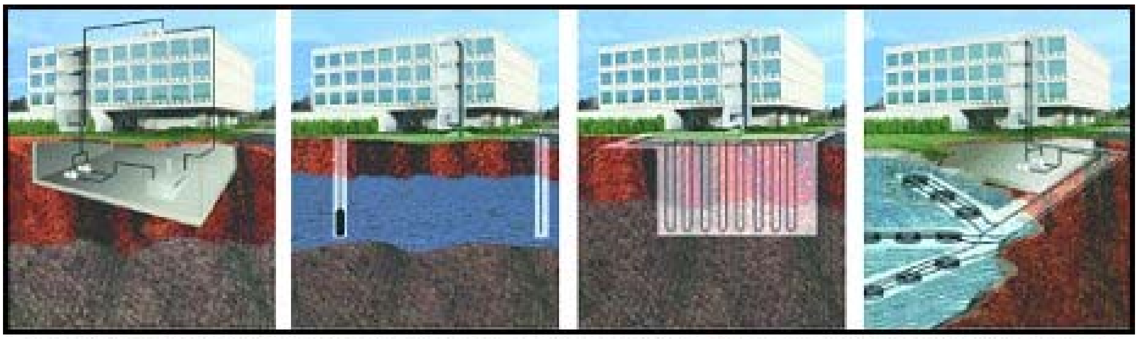
Ground-source Heat Pumps (Geothermal Heat Pumps)

지열식 열펌프



Ground-source Heat Pums use the earth, water or groundwater for heating and cooling.
Credit: Waterfurnace International

Definition

A ground-source heat pump extracts solar heat stored in the upper layers of the earth; the heat is then delivered to a building.

정 의

지열을 이용하는 열펌프란 지각의 상층부에 저장된 열을 회수하여 건물에 전달하는 장치를 말한다.

Building Use

- lowrise office
- lowrise apartment
- retail
- food service
- institutional

Building Type

- new
- retrofit

Development Status

- new technology

적용건물

- 저층 사무실
- 저층 아파트
- 소규모 상점
- 음식점
- 교육기관

건물종류

- 신축
- 리트로핏

개발단계

- 신기술

Description

Ground-source heat pumps (GSHP) can reduce the energy required for space heating, cooling and service water- heating in commercial/institutional buildings by as much as 50%. Ground-source heat pumps replace the need for a boiler in winter by utilizing heat stored in the ground; this heat is upgraded by a vapour-compressor refrigeration cycle. In summer, heat from a building is rejected to the ground. This eliminates the need for a cooling tower or heat rejector, and also lowers operating costs because the ground is cooler than the outdoor air.

개 요

지열식 열펌프(GSHP)는 상업용 및 산업용 건물에서 필요로 하는 냉난방 및 급탕용 에너지의 50% 가까이를 절감할 수 있다. 지열식 열펌프는 땅 속에 저장된 열을 이용함으로써 겨울철의 경우 보일러를 대신하게 되는데, 이 열은 증기압축 냉동사이클을 통해 더욱 증가하게 된다. 여름철에는 건물 내에서 발생한 열을 땅 속으로 배출하는 작용을 한다. 이에 따라 냉각탑이나 제열기가 필요치 않게 되며, 지중온도가 외기온도보다 낮기 때문에 운전비용 또한 절감할 수 있다.

Water-to-air heat pumps are typically installed throughout a building with duct work serving only the immediate zone; a two-pipe water distribution system conveys water to and from the ground-source heat exchanger. The heat exchanger field consists of a grid of vertical boreholes with plastic u-tube heat exchangers connected in parallel. Simultaneous heating and cooling can occur throughout the building, as individual heat pumps, controlled by zone thermostats, can operate in heating or cooling mode as required.

일반적으로 수공기식 열펌프는 건물 전체에 설치되어 덕트를 통해 인접한 존에만 공급을 하게 된다. 2관식 수공급 시스템은 지열 열교환기와 물을 순환시키게 된다. 열 교환기 부분은 병렬로 연결된 플라스틱 U-튜브 형태의 열 교환기들과 수직의 시추공 형태의 격자로 구성된다. 건물 전체에 걸쳐 냉방과 난방이 동시에 발생할 수 있는데, 각 존의 온도조절장치에 의해 제어되는 개개의 열펌프들이 각 존에서 요구되는 냉방 또는 난방 모드로 운전되어 진다.

Unlike conventional boiler/cooling tower type water loop heat pumps, the heat pumps used in GSHP applications are generally designed to operate at lower inlet-water temperature. GSHP are also more efficient than conventional heat pumps, with higher COPs and EERs. Because there are lower water temperatures in the two-pipe loop, piping needs to be insulated to prevent sweating; in addition, a larger circulation pump is needed because the units are slightly larger in the perimeter zones requiring larger flows.

전형적인 보일러/냉각탑 형식의 수순환 열펌프와 달리, GSHP 시스템에서 적용되는 열펌프는 일반적으로 저온의 급수온도에서 운전되도록 설계된다. GSHP 시스템은 높은 COP와 EER로 인해 전형적인 열펌프보다 더욱 효율적이다. 2관식 순환시스템에서 수온이 더 낮기 때문에 배관은 열손실을 막기 위해 반드시 단열처리가 되어야 한다. 또한 보다 큰 유량을 필요로 하는 외주부 존에서는 유닛이 약간 커지기 때문에 순환펌프 역시 커져야 한다.

Ground-source heat pumps reduce energy use and hence atmospheric emissions. Conventional boilers and their associated emissions are eliminated, since no supplementary form of energy is usually required. Typically, single packaged heat pump units have no field refrigerant connections and thus have significantly lower refrigerant leakage compared to central chiller systems.

지열식 열펌프는 에너지 소비를 줄여 대기로의 발열을 감소시킨다. 전통적인 보일러 및 이에 따른 발열이 제거되므로 대개 보조적인 에너지의 공급이 불필요하게 된다. 전형적인 단일 패키지형태의 열펌프 유닛은 냉매 연결부분이 없으므로 중앙식 냉동기 시스템에 비해 냉매 누출의 위험이 상당히 감소하게 된다.

GSHP units have life spans of 20 years or more. The two-pipe water-loop system typically used allows for unit placement changes to accommodate new tenants or changes in building use. The plastic piping used in the heat exchanger should last as long as the building itself.

GSHP 유닛의 수명은 20년 이상이다. 일반적으로 이용되는 2관식 수순환 시스템은 건물 이용상의 변화 또는 새로운 세입자를 위하여 유닛의 위치를 변경할 수 있다. 열 교환기에서 쓰이는 플라스틱 배관은 건물 수명만큼 이용할 수 있다.

When the system is disassembled, attention must be given to the removal and recycling of the HCFC or HFC refrigerants used in the heat pumps themselves and the anti-freeze solution typically used in the ground heat exchanger.

시스템을 해체할 경우, 열펌프에 사용되는 HCFC 또는 HFC 냉매와 지중 열교환기에서 일반적으로 사용되는 부동액의 제거와 재사용에 주의를 기울여야 한다.

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Benefits

- Requires less mechanical room space
- Requires less outdoor equipment
- Does not require roof penetrations, maintenance decks or architectural blends
- Quiet operation
- Reduces operation and maintenance costs

장 점

- 기계실 면적의 감소
- 외부 설비기기의 감소
- 옥상을 관통하거나 설비를 위한 층을 설치하는 것과 같은 건축적 고려가 불필요
- 저소음 운전
- 운전 및 유지관리비 절감

Limitations

- Requires surface area for heat exchanger field
- Higher initial cost
- Requires additional site co-ordination and supervision
- Higher design cost

문제점

- 열 교환기 부분을 위한 면적 필요
- 높은 초기 투자비
- 추가적인 대지 조성 및 관리 필요
- 높은 설계 비용

Application

The most economic application of ground-source heat pumps is in buildings that require significant space/water heating and cooling over extended hours of operation. Examples are retirement communities, multi-family complexes and schools. Building types not well-suited to the technology are retail shopping malls, large office buildings

적용방안

건물에서 지열식 열펌프를 가장 경제적으로 적용하기 위해서는 운전시간을 확대하여 냉난방 및 급탕량을 크게 할 필요가 있다. 그 예로써 퇴직자 커뮤니티 센터, 다가구 복합건물 및 학교 등이 있다. 그러나 난방 및 급탕 부하가 상대적으로 작거나 사용 시간이 제한적인 건물 및 대형 사무소건물과 소매 상가에는 이러한 기술을 적용하기가 쉽지 않다.

and other buildings where space and water heating loads are relatively small or where hours of use are limited.

Experience

Many buildings in Canada have ground-source heat pump systems, including over 50 schools in Ontario, many within the York Region Roman Catholic, Dufferin Peel Roman Catholic and Lambton County School Boards.

사 례

York 지방 로만 가톨릭, Dufferin Peel 로만 가톨릭과 Lambton 카운티 학교를 비롯한 Ontario의 50개 이상의 학교를 포함하여 캐나다에서는 많은 건물에 지열식 열펌프가 적용되고 있다.

Cost

Ground-source heat pump HVAC systems range from C$22 to $165/$m^2$, depending on heat source, location of building and cost of drilling. An average cost is in the range of C$85/$m^2$. Approximately 20% of the total energy costs of a building can be saved with the introduction of a GSHP system in most parts of Canada.

비 용

지열식 열펌프를 이용한 공조 시스템에 소요되는 비용은 1m^2당 22~165 캐나다달러 수준으로, 이것은 열원과 건물의 위치 및 천공 비용에 따라 달라지며, 평균 85 캐나다달러/m^2 정도이다. 캐나다 대부분의 지역에서 지열식 열펌프시스템을 도입함으로써 약 20% 정도의 에너지 소비를 절감할 수 있다.

Example Manufacturers

WaterFurnace International
9000 Conservation Way
Fort Wayne IN
USA 46809
tel 1 800 222 5667
fax 1 219 479 3272
www.waterfurnace.com

ClimateMaster Inc.
7300 Southwest 44th Street
Oklahoma City OK
USA 73179
tel 1 405 745 6000
fax 1 450 745 6058
info@climatemaster.com
www.climatemaster.com

Canadian GeoSolar Ltd.
640 Gartshore Street
Box 249 Fergus ON
Canada N1M 2W8
tel 1 519 843 3393
fax 1 519 843 6944

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Canadian GeoSolar Ltd.
640 Gartshore Street
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Canada N1M 2W8
tel 1 519 843 3393
fax 1 519 843 6944

Information Sources

ASHRAE Commercial/Institutional Ground-Source Heat Pump Engineering Manual, ASHRAE
1791 Tullie Circle NE
Atlanta GA
USA 30329-2305
tel 1 404 636 8400
fax 1 404 321 5478
www.ashrae.org/book/bookshop.htm

GS-2000TM is a computer program for designing and sizing ground heat exchangers for these systems.
Caneta Research Inc.
7145 West Credit Avenue
Suite 102, Building 2
Mississaga ON
Canada L5N 6J7
tel 1 905 542 2890
fax 1 905 542 3160

Canadian Earth Energy Association
130 Slater Street
Suite 1050
Ottawa ON
Canada K1P 6E2
tel 1 613 230 2332
fax 1 613 237 1480
www.earthenergy.org

The Energy Outlet

Natural Resources Canada's RETScreen software for renewable energy analysis
retscreen.gc.ca

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ASHRAE Commercial/Institutional Ground-Source Heat Pump Engineering Manual, ASHRAE
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Natural Resources Canada's RETScreen software for renewable energy analysis
retscreen.gc.ca

※ Appendix : 관련 Web-site

▷ UNEP (http://www.unep.or.kr) : United Nations Environment Programme

☞ http://unep.or.kr/energy/geothermal/geo_heatpump.htm

Geothermal Heat Pumps

Geothermal heat pumps, such as this commercial-size system on the Georgia Tech campus, use the relatively constant temperature of the Earth at shallow depths to warm buildings in the winter and cool them in the summer.

The geothermal heat pump, also known as the ground source heat pump, is a highly efficient renewable energy technology that is gaining wide acceptance for both residential and commercial buildings. Geothermal heat pumps are used for space heating and cooling, as well as water heating. Its great advantage is that it works by concentrating naturally existing heat, rather than by producing heat through combustion of fossil fuels.

The technology relies on the fact that the Earth (beneath the surface) remains at a relatively constant temperature throughout the year, warmer than the air above it during the winter and cooler in the summer, very much like a cave. The geothermal heat pump takes advantage of this by transferring heat stored in the Earth or in ground water into a building during the winter, and transferring it out of the building and back into the ground during the summer. The ground, in other words, acts as a heat source in winter and a heat sink in summer.

The system includes three principal components:

- Geothermal earth connection subsystem
- Geothermal heat pump subsystem
- Geothermal heat distribution subsystem.

Earth Connection

Using the Earth as a heat source/sink, a series of pipes, commonly called a "loop," is buried in the ground near the building to be conditioned. The loop can be buried either vertically or horizontally. It circulates a fluid (water, or a mixture of water and antifreeze) that absorbs heat from, or relinquishes heat to, the surrounding soil, depending on whether the ambient air is colder or warmer than the soil.

Heat Pump

For heating, a geothermal heat pump removes the heat from the fluid in the Earth connection, concentrates it, and then transfers it to the building. For cooling, the process is reversed.

Heat Distribution

Conventional ductwork is generally used to distribute heated or cooled air from the geothermal heat pump throughout the building.

Residential Hot Water

In addition to space conditioning, geothermal heat pumps can be used to provide domestic hot water when the system is operating. Many residential systems are now equipped with desuperheaters that transfer excess heat from the geothermal heat pump's compressor to the house's hot water tank. A desuperheater provides no hot water during the spring and fall when the geothermal heat pump system is not operating; however, because the geothermal heat pump is so much more efficient than other means of water heating, manufacturers are beginning to offer "full demand" systems that use a separate heat exchanger to meet all of a household's hot water needs. These units cost-effectively provide hot water as quickly as any competing system.

Environmental and Energy Benefits of Geothermal Heat Pumps

Geothermal heat pumps are among the most energy- and cost-efficient heating and cooling systems available today. They use less electricity and produce fewer emissions than conventional systems, reduce air and water pollution, and provide a comfortable indoor environment for building occupants. About 500,000 geothermal heat pumps are being used today for heating and cooling throughout the United States in residential, commercial, and government buildings.

Overview

Geothermal heat pumps (GHPs) represent a major clean energy technology. As a commercially viable technology now, GHPs are well positioned to help our nation achieve the increasingly desirable benefits of more efficient, clean energy technologies. While the consumer benefits from the economic and comfort-related benefits of using GHPs, everyone benefits from the substantial environmental and energy benefits resulting from GHP use, especially as GHPs become more widespread in the market. The geothermal heat pump is ideal for residential, commercial, and government building applications. Understanding the environmental and energy benefits of GHPs helps broaden appreciation of the overall potential of this outstanding technology.

Achieving the present market penetration level of 400,000 GHP installations reduces U.S. greenhouse gas emissions by over 1 million metric tons of carbon dioxide each year. In a landmark technical report (source: "Space Conditioning: The Next Frontier," EPA 430-R-93-004, April 1993). the U.S. Environmental Protection Agency (EPA) found that GHPs are the most energy efficient, environmentally clean, and cost-effective space-conditioning systems available. The EPA also found that GHPs offer the lowest carbon dioxide emissions and lowest overall environmental cost of all the residential space-conditioning technology readily available today. The few emissions that are released occur at the power plant, where they are carefully monitored and controlled.

Energy Under Foot

Resource Conservation

Over two-thirds of the nation's electrical energy and over 40% of natural gas consumption is used in buildings. Space heating and cooling and water heating account for over 40% of the electric power used in residential and commercial buildings. By decreasing or offsetting the amount of energy needed for space conditioning and water heating, the nation has a major energy-saving opportunity.

GHPs, also known as GeoExchangeSM systems, move the heat from the earth (or a groundwater source) into the home in the winter, and pull the heat from the house and discharge it into the ground in the summer. The underground (or underwater) piping loops serve as a heat source in the winter and a heat sink in the summer. In essence, it's the same heat-exchanging process used by the common refrigerator or air conditioner.

While many parts of the country experience seasonal temperature extremes?from scorching heat in the summer to sub-zero cold in the winter?a few feet below the earth's surface the ground remains at a relatively constant temperature.

Because a GHP system is so efficient, it uses a lot less energy to maintain comfortable indoor temperatures. This means that less energy?often created from burning fossil fuels?is needed to operate a GHP. According to the EPA, geothermal heat pumps can reduce energy consumption?and corresponding emissions?up to 44% compared to air-source heat pumps and up to 72% compared to electric resistance heating with standard air-conditioning equipment for residential applications.

Environmental Benefits

Greenhouse Gas Mitigation and Emissions Reductions

Nearly 40% of all U.S. emissions of carbon dioxide are the result of using energy to heat, cool, and provide hot water for buildings. This is about the same percentage that the transportation sector contributes. The EPA found that under most electricity generating scenarios, GHP systems have the lowest carbon dioxide emissions of all technologies analyzed, and the lowest overall environmental cost (source: "Space Conditioning: The Next Frontier").

Over an average 20-year lifespan, every 100,000 units of nominally sized residential GHPs will save more than 24 trillion BTUs of electrical energy, and save consumers approximately $500 million in heating and cooling costs at current prices. And over the same period, these 100,000 units reduce greenhouse gas emissions by almost 1.1 million metric tons of carbon equivalents.

Ozone Layer Damage

GHPs minimize ozone layer destruction by using factory-sealed refrigeration systems that will seldom or never have to be recharged. GHPs typically use less refrigerant than conventional air-conditioning systems. And using factory-sealed refrigeration systems also reduces leak potential from field connections and increases reliability.

Human Health and Comfort

GHPs are safe and clean because there are no combustion flames, no flues, and no odors; just safe, reliable operation year after year. And compared to most conventional HVAC systems, GHPs deliver constant comfort and improved humidity benefits, especially with 2-speed fan GHP systems. GHPs are quiet too; there's no noisy outdoor compressor.

GHP systems themselves are environmentally friendly?when properly installed, there is no danger of GHPs polluting ground water sources. The fluid in the ground-loop heat exchangers is typically an environmentally safe, water-based antifreeze solution. A recent EPA analysis ("Evaluation of Consequences of Anti- freeze Spills from Geothermal Heat Pumps," undated EPA report released in late 1998, GPO#1998-615-003/60624) found that the human health risk from ingesting groundwater contaminated by a GHP antifreeze leak is low.

Impressive Market Growth in case of United States

The present installation base of about 400,000 GHP systems comprises just a fraction of the technology's potential applications. Today, GHPs represent a rapidly growing sector of the heating and cooling industry. In 1997, the GHPC reported an annual growth rate of 22%. GHP sales grew even faster?24%?during the first quarter of 1998, according to data collected by the Air Conditioning and Refrigeration Institute.

A tremendous opportunity exists to reduce energy use and carbon emissions significantly by the accelerated and expanded deployment of GHP systems.

Case Study - Fort Polk Army Base in the United States

A great example of a large-scale application of GHPs is the highly successful project at Fort Polk, Louisiana, where 4,003 U.S. Army housing units at Ft. Polk were converted to GHPs. Since the new systems were installed, service calls on hot summer days have dropped from 90 per day to almost zero, testifying to the reliability of GHP systems.

Data were collected on the utility feeders serving the housing area, and on a sample of apartments before, during, and after the retrofits. The GHPs and other efficiency measures reduced electrical consumption by 26 million kWh (average of 6,445 kWh per housing unit) or 32% of the pre-retrofit consumption, as well as 100% of natural gas consumption. It also reduced summer peak demand by 7.5 megawatts, which is 43% of the pre-retrofit electrical consumption in family housing, and improved the 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, which gives project participants "green" bragging rights immediately.

As demonstrated by this Fort Polk project, GHPs shave peak loads and improve load factors. At Fort Polk, the whole-house load factor for a house with gas heating and water heating was 0.32 versus 0.60 for the GHP house.

Financed by Co-Energy Group, a GHP energy service company, the project bears no up-front costs to the government. The $18 million contract was signed in February 1994, and the installation was completed in August 1996. The contractor will receive payments amounting to

80% of the energy savings while providing maintenance during the life of the twenty-year contract. For maintenance, the Army will pay Co-Energy about 18 cents per square foot per year, saving the Army about 22% compared with previous maintenance costs.

At the time of installation, this project was the nation's largest energy savings performance contract (ESPC). Since this pioneer GHP project, both DOE and the Department of Defense have established a "Super ESPC" program. The agencies, through a competitive bid process, prequalify energy service companies based on past performance and their ability to finance work. Once selected, these energy service companies will be able to sign contracts with any federal agency within a matter of months?much quicker than the normal bid process. DOE's Federal Energy Management Program and Office of Geothermal Technologies have developed a technology-specific Super ESPC for geothermal heat pumps for all federal agencies.

The Fort Polk project received Vice President Al Gore's Hammer Award in 1997 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.

Geothermal Links

Geothermal Resources Council http://www.geothermal.org/index.html

Is an educational association with useful databases of geothermal energy information as well as an overview of the organization itself.

International Geothermal Association (IGA)

http://www.demon.co.uk/geosci/igahome.html

Geothermal Education Office (GEO)

http://geothermal.marin.org

Geothermal Energy Association (GEA)

http://www.geo-energy.org

GEOTHERMAL INDUSTRY LINKS http://www.geothermal.org/links.html

California Department of Conservation http://www.consrv.ca.gov/dog/geo.html

University Level Geothermal Information

Energy & Geoscience Institute, University of Utah

http://www.egi.utah.edu/geothermal/geothermal.htm

Geo-Heat Center-Oregon Institute of Technology (GHC-OIT) http://geoheat.oit.edu/

Lawrence Berkeley National Laboratory http://www-esd.lbl.gov/ER/geothermal.html

National Renewable Energy Laboratory http://www.nrel.gov/geothermal/

Southern Methodist University Geothermal Program http://www2.smu.edu/geothermal/

Stanford University Geothermal Program http://ekofisk.stanford.edu/geotherm.html

University of Auckland New Zealand http://www2.auckland.ac.nz/gei/

Virginia Tech Geothermal http://rglsun1.geol.vt.edu/

International Ground Source Heat Pump Association http://www.igshpa.okstate.edu/

Geothermal Heat Pump Consortium (GHPC) http://www.ghpc.org/

Geothermal Related and Technical Information Sites

California Energy Commission, Geothermal Energy http://www.energy.ca.gov/geothermal

Geothermal Energy Association http://www.geo-energy.org

International Geothermal Assocation http://www.demon.co.uk/geosci/igahome.html

Idaho National Enginering and Environmental Laboratory/ Geothermal Programme http://www.inel.gov/x-web/other/framed.shtml?http://geothermal.id.doe.gov

New Zealand Geothermal Association http://www.voyager.co.nz/~tking/nzgahome.html

Sandia National Laboratories, Geothermal Research Department http://www.sandia.gov/geothermal/

Solstice: Sustainable Energy and Development Online

The World Bank/Geothermal Programme http://www.worldbank.org/html/fpd/energy/geothermal/index.htm

U.S. DOE, Energy Efficiency and Renewable Energy Network (EREN)

U.S. Department of Energy, Energy Information Administration

U.S. Department of Energy Technical Site

U.S. Geological Survey

Associations

Geothermal Energy Association http://www.geotherm.org

U. S. industry trade association

Geothermal Heat Pump Consortium http://www.ghpc.org

Industry trade group for geothermal heat pumps

Geothermal Resources Council http://www.geothermal.org/index.html

International trade association

International Geothermal Association (IGA) http://www.demon.co.uk/geosci/igahome.html

International trade and advocacy group

Government

State Energy Alternatives - Technologies: Geothermal http://erendev/state_energy/technology_content.cfm?techid=5

State-by-state snapshot of renewable energy resources, technologies, and policies

FEMP - Geothermal Heat Pump Technical Resources http://www.eren.doe.gov/femp/financing/ghpresources.html

The Federal Energy Management Program works to incorporate renewable technologies in federal buidlings.

◎ 지열이용 냉방/난방 급탕 시스템 - (유)솔라하트
(http://www.solar1.co.kr/mainb-b2.htm)

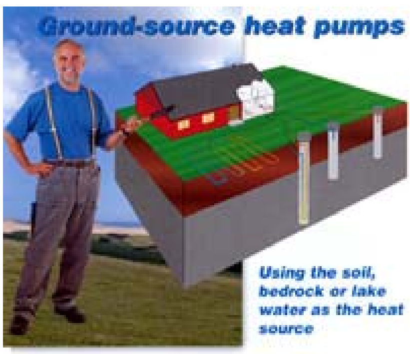
※ 지열이용 ‘파이터’

1. **품명** : GROUND-SOURCE HEAT PUMP SYSTEM
2. **용도**
   - 그린하우스, 지중난방 등 열에너지 수요처에 다양하게 적용가능
   - 열교환기(수냉식, 공랭식)를 별도 장착하여 냉방가능
3. **에너지원** : 지열
4. **특장점** : 열원공급이 안정적이고 영구적이며 환경친화적이다.
5. **제품적용방법** : Model 1310기준
   - 지열을 이용할 수 있는 관정수량 및 깊이
     - 관정수량 : 3EA
     - 관정깊이 : 150m
   - 관정관경 : 150mm
   - 관정간거리 : 15m~20m
   - 관정내배관 : 엑셀 30mm~40mm이용
   - 기타사항 : 안내자료참조(히트펌프용 에너지공)
6. **경제성비교(Model 1310)**

분　류	농사용전기를 사용한 제품	일반전기를 사용한 제품	비　　고
전기사용료	37원/kw	70원/kw	
히트펌프(파이터)	8~10원/kw	15.2~20원/kw	COP 4.6~3.5kw

7. **제품사양**

모델명	Fighter1110	Fighter1210	Fighter1310	비　고
열생산능력	15kwh	10kwh	30kwh	
성적계수	4.6~3.5	4.7~3.5	4.6~3.5	전기 1kw 투입시(압축기기동전력) 4.6kw~3.5kw의 에너지 생산능력표시
제품규격(mm)	965×600×600	175×600×600	1475×600×600	
무게	230kg	310kg	370kg	
전압	380V/3P	380V/3P	380V/3P	
냉매	R407C	R407C	R407C	



※ 히트 펌프용 에너지공(孔)

1. 히트펌프에 공급되는 열원?
   - 히트펌프는 열원으로부터 열을 획득하여 실내의 열사용 기구로 운송하는 장치이다.
   - 가장 안정된 열원으로는 지하암반과 지하수가 있으며, 지하암반을 덮히는 열에너지는 하절기 태양방사와 강우를 통해 얻는 열, 그리고 지구 내부로부터 얻은 열이다.
2. 지하 암반은 어디에나 있는가?
   - 지하암반은 어디에나 있는데 기반암과 퇴적암의 두 가지로 나뉜다. 기반암과 퇴적암 모두 열에너지 추출에 사용되나, 열전도율에서 차이가 있어 기반암에서 더욱 많은 열을 뽑아낼 수 있다. 이 말은 같은 양의 열을 추출하기 위해 퇴적암인 경우에는 더 깊이 굴착해야 한다는 뜻이다.
3. 기반암에 도달하기 위한 굴착 깊이는?
   - 암반에 도달하기 위해서는 토사층을 굴착해야하는데 토사층의 깊이는 지역에 따라 다르나 대개 7m정도의 두께이다.
   - 에너지 측면에서 보면 토사층은 상대적으로 적은 에너지를 함유하고 있는데 보통 암반층의 1/3수준이다.
4. 히트펌프를 설치하기 위한 타공의 깊이는?
   - 에너지공의 타공깊이는 에너지 소요량에 의해 결정된다. 타공의 깊이는 대개 지표로부터 지하암반까지의 깊이에 따라 달라지는데, 토사층을 타공할 때는 "케이싱"이라고 부르는 금속튜브를 설치해야 하는데 이 "케이싱"은 최소 암반 속 2m까지 되어야 한다. 따라서 에너지공을 타공하는데 있어 가장 비용이 많이 드는 부분이 바로 이 "케이싱"작업이다.
5. 지하 암반으로부터 열을 획득할 수 있는 기간은?
   - 적절한 깊이로 에너지공을 설치할 경우 지하 암반으로부터의 열획득은 영구적이다. 일반적으로 계속 작동상태에서 에너지공 1m당 10-30w/m의 열을 획득할 수 있다.
6. 에너지공의 굴착 깊이는?
   - 에너지공의 깊이는 설치하고자하는 [히트펌프]의 용량과 암반의 열전도율에 의해 결정된다. [히트펌프]의 용량이 커질수록 에너지공의 깊이를 깊게 하든지 에너지공의 숫자를 늘려야 한다.
7. 에너지공의 설치위치?
   - 에너지공은 자신의 대지경계 내에 설치되어야 하는데 이웃과의 경계로부터 최소 10m는 떨어져 설치되어야 한다. 또한 히트펌프 설치 위치로부터 가급적 가까운 거리에 에너지공을 설치하는 것이 좋다.
8. 다수의 에너지공을 뚫어야 할 경우는?
   - 상업용이나 학교 등 대규모 열이용 시설에 히트펌프를 설치코자 하면 에너지공의 깊이 또한 깊어져야만 하나 이때는 굴착비용과 굴착기술의 문제가 발생하므로 얕은 에너지공을 여러 개 굴착할 수 있다. 이때 중요한 것은 에너지공간의 거리가 최소 20m는 떨어져야 한다는 점이다. 에너지공이 너무 인접해 있으면 서로간 열을 빼앗겨 계산된 양의 열이 발생되지 않는다. 20m를 떨어져 굴착하기가 어려운 경우에는 에너지공을 경사지게 각도를 주어 타공하여 공간 거리가 10-20m는 유지되도록 한다.
   - 에너지공 1개의 깊이가 105m이상이면 복수공을 굴착하는 것이 좋다.
9. 에너지공과 지하수정간의 거리는?
   - 일반적으로 지질학적, 수문지질학적 조건에 따라 다르나, 타공의 측면에서 약10m정도 간격이면 안전하다. 이때 지하수정의 지하후가 단기적으로 영향받기는 하나 장기적인 위험은 아주 미세하다.

10. 지하수정을 에너지공으로 사용할 수 있나?

- 굴착 공학적 입장에서 지하수정과 에너지공간에 차이는 없다. 따라서 지하수정을 에너지공으로 사용할 수 있다. 다만 집열관이 들어갈 수 있도록 구경이 최소 105mm이상이면 된다.
- 따라서 구경만 확보되면 용수량이 부족하거나 수질이 나쁜 지하수정을 에너지 공으로 재활용할 수 있다.

11. 에너지공의 구경은?

- 에너지공의 구경에 대한 제한 규정은 없으며, 대개 관정 개발업자 들은 115mm, 140mm,165mm 구경의 굴착헤드를 사용한다.
- 에너지공의 구경은 굴착깊이나 필요에너지량등에 의해 결정되어야 하는데, 필요이상으로 구경이 클 필요는 없으나 최소 115mm이상 이면 된다.

12. 에너지공에 "케이싱"을 하는 이유는?

- 에너지공 벽면의 토사층이 무너지거나, 지표수가 흘러드는 것을 방지하기 위해 "케이싱"을 한다.
- "케이싱"은 대개 금속파이프나 플라스틱 파이프를 이용하는데 3m나 6m 길이로 공급되는 파이프를 용접해 이어간다.

13. 물이 없는 빈 공으로부터 에너지를 얻을 수 있나?

- 그렇다. 대부분 에너지공이 완전히 건조한 경우는 드물고 시간이 흐르면 물이 차게 된다. 따라서 에너지 공에 전혀 물이 스며들지 않을 경우에는 인공적으로 물을 채워 넣으면 된다.

14. 에너지공의 내구기간은?

- 에너지공이 에너지를 공급하는 수면은 영구적이다. 다만 에너지공에 사용되는 설치 부품들은 내구년한이 있는데 "케이싱"과 집열기관의 수면은 100년 정도이다.

15. 에너지공을 이용해 냉방을 할 수 있나?

- 수냉식 또는 공냉식 열 교환기를 별도로 설치하며, 에너지공을 이용하여 실내공기 온도를 조절 할 수 있다.
- 이 경우에는 [히트펌프]는 작동되지 않으며 단순한 순환 펌프만 작동하게 된다.

16. 동절기 중 충분한 열량을 확보하기 위해 에너지 공을 가열해야 하는가?

- 물론이다. 하절기중 적절한 열 교환 시스템을 이용하여 더운 실내공기를 에너지 공에 전달하거나 집열호스내의 열전달에너지를 태양열 집열기를 통해 직접가열 할 수 있다.

17. 집열관, 집열매체는 무엇인가?

- 집열관은 히트펌프 본체와 에너지 공을 연결하는 폐쇄형 호스이다. 이 호스는 통상 pvc나 철제 파이프로 구경이 32mm 또는 40mm이다. 이 호스를 에너지 공에 넣을 때는 구부려서는 안되며, U-밴드를 용접하여 관내의 열매체가 자유롭게 흐르도록 해야한다.
- 또한 열매체로는 에탄올을 이용하는데 물과 3:1로 혼합하여 사용한다. 열매체의 사용 목적은 동결방지이다.

18. 집열기의 매설 깊이는?

- 통상 집열기 호스는 지면으로부터 0.5m 정도 깊이로 묻고, 차가운쪽 호스(히트펌프로부터 나와서 에너지 공으로 들어가는 쪽)는 추가적인 보온을 해야 한다.

19. 히트펌프의 에너지 부담율은?

- 전체 년간 에너지 소요량 대비 히트펌프의 에너지 공급량을 에너지 부담율이라 하는데, 통상 년간 소요량의 65~90%를 부담토록 설계한다. 따라서 10-35% 있는 별도의 보조열원이 필요하다.

Renewable Energy Decision Support Centre
(http://www.retscreen.net/ang/g_ground.php)

The RETScreen International Ground-Source Heat Pump Project Model (Version 2000) can be used world-wide to easily evaluate the energy production (or savings), life-cycle costs and greenhouse gas emissions reduction for the heating and/or cooling of residential, commercial, institutional and industrial buildings. The model can be used to evaluate both retrofit and new construction projects using either ground-coupled (horizontal and vertical closed-loop) or groundwater heat pumps.

Improvements found in Version 2000 include:

1) updated Energy Model and Heating & Cooling Load Calculation worksheets that incorporate calculations based on manufacturer specific data for various heat pumps, as well as improvements to the heating and cooling load calculator;
2) an upgraded Cost Analysis worksheet that allows the user to switch currencies, enter custom cost items, build a custom cost database and consider periodic costs;
3) a new Greenhouse Gas (GHG) Emission Reduction Analysis worksheet, developed with UNEP, that allows users to calculate the estimated GHG emissions avoided for the proposed project;
4) an enhanced Financial Summary worksheet that allows for the analysis of income taxes, greenhouse gas reduction credits and a number of other parameters; and
5) new blank worksheets that allow the user to prepare a customised RETScreen project analysis or to develop a companion model to RETScreen.

Version 2000 also includes a number of other new features such as: product, cost and weather databases (ground station data and NASA satellite derived surface meteorology and solar energy data, including mean earth temperature data across the globe); an online manual; and a training course.

(http://www.retscreen.net/ang/12.php)

Renewable Energy Project Analysis: RETScreen Engineering & Cases

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Chapter 1	Introduction to Renewable Energy Project Analysis	
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Chapter 4	Photovoltaic Project Analysis	Photovoltaic Case Studies
Chapter 5	Solar Air Heating Project Analysis	Solar Air Heating Case Studies
Chapter 6	Biomass Heating Project Analysis	Biomass Heating Case Studies
Chapter 7	Solar Water Heating Project Analysis	Solar Water Heating Case Studies
Chapter 8	Passive Solar Heating Project Analysis	Passive Solar Heating Case Studies
Chapter 9	Ground-Source Heat Pump Project Analysis	Ground-Source Heat Pump Case Studies

Chapter 9 – Ground-Source Heat Pump Case Studies						
File Name	Project Name	Country	Location	Assgmt.	Solution	Real Project
GSHP01	Office and Warehouse	Canada	New Brunswick	1A	1B	1C
GSHP02	Single Family Home	USA	Connecticut	2A	2B	2C
GSHP03	School	USA	Tennessee	3A	3B	3C
GSHP04	School	Canada	Quebec	4A	4B	4C
GSHP05	Office Building	Germany	Hessen	5A	5B	5C
GSHP06	Community Hall	Canada	Manitoba	6A	6B	6C
GSHP07	Prison Facility	Canada	Nova Scotia	7A	7B	7C