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Geothermal Heat Pumps As A Cost Saving and Capital Renewal Tool

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GEOTHERMAL HEAT PUMPS AS A COST SAVING AND CAPITAL RENEWAL TOOL

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ABSTRACT
An independent evaluation of the Fort Polk, Louisiana energy savings performance contract (ESPC) has verified the financial value of geothermal heat pump (GHP)-centered ESPCs to the federal government. The Department of Energy (DOE) Federal Energy Management Program (FEMP) has responded by issuing an RFP for the "National GHP-Technology-Specific Super ESPC Procurement." Federal agency sites anywhere in the nation will be able to implement GHP-centered ESPC projects as delivery orders against the awarded contracts.

REVIEW OF THE FORT POLK PROJECT
Between March 1995 and August 1996, the world's largest installation of geothermal heat pumps was completed on the U. S. Army base at Fort Polk, Louisiana. The project was a joint effort of the Army and Co-Energy Group, an energy services company (ESCO), and was funded by private capital under an energy savings performance contract (ESPC). This massive project—the largest-ever federal ESPC at the time—has proven the potential of geothermal heat pumps (GHPs) to deliver significant energy savings and maintenance cost savings as the centerpiece of a comprehensive energy efficiency retrofit.

Table 1 summarizes the major impacts of the GHP-centered ESPC at Fort Polk. After the table, various important aspects of the project are reviewed.

TABLE 1. THE FORT POLK STORY — AT A GLANCE

Capital Costs:	$0 for Fort Polk. $18.9 million in private investment arranged by the ESCO.
Energy and energy-related maintenance costs:	Fort Polk saves $345,000 per year.
Capital renewal of energy-consuming systems:	Fort Polk gets new equipment for heating, cooling, water heating, lighting, and shower flow restriction in 4,003 apartments.
Maintenance headaches:	For Fort Polk, the history of the lowest bidder taking on the job and getting overwhelmed by peak-season service calls is over. For the next 20 years the maintenance burden belongs to the ESCO.
Energy savings:	Fort Polk takes a giant step toward achieving the energy savings mandated by the Energy Policy Act of 1992 and Executive Order 12902. The project saves 26 million kWh of electricity and 260,000 therms of natural gas per year. By exceeding the savings mandates in family housing, which represented about 40% of base-wide consumption before the project, Fort Polk can meet its overall savings mandate with targeted actions elsewhere.
Improved energy use pattern:	By improving the annual electric load factor in family housing from 0.52 to 0.62, Fort Polk can likely procure lower-cost electricity for the entire base.
Financial benefit of reduced pollutant emissions:	If policy makers institute a system of emissions allowances based on energy savings, measurement and verification will have given Fort Polk the hard numbers it needs to claim the allowances.

The Hammer Award

For their trailblazing project at Fort Polk—renewing the heating and cooling systems in 4,003 homes and lowering operating costs, without tapping government capital appropriations—Fort Polk, the Army Corps of Engineers, and Co-Energy Group were awarded Vice President Gore's Hammer Award. The Hammer Award recognizes work that makes government "work better and cost less" and symbolizes efforts to "hammer away" at unnecessary bureaucracy and costly inefficiency.

Energy Savings Success

An independent evaluation conducted by the Department of Energy's Oak Ridge National Laboratory (ORNL) found that the Fort Polk project was a success by many measures, with energy savings being first among them:

- Data show that the GHP systems and other energy retrofit measures have reduced overall electrical consumption in Fort Polk family housing by 33% while eliminating natural gas consumption altogether.

- Peak electrical demand was reduced by 43%.

- Electrical energy savings and reduction of peak demand have dramatically improved the electric load factor—from 0.52 to 0.62—which may allow the Army to negotiate lower rates for the remaining electrical load.

These energy savings at Fort Polk correspond to an estimated reduction in CO_2 emissions of 22,400 tons per year, which gives project participants "green" bragging rights immediately, but may also translate into cash rewards if policy makers go ahead with plans to establish a CO_2-emission-allowance trading system. In that case, the Army could trade their earned allowances for cash. Even without rate reduction or sale of emission allowances, Fort Polk benefits financially from the project and the ESPC.

The Contract

The ESPC provides for the Army and Co-Energy Group to share the dollar value of the cost savings realized through the energy retrofit over the 20-year life of the contract. Under the terms of the contract, Co-Energy Group is responsible for maintenance of the GHPs and for providing ongoing measurement and verification (M&V) to ensure that cost and energy savings continue to be delivered to the Army. Fort Polk saves about $345,000 annually and benefits from complete renewal of the major energy-consuming systems in family housing and maintenance of those systems for 20 years. After the contract expires, the Army continues to reap the benefits of the GHPs' energy efficiency—about $2.2 million per year over the remaining equipment service life, if any.

Just the Beginning

The happy outcome of this project for Fort Polk, though impressive, is just the beginning of the story. The project and the ORNL evaluation propelled GHP technology out of the "novelty" realm and into orbits much closer to the mainstream, with verification of the actual energy and maintenance cost savings that GHP systems can deliver. The project led to the development and manufacture of higher-efficiency GHPs that were configured especially for low-cost installation and maintenance. The project also provided a test ground for advanced installation techniques and ground heat exchanger design methods.

The success at Fort Polk has created the momentum to promote GHPs and ESPCs in the federal sector by demonstrating how current state-of-the-art GHP technology can provide significant financial benefits to the federal government. FEMP (the DOE Federal Energy Management Program) is now implementing a national GHP-technology-specific "Super ESPC" to address unique barriers to realizing the great potential energy and cost savings of GHP-centered ESPCs at federal sites.

The Fort Polk story illustrates the opportunities presented by GHP-centered ESPCs:

—opportunities to increase the energy efficiency in schools, housing, hospitals, office buildings, and many other kinds of facilities by 33% or more;

—opportunities to free up operating budgets and escape the downward spiral of deferred maintenance; and

—opportunities for businesses to participate in the growth of an industry that will find natural markets in large, small, public, and private organizations.

DEVELOPING THE LARGEST INSTALLATION OF GHPs IN THE WORLD

The Fort Polk Joint Readiness Training Center in west-central Louisiana is a mammoth 200,000-acre facility containing military offices, training centers, warehouses, a hospital, and housing for some 15,000 service members and their families. About 12,000 people live in Fort Polk family housing, which consists of 4,003 living units in 1,290 buildings that were built in nine phases between 1972 and 1988.

The Army's primary motive for buying a package deal to renew the heating and cooling systems in family housing and shed maintenance responsibility came from acute and worsening maintenance headaches. An unfortunate outcome of conventional bid-from-spec government procurement, the HVAC equipment in family housing was a hodgepodge of minimum-efficiency units selected on the basis of low bids, often misapplied in terms of sizing, and suffering from poor-quality installation. In the face of increasing service requests, the base had outsourced family housing maintenance to a series of the lowest-bidding contractors. As service calls increased and the difficulty of stocking parts and training technicians for the miscellaneous units overwhelmed the contractors' budgets, the net result was poor service for the residents and financial difficulties for some contractors. By the early 1990s all of these problems, aggravated by aging equipment, made the situation intolerable. In July of the last year before the retrofit, there was an average of 90 service calls per day and over 100 calls on the worst days. Leesville, Louisiana, is not a place many people, including the families of military personnel, would want to live without air conditioning.

Fort Polk also faced budget constraints familiar to federal agencies nation-wide: No one knew when a capital appropriations request might be approved, and some feared that when funding for renewal did become available, it would be phased so that the history of piecemeal upgrades would repeat itself. Still, mandates of the Energy Policy Act of 1992, which established energy savings requirements for federal facilities, would have to be met. The deficit reduction mood in Congress also meant that Fort Polk's $13 million annual energy budget—in which family housing represented a 40% and rising share—would be flat at best, so that any growth in energy costs would have to come out of training or salary dollars. All of these factors led Fort Polk to seek a shared energy savings contract in which the ESCO would provide the financing and assume responsibility for maintenance.

Fort Polk paid the Army Corps of Engineers–Huntsville, the Army's Center of Excellence for performance contracting, about $140,000 to determine project feasibility, develop a request for proposals (RFP), solicit bids, support negotiations, award the contract, and provide support during implementation. Greg Prudhomme, an engineer in Environmental Engineering at Fort Polk, was an early champion of a GHP-centered project and was later honored with the Hammer Award for his efforts. The RFP conveyed a preference, but not a requirement, for GHPs. Co-Energy Group's proposal, the only one submitted, was centered on GHPs. When the RFP was issued, the maintenance savings advantage of GHPs was a well-kept secret, but the word is getting out. If the RFP were issued today, more ESCOs would bid.

Co-Energy agreed to bear all the up-front costs of the project and assume responsibility for maintenance in exchange for a 77.5% share of the energy savings and a fixed price for maintenance equal to 77.5% of the Army's projected cost for maintenance without the energy retrofit. The 4,003 existing HVAC systems would be replaced with GHPs, and Co-Energy Group would install other energy- and water-conservation features that had proven cost-effective in similar projects.

The Fort Polk GHP Systems

The GHP configuration proposed and implemented at Fort Polk is a closed-loop, vertical-borehole ground heat exchanger system. The underground piping is high-density polyethylene, which will outlive several heat pumps. All joints are thermally fused, and purchasing the pipe in "uni-coils" put the only outdoor fusion joints near the surface. The loop piping is brought indoors to the heat pump. The heat pump is a packaged water-to-air unit that is factory-charged with refrigerant, avoiding the problems associated with field-charged, split-system refrigeration systems. Since there is no interface to outdoor air, there are no defrost controls to maintain. These are important considerations to an ESCO bearing the actual cost of maintenance while being paid a fixed price.

Efficient performance and improved comfort are also important advantages of GHPs. GHPs exchange (reject or extract) heat with circulating water, rather than circulating outdoor air, as air-source heat pumps do. The entering water temperature to the heat pump is generally cooler than outdoor air when space cooling is required, and warmer than outdoor air when space heating is required. Consequently, the temperature "lift" across a GHP is generally less than the "lift" across an air-source heat pump, leading to greater efficiency, capacity retention, and indoor humidity control, and eliminating the need for supplemental electric resistance heat in the Leesville climate. Since the unit is not exposed to the weather, the performance degradation sometimes observed with air-source systems when outdoor units clog with leaves or mud is not an issue. In heating mode GHPs deliver air to the registers at about 105°F, which is 10 - 15°F warmer than air-source heat pumps and warm enough to preclude complaints about the system "blowing cold air." As any ESCO experienced in housing projects knows, rule number 1 is to keep the occupants happy, because they have a major influence on energy use. These are important considerations to an ESCO that is paid a share of the energy savings actually realized.

New GHP Design for Efficiency and Low-Cost Installation

When Co-Energy Group was developing the project, none of the 1.5- to 2-ton GHPs on the market had high enough efficiency and low enough installation costs to make the project feasible. Co-Energy's partner, the GHP manufacturer ClimateMaster, overcame that obstacle by redesigning some of its smaller units to project specifications. These new "VZ" units were designed for easy installation and maintenance as well as compactness and efficiency. Installation costs were reduced significantly by building the ground loop and desuperheater loop circulators into the unit, along with all controls and valves for purging air from the loops and isolating and servicing the unit. This avoids the expense associated with mounting components on walls and making multiple power and plumbing connections. It also saves valuable floor space and makes for a more aesthetic installation. This partnership between Co-Energy Group and ClimateMaster is one of the main reasons Co-Energy Group was able to bid the project while others were unable to find savings sufficient to cover costs.

Other manufacturers do not yet offer the level of efficiency (15.4 EER) in the size range available in the VZ model, but there is reason to expect that others also would custom-design and build for a 4,000-unit order. At the time the Fort Polk's order was placed, it represented 10% of the annual unit shipments of the entire GHP industry.

During the Army Corps feasibility analysis, a dollars-per-ton installed cost for GHPs was established via telephone survey with contractors. Based on experience with projects of similar size and visibility, the Army Corps assumed that this cost could be reduced by 20%. The Army felt that the ESCO would use the magnitude of the order and the high visibility of the project to negotiate prices aggressively with suppliers and manufacturers, thereby benefiting both the government and the ESCO. The Army was right: the ESCO achieved the best pricing the industry has ever seen for heat pumps, pipe, drilling, and indoor installation.

Co-Energy Group installed the heat pumps in nominal capacities of 1.5, 2.0, and 2.5 tons, with one heat pump per living unit. A total GHP capacity of 6,593 tons was installed, an average of about 1.65 tons per apartment. By the time the crews installed the last of the heat pumps at the end of summer 1996, they had drilled a total of 1.8 million feet of 4 1/8-inch bore and had installed 3.6 million feet of 1-inch SDR-11 high-density polyethylene pipe in the bores—about 686 miles' worth. Each of the 4,003 GHPs has its own ground heat exchanger, which consists of two vertical, U-shaped pipe loops placed in separate bores and connected in parallel.

The Supporting Cast of Energy Savers

Seventy-five percent of the new heat pumps utilize desuperheaters, which recover waste heat from the GHPs when they run for heating or cooling and dump it into the water heater. In the other 25% of the living units, the heat pumps and water heaters were too far apart to make desuperheater installation practical. Co-Energy Group also installed attic insulation where needed, low-flow shower heads, and compact fluorescent lights. Weather-stripping and storm windows were not installed because the housing units were already fairly tight and the potential energy savings did not justify the investment. So, too, with duct sealing work, except in cases where leaks were large enough to cause serious performance or comfort problems. Window treatments were upgraded in some apartments to allow use of smaller heat pumps.

The Importance of Engineering and Project Management

The quality of engineering and project management that went into the Fort Polk project was certainly key to its success. Observers of the project have applauded the remarkable project management and coordination achievements of Co-Energy Group and the thorough engineering performed by Applied Energy Management Techniques, a subcontractor to Co-Energy Group. ClimateMaster also contributed significantly to engineering efforts, and other mechanical engineering firms were consulted as well. The magnitude of the project demanded second and third opinions.

The engineering tasks alone represented a major undertaking; these were: (1) developing models of energy consumption and performing design calculations to size heat pumps and ground heat exchangers for 4,003 apartments; (2) engineering the other retrofits for each apartment, and (3) estimating overall energy savings. Fortunately, the central management and uniformity of military family housing facilitated economies of scale in engineering the retrofits. The archived information from technical records and plan vaults enabled the identification of 64 unique "building block" housing units that described the entire housing population. All housing units represented by the same "building block" are identical from the point of view of heating and cooling design load, except for compass orientation. Calculated design loads for each "building block" and orientation created the equivalent of a spreadsheet-based lookup table for each of the 4,003 apartments.

The "after" characteristics were documented in the form of input files to the heating/cooling design load calculations used to size the GHPs. In addition, the "before" and "after" characteristics were documented in the form of input files to the energy analysis program used to estimate the energy savings of the project. The designs were then documented in the spreadsheet-based lookup table for each building block and orientation. The spreadsheet defined all 4,003 apartments by building block and orientation, design loads, GHP size, ground heat exchanger size, lighting fixture count and change, building number, and serving electric distribution feeder.

The Construction Challenge

In the early stages of construction, chaos seemed to rule, as unexpected problems plagued the ESCO. The major challenge was drilling and installing 8,006 borehole heat exchangers. The Fort Polk site has a high water table, and the soft, damp, expansive clay clung to drill bits and tended to slump into freshly bored holes after the drill stem was removed and before the U-tube could be inserted. To keep the project on track, local Louisiana drilling crews were joined by crews imported from Texas, Oklahoma, and Arkansas. At the peak of the drilling phase, 27 drill rigs were on site installing 100 borehole heat exchangers per day to depths of about 200 feet and the pipe supplier was delivering four truckloads of pipe per week. Some of the crews were water-well drillers; others were shothole seismic prospectors, as they're known in the oil industry, who use explosives to find oil when they're not installing GHPs.

Co-Energy Group normally subcontracts design and construction as needed, and has only about 12 core employees who coordinate energy projects. On this project, to get the indoor installations done, Co-Energy took on more of the construction tasks themselves, as subcontractors bailed out or failed to meet expectations. The company swelled to some 150 temporary employees at its peak. A year before construction began, Co-Energy had taken over maintenance and hired in the core staff of the last of Fort Polk's maintenance contractors. These people were trained to lead indoor installation crews, and more locals were hired to staff the crews. At the peak of the work, 20 heat pumps were being installed per day.

The GHPs were shipped from the factory in trailers owned by Co-Energy Group that were parked on site until the GHPs were needed. This approach saved both storage costs and material handling costs. An outdoor area was used as a "graveyard" for old equipment until the recycler could catch up. The lighting, showerhead, and attic insulation retrofits were installed before the GHPs by different crews.

The Results: Dramatic Energy Savings

The Fort Polk retrofits are producing dramatic savings. According to ORNL's evaluation, annual electricity consumption in Fort Polk family housing dropped by about 26 million kWh, a 33% reduction. Natural gas consumption for space and water heating of 260,000 therms per year was eliminated completely. These savings result in an estimated reduction in CO_2 emissions of 22,400 tons per year. Summer peak electrical demand has been reduced by 7.5 MW, a 43% reduction. The electrical energy and demand savings correspond to an improvement in annual electric load factor from 0.52 to 0.62.

The energy savings quoted here are the "apparent" energy savings for a typical weather year, figured from metered electricity use and assuming that factors such as comfort setpoints, occupancy rate, and appliance/plug loads remained the same after the retrofits as they were before. "Contract" energy savings take into account changes in these factors through adjustment of the baseline, so may be different from "apparent" savings. The Fort Polk ESPC specifies how to determine "contract energy savings" for the purpose of figuring payments to the ESCO (the ESCO receives about 77% of the value of energy savings attributable to the retrofits). In fact, some factors such as comfort setpoints and appliance/plug load did change after the retrofits, increasing post-retrofit energy usage. The Army, under the contract, is responsible for such increases, so "contract" energy savings are larger than "apparent" energy savings. Even when paying for the higher contracted savings, the Army saves about $345,000 per year during the 20-year contract and over $2 million annually thereafter.

The 33% reduction in electricity use was achieved even though in 20% of the apartments, natural-gas-fueled appliances were replaced with electric ones. As expected, the average electricity savings in housing units that were originally all-electric was substantially higher than the savings in units that had used natural gas before the retrofit, measuring 35% and 14%, respectively. In apartments that were all-electric before the retrofit, the GHPs were found to save about 42% of the pre-retrofit electrical consumption for heating, cooling, and water heating. The proportion of total energy savings attributable to the new GHPs—through the heat pumps themselves and through the desuperheaters for water heating—was a whopping 66% in 200 apartments on Feeder 1 that were all-electric before the retrofit.

Evaluation Methodology

In the independent evaluation of the Fort Polk retrofit, researchers from ORNL analyzed data taken between August 1994 and February 1997 to determine the impacts of the project on energy use, electrical demand, and maintenance costs. The energy evaluation was based on a three-level data collection strategy known as a multi-tiered, nested evaluation design.

The most aggregated level of data was taken at the electric distribution feeder level—Level 1. For example, Feeder 1 serves all of the electrical loads in 200 apartments in 46 buildings, as well as streetlighting in the neighborhood.

The evaluation addressed maintenance costs by developing an estimate of the maintenance cost baseline (i.e., maintenance costs that would have occurred had the project not been done). An actuarial approach was used to estimate equipment replacement rates over the 20-year contract term, based on a census of the age of existing HVAC equipment. Estimates of service call frequency, required maintenance actions, and required labor were derived from apartment service records from the last year before the retrofit. ORNL's estimate of baseline maintenance costs was higher than that in the contract (26¢ per square foot per year versus 24¢, as a 20-year average), indicating that actual maintenance savings may be slightly undervalued in the contract.

In addition to verifying the financial value of the project, the evaluation addressed a host of technical issues surrounding the development and implementation of GHP-centered ESPC projects. The final report on the evaluation gives much more information and full technical details.

HOW GHPs AND ESPCs SERVE THE CUSTOMER'S INTERESTS

A universal objective of facility managers is to minimize capital investment and operating expenses while maintaining their buildings and delivering the environments that occupants need. A GHP-centered ESPC can be an effective tool for meeting the objectives of all interested parties, customers who

—*pay the bills*: owners, CFOs, tenants, programs;

— *run the buildings*: facility managers, energy managers, operators, maintenance staff; and

— *occupy and work in the buildings*: employees and tenants.

Tables 2 and 3 summarize how GHPs and ESPCs serve customer's interests.

TABLE 2. BENEFITS OF GHPs

. . . If You Pay the Bills	***. . . If You Run the Buildings***	***. . . If You Occupy the Buildings***
Lower energy costs because of lower energy consumption.	Operators are freed up to run other buildings.	Improved comfort levels, indoor air quality, and productivity in many cases.
Lower energy costs because of improved energy use patterns.	Simple preventative maintenance can be performed by custodial staff.	No semiannual periods of discomfort associated with the seasonal switch of central HVAC systems between heating and cooling.
A simple system that requires no "operators" or specialized service contracts.	Maintenance staff are freed up to maintain other buildings.	Greater comfort control for occupants, with thermostats in each zone.
An inherently low-maintenance system and lower maintenance costs.	Less staff time off the job for O&M training, and less retraining needed because of staff turnover.	No feeling that the system is "blowing cold air".
A more comfortable building, and greater productivity among occupants.	Fewer service calls from occupants who feel uncomfortable even though the HVAC equipment is functioning properly.	

Possible future cash benefits from emissions allowances, and "green" bragging rights in the meantime.		

TABLE 3. BENEFITS OF ESPCs

. . . If You Pay the Bills	*. . . If You Run the Buildings*	*. . . If You Occupy the Buildings*
Total costs are lowered by a combination of eliminating energy waste, decreasing maintenance costs, changing energy use patterns, switching systems to lower-cost fuels (or allowing choice if lowest-cost fuel varies), obtaining lower rates from current energy suppliers, or finding lower-cost energy suppliers.	An ESPC uses future energy and maintenance savings to get resources to fix problems now.	Renewed systems improve comfort, indoor air quality, and productivity.
With flat or declining energy and maintenance budgets, you can renew energy-consuming systems in buildings using someone else's capital.	An ESPC lightens the workload of beleaguered O&M staff by renewing systems and, if needed, by supplementing O&M resources.	ESPCs motivate ESCOs to educate building occupants and keep occupants happy, because occupants affect energy consumption.
Adequate operating budgets can be guaranteed: ESPC project cost savings can be guaranteed to exceed payments for debt service and ESCO services.	An ESPC taps expertise not available in-house to develop, finance, install, and operate projects.	
The guaranteed savings style of ESPCs allows use of low-cost tax-exempt financing for eligible customers.	An ESPC accomplishes energy projects in an environment where energy projects are not a high priority.	
ESPCs can conserve scarce capital resources for investment in core business activities.	An ESPC provides broad integration of services; the customer deals with one ESCO rather than a number of contractors and suppliers.	
If outsourcing of some functions related to energy procurement, facility management, operations, or maintenance is part of your strategic plan, ESPCs provide a means to do so.	An ESPC provides a structure that aligns the interests of the ESCO with those of the customer and allows shifting of risks to the ESCO.	
The contract, through M&V, offers hard numbers on energy savings—importa nt if emissions-allowance-trading systems are established.	In-house staff may be trained to operate and maintain ESCO-installed systems, and those skills can be applied in other buildings, even those not part of the ESPC project.	

WHY GHPs AND ESPCs MAKE GOOD BUSINESS SENSE FOR ENERGY SERVICE PROVIDERS

GHP-centered ESPCs offer extraordinary benefits to customers in settings and climates where GHPs are the right choice. Performance contracting is also presenting extraordinary opportunities to businesses—experienced ESCOs as well as new entrants in the field, the many types of businesses that provide services integrated by ESCOs, and financial institutions that invest in these projects. The large market for energy-efficiency retrofit projects and the inherent efficiencies and advantages of GHP technology mean that GHP-centered ESPCs make very good business sense.

- ORNL's evaluation of the Fort Polk project verified the financial value of GHP-centered ESPCs.

• The relatively large capital outlay required for GHP systems is their major drawback, but an ESPC eliminates that problem for the customer.

• GHPs for space conditioning and water heating generate very large energy savings.

• GHPs improve energy use patterns—dramatically, in some applications.

• Properly designed and installed systems are extremely simple to operate and maintain and require no "operators" or specialty service contracts.

• In many applications the GHP has the lowest life-cycle cost of any HVAC system.

• The industry is still small enough for large projects to leverage custom-designed equipment.

• The Fort Polk project showed that large projects can succeed by supplementing the local installation infrastructure. As in a "Drill Field of Dreams"—if you bid it, the drillers will come.

• Several natural markets for GHPs are also natural markets for ESPCs. For example, K-12 schools are eligible for tax-exempt financing in guaranteed savings projects and also generally have the space for ground heat exchangers.

• GHP-centered ESPCs are primed for moving into an untapped export markets.

• GHP technology is advancing rapidly, with improving design methods and improving bore backfill materials, for example.

• Most organizations will need the help of a GHP-focused expert ESCO to implement GHPs, because engineers, architects, and local construction firms are generally not yet familiar with the technology.

FEDERAL MARKET OPPORTUNITIES

Streamlining of federal energy savings performance contracting is well under way with the advent of "Super ESPC" procurements. Under these agreements, competitively selected ESCOs receive indefinite-delivery, indefinite-quantity (IDIQ) contracts covering any federal facility in a specified region. Federal customers can then implement their ESPC projects as delivery orders against the IDIQ contracts. The Fort Polk ESPC took 3 years to develop from concept to start of construction; delivery orders can now be done in 6 to 8 months. The country is now blanketed with IDIQ contracts with ESCOs, but these are mostly "general-purpose" awards that limit allowable ECMs to about 15 mainstream technology categories.

The success at Fort Polk has created the momentum to promote GHP-centered ESPCs in the federal sector. FEMP is now implementing a national GHP-technology-specific Super ESPC to address the unique challenges in realizing energy and cost savings through GHP-centered ESPCs at federal sites. These contracts will cover comprehensive multi-ECM projects centered on GHP systems. As demonstrated at Fort Polk, GHP projects offer 30%-plus deep savings, but the energy and maintenance savings will not be found unless the ESCO plans and designs specifically to achieve them. An IDIQ contract that requires delivery orders to be GHP-centered provides the necessary motivation. These contracts will also offer assurance to customers wary of innovative technologies that their ESCO is fully competent to build GHP projects even though GHP technology is relatively new and is evolving quickly.

The RFP for the "National GHP-Technology-Specific Super ESPC Procurement" was released June 1, 1998. For more information on the procurement, contact Angela Carroll Hart of DOE Oak Ridge Operations at 423-576-0999 or e-mail at hartap@oro.doe.gov.

OTHER GHP CONFIGURATIONS

The GHP system at Fort Polk is only one of many configurations in common use. A few examples are shown in Figures 1, 2, 3, 4, and 5. The "National GHP-Technology-Specific Super ESPC Procurement" covers the entire family of GHP systems. Larger buildings often have many heat pumps serving individual zones that are connected to a common loop conditioned by a bore field (i.e., a matrix of vertical-borehole ground heat exchangers). Single GHP loops or common loops can also be conditioned by various types of horizontal ground heat exchangers, or surface water heat exchangers.

Common loop systems can also be conditioned by groundwater isolated from the closed loop by a plate heat exchanger. Groundwater systems are the most cost-effective GHP option under some circumstances. For example, some federal sites are currently pumping groundwater to the surface for treatment and reinjection as part of groundwater remediation programs. This water could be used to condition common loops in heat pump systems or condenser loops in chiller systems for nearby buildings.

In some places groundwater quantity, quality, and depth can accommodate the development of wells specifically for the GHP application. For example, several high-rise buildings in Louisville, Kentucky, pump water from shallow aquifers replenished by the Ohio river and discharge water to the river. Many populated areas and federal facilities are adjacent to large rivers.

Standing-column wells for conditioning common loops are feasible in areas with near-surface bedrock. Deep bores are drilled, creating a long standing column of water from the static water level down to the bottom of the bore. Water is recirculated from one end of the column, through a plate heat exchanger to condition the common loop, to the other end of the column. During peak heat rejection or extraction periods the system can bleed part of the water rather than reinjecting it all, causing water inflow to the column from the surrounding formation, which cools the column during heat rejection and heats the column during heat extraction.

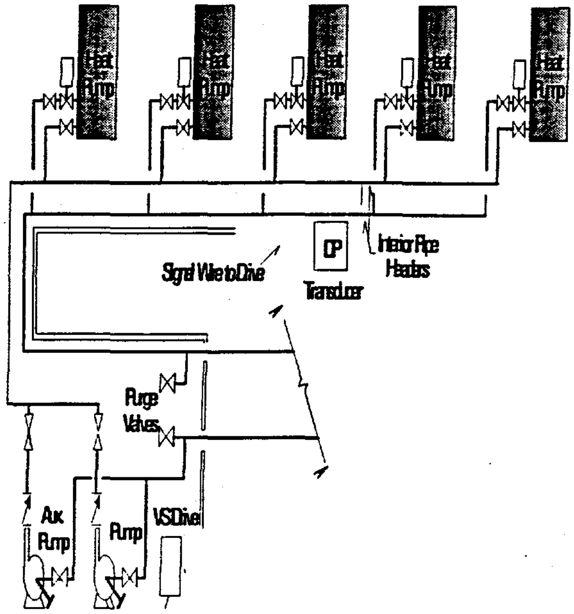

FIGURE 1. MULTIPLE HEAT PUMPS ON A COMMON LOOP

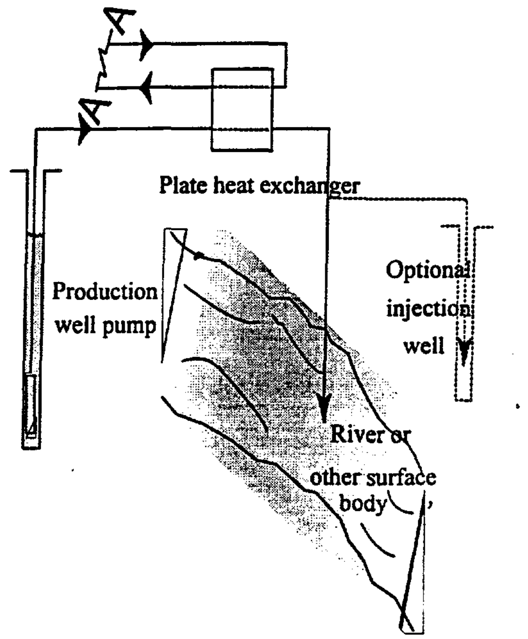

FIGURE 3. COMMON LOOP CONDITIONED BY GROUNDWATER

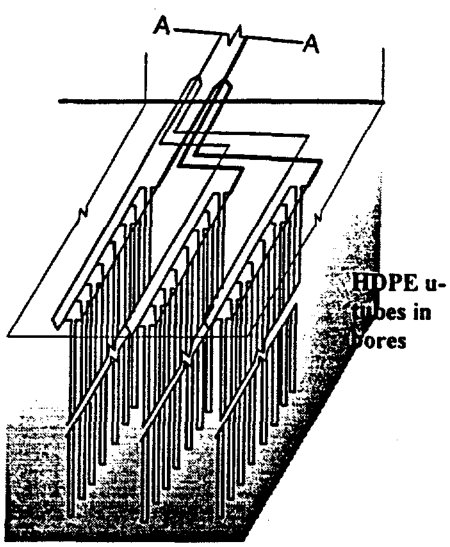

FIGURE 2. COMMON LOOP CONDITIONED BY VERTICAL BORE HOLE GROUND HEAT EXCHANGER

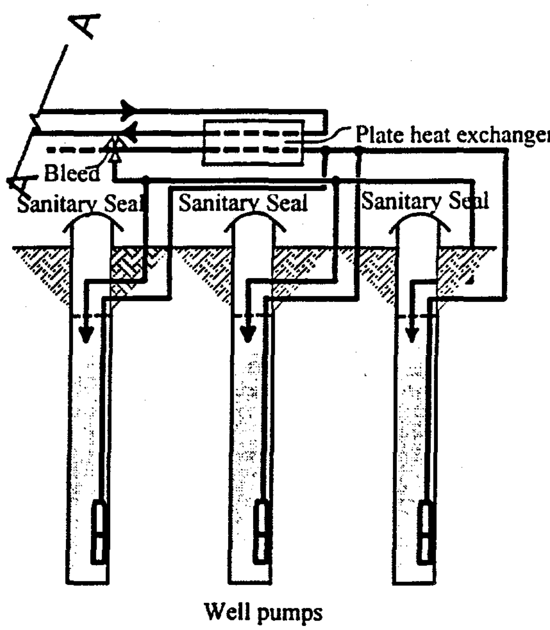

FIGURE 4. COMMON LOOP CONDITIONED BY STANDING COLUMN WELLS

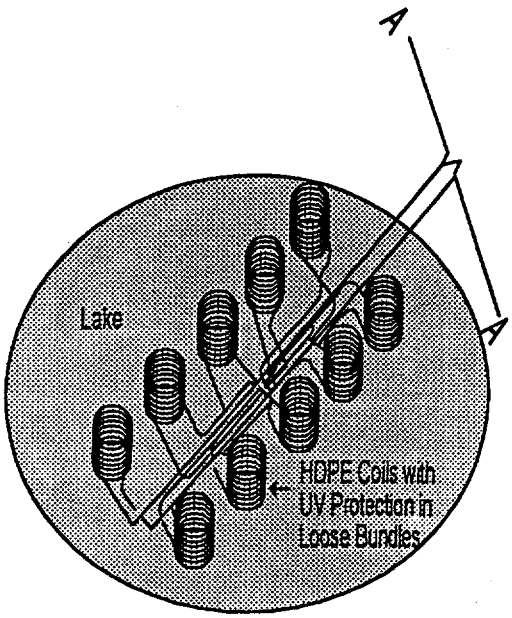

FIGURE 5. COMMON LOOP CONDITIONED BY SURFACE WATER

REFERENCES

1. P.J. Hughes and J. A. Shonder, *The Evaluation of a 4000-Home Geothermal Heat Pump Retrofit at Fort Polk, Louisiana: Final Report* (ORNL/CON-460), Oak Ridge National Laboratory, Oak Ridge, TN, 1998

2. P.J. Hughes and J. A. Shonder, *Methodology for the Evaluation of a 4000-Home Geothermal Heat Pump Retrofit at Fort Polk, Louisiana* (ORNL/CON-462), Oak Ridge National Laboratory, Oak Ridge, TN, 1998

Both are available to the public from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161 (703-487-4650) and to DOE and DOE contractors from the Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831 (423-576-8401).