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GEOTHERMAL HEAT PUMPS

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KEY WORD

geothermal heat pumps, ground source, space heating, air conditioning, HVAC, energy efficiency, Strategic Environmental Research and Development Program (SERDP)

PROJECT BACKGROUND AND STATUS

Sandia National Laboratories (SNL) initiated a modest geothermal heat pump (GHP) program in FY 92, funded through a combination of the Department of Energy's (DOE) Geothermal Division (GD) and the Department of Defense's (DoD) Strategic Environmental Research and Development Program (SERDP) sources. The tasks prior to FY 94 focused mainly on drilling technology applied toward installation of vertical ground source heat exchangers and acquiring data at a few GHP installations. The arrival of the SERDP program and the Geothermal Heat Pump Consortium (GHPC) expanded the program emphasis to the three areas of drilling and completions, demonstration projects, and technology transfer.

The use of GHPs is rapidly growing because the electric utilities, the Environmental Protection Agency (EPA), DOE, DoD, and the grass-roots GHP industry are aware of GHPs' outstanding potential to reduce energy and emissions associated with space conditioning and water heating. Our challenge for the next few years is to provide technology transfer services and solid research and development for this emerging technology, with the goal of increasing annual GHP sales from 40,000 units today to 400,000 in the year 2000.

PROJECT OBJECTIVE

Geothermal Heat Pumps (GHPs) have gained international attention as a proven means of energy conservation and demand reduction. However, the high first cost of ground heat exchanges for residential and commercial heating and cooling applications is a major obstacle to market penetration of this technology. Our research program is aimed at reducing installation costs of the ground heat exchanger and, therefore, increase the marketability and effectiveness of the GHP technology.

A comprehensive measurement program for installed GHP systems (funded by SERDP) yielded several demonstration projects which have been monitored for a year or more.

Technical Objectives

- Define and implement a comprehensive R&D program in cooperation with the GHP industry to reduce the installed cost of drilled ground source heat exchangers by 25%.
- Prepare a set of case histories for GHP installations, including quantitative evaluation of system performance, cost, and design quality. Document four or more installations covering a wide range of weather and geological conditions.

Expected Outcomes

- Develop a vital industry-supported R&D program focused at reducing the initial cost of drilled ground heat exchangers. Key program elements include improved bit systems, incremental improvements in drilling equipment, and enhanced grouting/loop installation methods.
- Establish a clear set of performance measurements of installed hardware that will allow industry to more accurately set design specifications for existing technology, and to identify areas needing improvement.

APPROACH

The program consists of four basic elements:

1. Performance of existing GHP hardware will be monitored with automated data acquisition equipment and documented so that the energy savings expected from GHPs can be confirmed and areas for improvement identified.
2. Advanced concepts for constructing improved geothermal heat exchangers will be developed and their performance confirmed through analysis and testing using a simple test loop at SNL or test facilities at other organizations involved in GHP research. Suggestions for further research for drilling techniques and equipment will be made and implemented.
3. A vertical loop handbook and training manual will be written to enable water or oil/gas drillers to enter the GHP marketplace.
4. Finally, we will provide technical support for the DOE efforts to market and increase awareness of the GHP concept among A&E (architectural and engineering) firms, building owners, utilities, researchers, and government agencies.

All of the R&D work will be published in appropriate journals and/or presented at conferences and workshops.

RESEARCH RESULTS

- Sandia managed a major portion of the SERDP program to encourage geothermal heat pump use on military bases. As part of this project, more than 25 proposed or ongoing GHP projects at DoD facilities were identified and given technical or direct financial support. Major measurement programs to evaluate performance of GHP's were initiated at Ft. Polk, LA; Ft. Hood, TX; Patuxent River, MD; and Selfridge, MI. The data from these projects has proven invaluable for marketing GHP's and assessing the effectiveness of these systems. These results have been presented at several DoD and GHP conferences throughout the year. The SERDP activity has additionally provided technical consulting or direct grants to the following facilities: Dyess AFB, TX;; Ft. Irwin, CA; Camp Merrill, GA; Ft. Leavenworth, KS; Ft. Riley, KS; Naval Security Facility, VA; and Bolling AFB, VA.
- Sandia established a jointly funded project with the Electric Power Research Institute (EPRI), Atlantic Electric, and Stockton College, NJ, to acquire short-term and long-term performance data on the Stockton College GHP installation, where most of the campus was converted to GHPs. This project and the SERDP demonstrations are now yielding key engineering and cost data on the effectiveness of GHP systems.
- SNL installed and instrumented a GHP vertical test loop in Albuquerque. This facility identified a number of issues needing further research. In FY 95, an experimental 18 bore, 15 ton heat exchanger was installed at Sandia's Photovoltaic Systems Scientific Laboratory (PSSL), DOE's first GHP building. This loop field was jointly designed by South Dakota State University and Sandia Laboratories to evaluate the relative effectiveness of six different grouting methods. A long-term evaluation is planned to assess the stability and heat transfer of the grouts.
- A survey of vertical heat exchanger drilling techniques now in use around the country has been completed. This document has been useful for identifying inadequate drilling practices such as using worn-out or inappropriate drilling bits and educating potential drillers about the costs of vertical installations. A draft drilling handbook was also completed in FY 95.
- Sandia has consulted with many interested parties in government and the private sector on the advantages of GHP technology. SNL has provided consulting time to encourage developing GHP options for buildings at SNL itself, the SERDP military installations, Jemez Indian Pueblo, United World College, and Virginia State Energy Office.

FUTURE PLANS

We will focus our program next year more toward the development of improved drilling methods. The specific program is still being finalized, but it will deal with component improvements (e.g. drill bits, mud handling, downhole hammers, clay management schemes), development and testing of enhanced rigs, and improvements in well completions (high performance grouts, more effective

downhole heat exchangers, and loop insertion tools). The PSSSL GHP installation will be monitored next year to provide head-to-head comparison of vertical loops installed with six different completion methods.

Connection of our R&D effort with the growing loop drilling industry is vital to maintaining focus and relevance. Sandia National Laboratories plans to sponsor frequent forums to solicit industry reviews of ongoing and future R&D projects. When possible, R&D projects will be partnerships between industry and Sandia.

We plan to maintain our measurement program for sites developed previously to determine the long-term maintenance and thermal performance of GHP systems. We will continue our efforts at technology transfer and consulting with potential end-users of GHP technology.

INDUSTRY INTEREST AND TECHNOLOGY TRANSFER

There is a developing industry in this area which needs nurturing and is amenable to technology transfer and joint activities. The following industry entities have programs with the SNL/DOE GHP program. We anticipate expanded efforts in joint activities through FY 96.

Organization(s)	Type and Extent of Interest
Geothermal Heat Pump Consortium (GHPC)	Serve on R&D advisory panel, identify key GHP R&D initiatives
Atlantic Electric/EPRI	Joint program at Stockton State
Detroit Edison	Joint measurement program at Selfridge ANG Base
TU Electric	Joint measurement program at Fort Hood
WTU Electric	Joint measurement program at Dyess Air Force Base
South Dakota State University	Design of PSSSL loop experiment completion
Cold Regions Research and Engineering Lab (DoD)	Conduct measurement programs at DoD sites

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