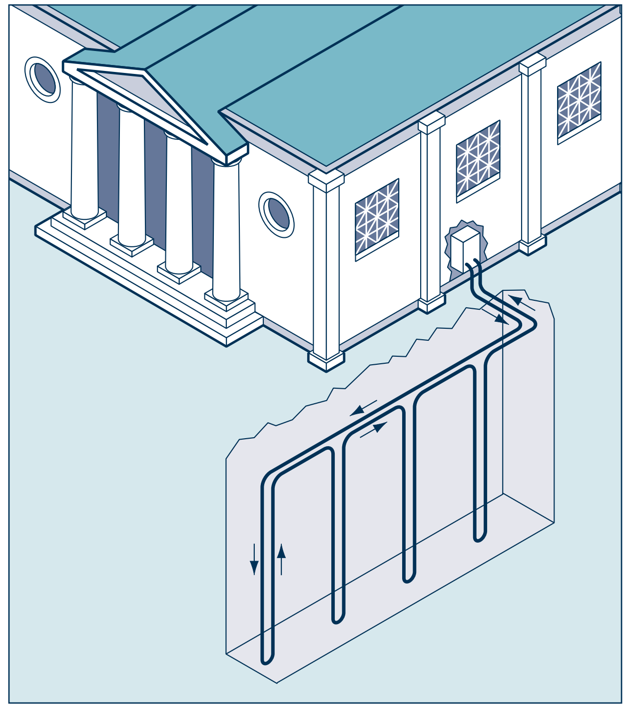
OFFICE OF GEOTHERMAL TECHNOLOGIES

Geothermal Heat Pumps for Federal Buildings

The U.S. Government spends approximately $8 billion annually on its energy needs. To reduce energy use in Federal buildings, President Bill Clinton issued Executive Order 13123 in June 1999, which calls for a 35% reduction in Federal energy use from 1985 levels by 2010. Geothermal heat pumps—when installed in virtually any type of building—can help accomplish this goal with energy savings of up to 40%.

Geothermal heat pumps (GHPs) can provide significant energy savings to a wide range of Federal facilities including office buildings, housing, medical facilities, schools, training facilities, communications facilities, and court houses. GHPs have been installed in virtually every type of building—new or retrofit—nationwide.

In fact, about a dozen Federal agencies—ranging from the Department of Defense (DOD), Bureau of Indian Affairs, Veteran's Administration, Environmental Protection Agency (EPA), U.S. Postal Service, and Housing and Urban Development—have installed GHP systems in some of their buildings. To date, DOD alone has installed more than 7,500 GHPs. The Department of Energy's (DOE) national goal over the next 10 years is to have more than 100,000 GHPs installed in Federal facilities.



Geothermal heat pumps use the stable temperature of the ground (vertical boreholes are typically 100 to 400 feet deep) as a heat source to warm buildings in winter and as a heat sink to cool them in summer.

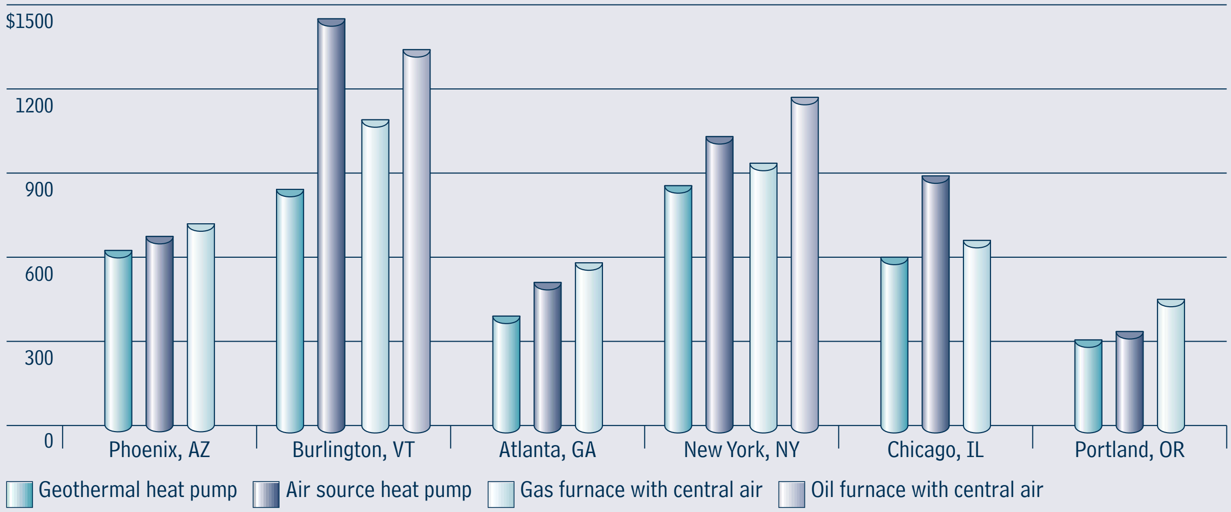
Federal facility managers can easily find assistance with financing, designing, installing, and maintaining GHP systems. For example, GHP equipment can be obtained and installed at no up-front cost through Energy Savings Performance Contracts (ESPCs) through energy service companies (ESCOs). In addition to ESCO expertise and financing available through the various forms of ESPC, many utilities also have contracting vehicles for implementing and financing GHP projects in Federal facilities (see *ESPCs and Super ESPCs, and Utility Area-Wide Contracts* in this publication).

Today, GHPs are becoming a widespread technology, and not just among Federal agencies. There are over 400,000 GHPs in service in the United States. According to the EPA, residential GHP systems are the most energy-efficient, environmentally clean, and cost-effective space conditioning systems available in each region of the country (see Figure 1). Furthermore, when evaluating total energy loads for commercial building systems, including compressor and related fan and pump costs, GHP systems require less power/ton than conventional systems (see Figure 2).

Oak Ridge National Laboratory/PIX07061

Fort Polk Army Base is the largest Department of Defense project at 4003 units.

Figure 1. Annual Heating and Cooling Costs by Region Source: EPA, 1993



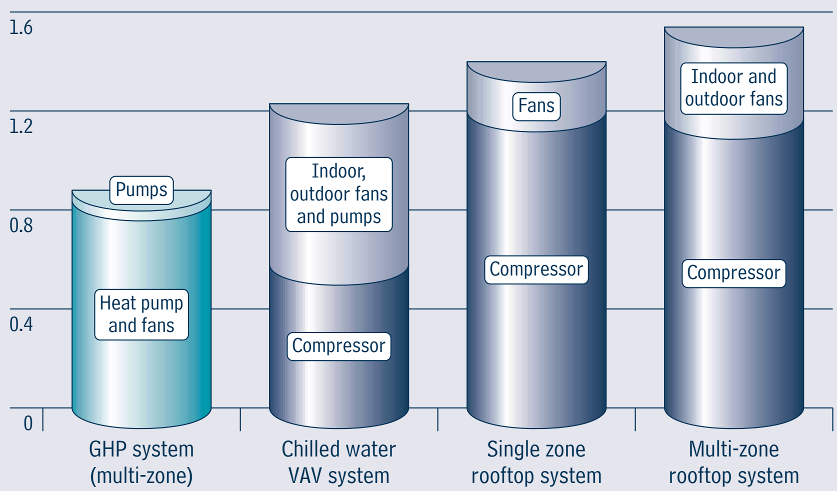
Advantages and Benefits of GHP Systems

- Lower maintenance costs and easier-to-outsource maintenance tasks
- Lowest life-cycle cost in most applications
- Comfort and quiet operation for building occupants
- Design flexibility appropriate for both new construction and retrofits
- Energy cost reductions between 20% and 40%
- Essentially free hot water with a "desuperheater"
- Less mechanical room space needed for HVAC equipment
- Eliminates corrosion due to saltwater environments
- Eliminates risk of vandalism because equipment is located inside building
- Used in historic buildings to conceal HVAC equipment
- Eliminates need for rooftop equipment
- Private financing available for up-front costs of retrofits—no appropriations needed.

> *"These [GHP] contracts alone can save each site up to 40% on their energy bills. This innovative business and technology strategy is good for taxpayers and good for the environment."*
>
> Secretary of Energy Bill Richardson

> *"The initial cost of a GHP system is often competitive with conventional HVAC equipment, and the operation and maintenance costs are usually much lower, typically yielding a simple payback of 5 years or less. In addition, every room in the building can have its own comfort control. In my 45 years in the business, I've worked with nearly every HVAC system available, and you can't beat GHP systems for economy, comfort, flexibility, and environmental benefits."*
>
> Marion Pinckley, Pinckley Engineering, Inc., Louisville, KY

Figure 2. Comparison Between GHP and Conventional Systems: Electricity Used (kW/ton) Source: IGSHPA, 1996



This figure shows a comparison of three typical commercial-scale conventional systems and one GHP system in terms of electricity used (kilowatts) for each delivered ton of cooling capacity.

How They Work

GHPs are also known as ground-source heat pumps and as GeoExchange systems. They use the relatively constant temperature of the soil and water available at the site to provide efficient heating, cooling, and water heating year-round. And in buildings with many GHPs, there is no need to switch between heating and cooling because GHPs can heat and cool various zones simultaneously. Some GHP systems exchange heat with the earth through a system of buried plastic pipes called a ground heat-exchanger. Others exchange heat with surface or groundwater through various types of water-source heat-exchangers.

Ground Heat-Exchanger Systems

In the winter, fluid within the pipes extracts heat from the earth (i.e., heat source) and carries it to the heat pump where its temperature increases for use in heating the building. In the summer, heat is pulled from the building, carried through the system, and deposited in the cool earth (i.e., heat sink). The GHP system can also provide hot water all year long by recovering heat from operating GHPs via desuperheaters, or with dedicated water-to-water heat pumps. In some buildings, such as restaurants or gas stations/convenience stores, excess heat from refrigeration equipment is captured and transferred to ground heat-exchangers, where it is stored during the summer. Then, in the winter, the stored heat is used to melt snow on sidewalks or driveways.

Water-Source Systems

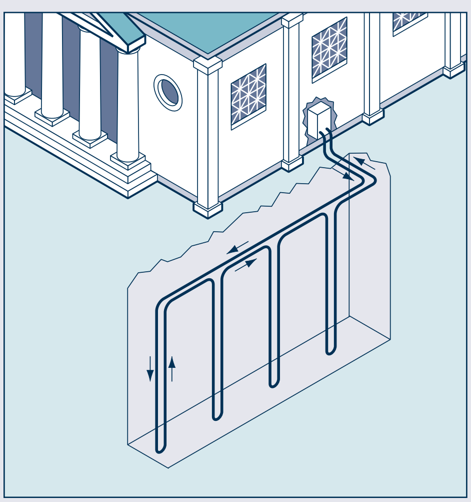
Many water sources, including groundwater, rivers, or lakes (such as those from a water supply or a water treatment plant) can be used to provide the heat source or sink for a GHP system. For example, a GHP system can be installed near a Federal site involved with EPA-required groundwater remediation where the water is already being pumped to the surface for treatment. By "tapping" into the stream of pumped water, a GHP system would be able to condition nearby buildings without the expense of developing new supply and injection wells.

Not only do GHP systems achieve impressive efficiencies that allow users to save up to 40% over conventional heating and cooling systems, they also achieve substantial maintenance savings. Since GHP systems can be designed with all equipment located inside the building, they escape the ravages of harsh weather, saltwater corrosion, and the threat of vandalism. In addition, GHP systems, which typically last over 20 years, are much simpler than boilers, chillers, cooling towers, and steam systems. This simplicity results in lower maintenance costs.

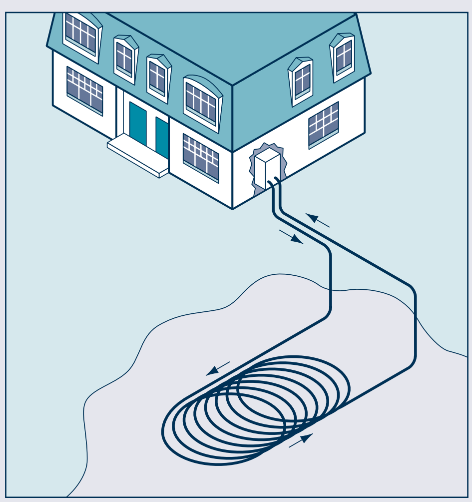
> *"Federal agencies now have this exciting but little known technology—geothermal heat pumps—available to them at minimum cost and risk to help them meet their energy savings targets and cut greenhouse gas emissions."*
>
> Secretary of Energy Bill Richardson

Efficiency and low maintenance costs are not all; GHP systems also take up less space. In large buildings, they use smaller central system ducts, because the central air handling system only provides ventilation air rather than also being responsible for distribution of heating and cooling. This results in smaller floor-to-floor heights as BTUs are transported around the building via 2- to 4-inch pipes instead of through more space-consuming ducting. By eliminating roof-mounted equipment in new construction, the roof lasts longer, thereby extending warranties; the structural elements can be downsized; and the architects have greater design freedom.

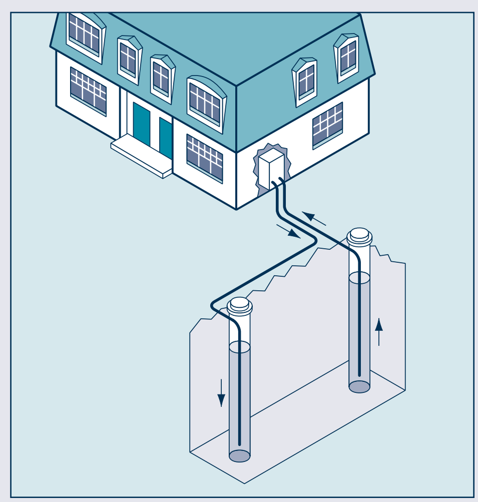
Closed-Loop
Vertical Heat-Exchanger



Closed-Loop
Surface Water Heat-Exchanger



Open-Loop
Well Water Heat-Exchanger



ESPCs and Super ESPCs

In the Federal sector, tight budgets have provided a push toward private-sector financing through innovative contracting methods, such as ESPCs, which are authorized under the National Energy Conservation Policy Act and the 1992 Energy Policy Act. Through an ESPC, an ESCO may bear all costs to design, install, operate, and maintain energy systems including GHPs, as with the Fort Polk project (see Case Study on page 5). The ESCO guarantees a minimum level of cost savings to the facility owner. In return, the ESCO receives a percentage of energy and maintenance cost savings during the contract term. An ESPC is established for a defined period of time, usually 10 to 20 years. After that time, all energy savings and the GHP equipment go to the facility owner.

Federal agencies are using the Indefinite Delivery, Indefinite Quantity (IDIQ) contract form to streamline the ESPC process. DOE's vision of a streamlined ESPC process is called the "Super ESPC." Under the Super ESPC process, a small group of ESCOs receive IDIQ contracts based on competition; and thereafter, Federal agency sites can select a preapproved ESCO and implement projects as delivery orders. Compared to ESPC projects, contracts can be awarded under the Super ESPC process in months rather than years.

DOE Selects ESCOs for GHP Super ESPC

In early 1999, DOE chose five companies, through a competitive process, as ESCOs to finance and manage projects valued at as much as $500 million for the installation of GHP systems at military bases and other Federal agency sites.

The first ESCO project under this program will replace about 1200 tons of cooling capacity of outmoded conventional HVAC systems at two U.S. Navy sites near Virginia Beach, Virginia. The buildings in the Navy's initial project, covering nearly 350,000 square feet, are a mix of offices, training facilities, hangars, shops, barracks, a cafeteria, and a lounge.

Any of the approximately 500,000 Federal buildings in the 50 states, District of Columbia, or U.S. Territories may be upgraded using these contracts, provided that pay-from-savings GHP projects are feasible. The ESCOs selected under this GHP Super ESPC are:

- Constellation Energy Source, Baltimore, MD (410) 468-3850
- Duke Solutions, Inc., Charlotte, NC (704) 382-1190
- Exelon Energy Services Inc., King of Prussia, PA (610) 278-6633
- The Enron Team: Co-Energy Group, Las Vegas, NV; Enron Energy Services, Houston, TX; and The Bentley Company, San Ramon, CA (925) 543-3848
- Trane Company Asset Management Services, St. Paul, MN (651) 407-3852

Utility Area-Wide Contracts

Besides using ESPCs to obtain GHP systems, Federal facility managers may have another option—a Utility Area-Wide contract. This contract is an agreement made specifically between the General Services Administration (GSA) and a utility for a range of utility services, including energy saving services. Once the GSA signs an area-wide contract, any agency in the utility's service area can use it. Therefore, an agency can quickly start an energy savings project without a lengthy bid process.

GSA area-wide contracts spell out the general terms and conditions of service; contain all applicable Federal clauses; and provide simple, standardized instructions for Federal agency use. Agencies can use these contracts for either renovation, like the Little Rock Air Force Base (see Case Study on page 5), or for new construction projects. The contracts also allow agencies to negotiate special electric rates and to satisfy any unusual utility requirements. These special arrangements are included in an addendum to an agency's funding authorization form. Area-wide contracts are usually awarded for a period of 10 years, but they may be renewed.

> *"Energy Savings Performance Contracts (ESPCs), which are authorized under the National Energy Conservation Policy Act…, provide significant opportunities for making Federal buildings more energy efficient at little or no cost to taxpayers. Under ESPC authority, agencies can contract with private energy service companies to retrofit Federal buildings with no up-front payments by the government."*
>
> President Bill Clinton, July 25, 1998

FEMP

The mission of the DOE Federal Energy Management Program (FEMP) is to reduce the cost of Government by advancing energy efficiency, water conservation, and the use of solar and other renewable energy. FEMP is a customer-focused organization providing services to other Federal agencies. With FEMP assistance, agencies can acquire the skills, the means, and the initiative to undertake projects to use energy and water more efficiently; and promote the use of renewable resources. FEMP (see *For More Information* on page 6) sponsors several technical and procurement assistance programs.

FEMP Service Network

The FEMP Service Network (FSN) assists Federal agencies in getting their energy projects completed. The near-term focus of the network is on helping Federal agencies use DOE's Super ESPCs, GSA's Utility Area-Wide contracts, and technical assistance services such as SAVEnergy audits. FSN is a virtual organization of several partners, including DOE offices, DOE national laboratories, and private sector contractors. See *For More Information* on page 6 for contact information about FSN.

U.S. Air Force/PIX07642

Little Rock Air Force Base used a Utility Area-Wide contract to install 1,547 GHP units.

Case Study—Little Rock Air Force Base

Like many Federal facilities, the Little Rock Air Force Base (LRAFB) had to find ways to cut energy costs up to 30% by 2005, as required by Executive Order 12902. In 1996, after careful life-cycle cost and payback analysis, GHP systems were chosen to replace 20-year-old, air-source heat pumps in 1,535 residential housing units. Because some housing units required more than one GHP, 1,547 GHP systems actually were installed. Half of them are 1½-ton units, while the other half are 2-ton units.

Through a Utility Area-Wide contract, LRAFB contracted with Entergy in Searcy, Arkansas, to manage the GHP system's design and installation. Entergy provided all up-front capital, and the project is financed through savings on electricity consumption and maintenance.

As a result of this GHP project, LRAFB expects to save taxpayers annually more than $1 million in electricity costs and $285,000 in maintenance expenses. It's also expected that a 16% reduction will be achieved in overall total annual electricity usage at LRAFB.

> *"The beauty of the Fort Polk Energy Savings Performance Contract is that the onus to save BTUs is on the contractor. I'm a happy camper knowing that I have a single entity that I am going to deal with over the next 20 years, an entity with a profit motivation for saving energy and maintenance dollars."*
>
> Jim Kelley, Manager of Engineering and Planning, Public Works, Fort Polk, LA

In the end, the GHP project at LRAFB is projected to account for 22% of the 30% savings required by the Executive Order. Other energy-efficient improvements (e.g., more efficient lighting retrofits) also installed as part of the project will provide the balance of additional savings.

Case Study—Fort Polk Army Base

A great example of a large-scale, highly successful application of GHPs can be found at Fort Polk, Louisiana, where 4,003 U. S. Army housing units were converted to use GHP systems. Since the new systems were installed, service calls on hot summer days have dropped from about 100 per day to just a few, testifying to the reliability of GHP systems. Financed by Co-Energy Group, a GHP ESCO, the project imposed no up-front costs on the Government. The $18 million contract was signed in February 1994, and the installation was completed in August 1996. At the time of installation, this project was the nation's largest completed ESPC. It is still the largest installation of GHPs in the world.

Before, during, and after the retrofits, statistically valid data were collected on the utility feeders serving the housing area and on a sample of apartments. The GHPs and other efficiency measures reduced electrical consumption by 26 million kWh (average of 6,445 kWh per housing unit) or 33% of the pre-retrofit whole-house electric consumption, and reduced natural gas consumption by 100%. It also reduced summer peak demand by 7.5 megawatts or by 43%, and improved the annual electric load factor from 0.52 to 0.62. These energy savings correspond to an estimated reduction in carbon dioxide emissions of 22,400 tons per year.

As the ESCO, Co-Energy receives payments amounting to 80% of the energy cost savings while providing maintenance during the life of the 20-year contract. For maintenance, the Army pays Co-Energy annually about 18 cents per square foot, saving the Army about 22% compared with baseline maintenance costs.

Oak Ridge National Laboratory/PIX07067

Fort Polk Army Base is being carefully monitored to measure savings.

Fort Polk Receives Special Award

In 1997, the Fort Polk project received Vice President Al Gore's Hammer Award for "hammering away at building a better Government"—one that works better and costs less. This award, one of the Clinton Administration's highest, is given to individuals or groups who have demonstrated exemplary reinvention of Government.

For More Information

The following organizations serve as excellent resources for information on geothermal energy and its various applications.

U.S. Department of Energy (DOE)
Office of Geothermal Technologies, EE-12
1000 Independence Avenue, SW
Washington, DC 20585-0121
(202) 586-5340
http://www.eren.doe.gov/geothermal/

DOE's Federal Energy Management Program
Doug Culbreth, Contracting Officer's Representative
National Technology-Specific GHP Super ESPC
221 Elwood Drive
Raleigh, NC 27609
(919) 782-5238
Fax: (919) 788-0996
e-mail: carson.culbreth@hq.doe.gov
http://www.eren.doe.gov/femp/financing/tecspec.html

DOE's Oak Ridge National Laboratory
Patrick Hughes, Technical Team Leader
FEMP's National Technology-Specific GHP Program
P.O. Box 2008, Bldg. 3147, MS 6070
Oak Ridge, TN 37831-6070
(423) 574-9337
e-mail: pj1@ornl.gov

Geothermal Heat Pump Consortium, Inc. (GHPC)
701 Pennsylvania Avenue, NW
Washington, DC 20004-2696
(888) ALL-4-GEO (255-4436)
http://www.geoexchange.org/

International Ground Source Heat Pump Association (IGSHPA)
490 Cordell South
Stillwater, OK 74078-8018
(405) 744-5175
(800) 626-4747
http://www.igshpa.okstate.edu/

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U.S. Army Cold Regions Lab
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