summer, winter and spring weather conditions, were run on a 600 kW ORMAT geothermal binary power generation machine. The machine, located at Wabuska, Nevada, was supplied with approximately 830 gpm of geothermal fluid at 221°F and has two spray cooling ponds. During the tests, temperature, pressure and flows of supplied fluid, working fluid, cooling water and instantaneous electrical production were recorded at hourly intervals. Performance analysis was conducted on the system as a whole and on each subsystem (i.e., production well and pump, binary machine, and cooling ponds). This consisted of energy balance calculations and comparison of the results with predictions of a computer program. Further analysis of the system was performed to obtain Second Law efficiencies for each component using energy analysis. This work provided valuable information on both machine performance and instrumentation selection.

1988-1995 Injection Well Monitoring Program. The Geo-Heat Center designed and maintains a computerized well testing and long-term monitoring network of observation wells (5). The purpose is to monitor reservoir (water level and bottom hole temperature) and environmental effects due to injection of geothermal fluids by Oregon Institute of Technology and Merle West Medical Center wells.

1988-1989 A Materials and Equipment Review of Selected U.S. Geothermal District Heating Systems. Information was assembled by the GHC on the original design and subsequent performance of a selected group of geothermal district heating systems, which have logged at least three years of operation. Specific areas of investigation were equipment type and materials of construction for: production pumps, transmission piping, customer connect time, and disposal. The operational performance of the equipment in each of these areas was described and will serve as a reference to designers of new systems and operators of existing systems.

1989-1991 Geothermal Direct Use Engineering and Design Guidebook. The OIT GHC published the Guidebook for the technical community and users of low-to moderate-temperature geothermal resources. The Guidebook, 401 pages, represented two years of cooperative effort by the Geo-Heat Center, Idaho National Engineering Laboratory, University of Utah Research Institute, Battelle Pacific Northwest Laboratories, Radian Corporation and Washington State Energy Office. Its purpose is to provide engineers with comprehensive technical information for space heating and cooling of buildings, district heating, greenhouse heating, aquaculture and industrial processing using geothermal resources. It also covers geology, exploration, well drilling, reservoir engineering, materials selection, well pumps, piping, heat exchangers, space heating equipment, heat pumps, absorption refrigeration, engineering cost analysis, regulatory codes and environmental aspects. The Guidebook was updated and reprinted in 1991.

1992-1995 Low Temperature Assessment for 10 Western States. The purpose of the project was to bring the inventory of the nation's low-to moderate-temperature (20 to 150°C) geothermal resources up-to-date and to encourage development of the resources. A database of more than 9,000 thermal wells and springs has been compiled for ten western states, an increase of 80% compared to the previous assessments in the early 1980s. The databases developed by State Teams include location, descriptive data, physical parameters, water chemistry and references for sources of data. Computer generated maps are also available for each state. State Teams have identified more than 50 high priority areas for near-term comprehensive resource studies and development. Collocated resources (a city within 5 miles of a resource) were identified for 256 cities in nine western states and resource information was sent to Economic Development Centers in the counties.

CONCLUSIONS

The Geo-Heat Center continues to provide geothermal services to the public, consultants and potential users of resources. These services are in the form of Technical Assistance, R&D activities and dissemination of information through the publication of the Quarterly Bulletin, technical papers, reports and tours of geothermal facilities in the Klamath Basin. The Technical Assistance program provides information to about 360 requests per year. R&D projects to help solve problems and reduce the cost of building and operating direct-use systems, projects planned for FY-96 include: (1) economics of moderate density geothermal district heating systems, (2) geothermal district heating marketing strategy continuation and (3) strategies for geothermal greenhouses. A geothermal library of over 5,000 volumes is maintained and made available through the Geothermal Resources Council's online library system. A publications list of over 120 items can be obtained by writing the Center.