



An Energy Efficiency Workshop & Exposition
Palm Springs, California

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and
Set pagers to vibrate**



An Energy Efficiency Workshop & Exposition
Palm Springs, California

***New Resources Coming From the Burst
of GHP Project Activity***

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Session 7, Technology Track



What are GHPs?

- Geothermal Heat Pumps (GHPs) Are NOT:
 - Geysers harnessed for power generation
 - Central-station or distributed green power
- GHPs ARE:
 - NEGAWATT generators
 - A form of distributed thermal renewables (like active or passive solar thermal)
 - Means of reducing energy/demand and maintenance costs

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3



GHP History

- Roots starting in 1950s
- 1970s - early 80s: entrepreneurial contractors and manufacturers
- Late 1970s on: rural electric cooperatives
- Early 1980s on: investor-owned utilities
- Early 1990s on: U.S. federal policymakers
- 1990s to present: major U.S. GHP programs

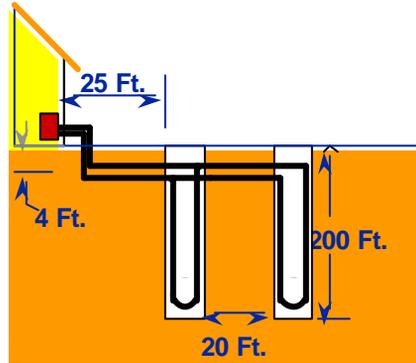
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4



1950's pump & dump ? late 1970's early 1980's closed loop



One Heat Pump on its own Loop

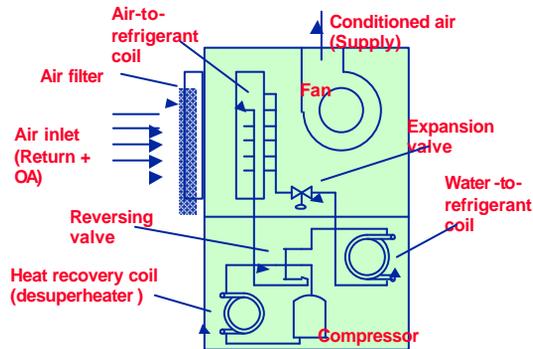
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5



Minor heat pump refinements to enable closed loop



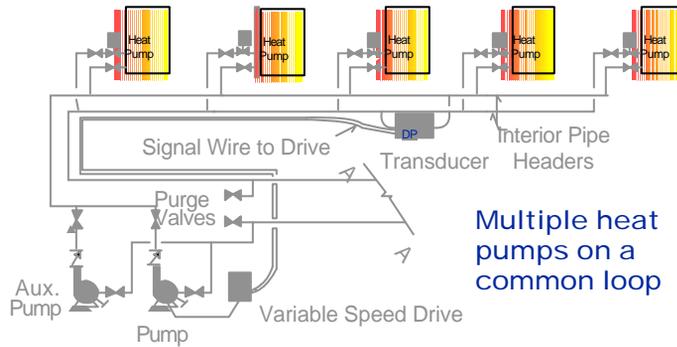
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6



1960's boiler/tower ? early 1980's closed loop



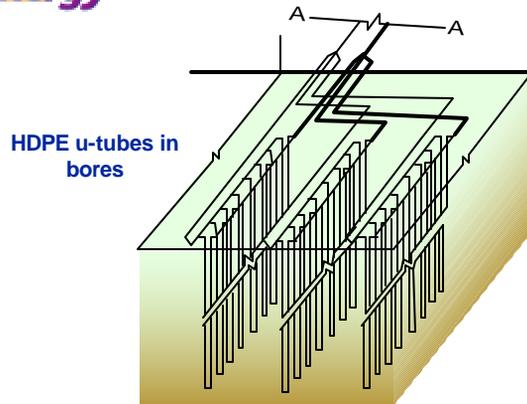
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7



Common Loop Conditioned by Vertical Ground Heat Exchanger



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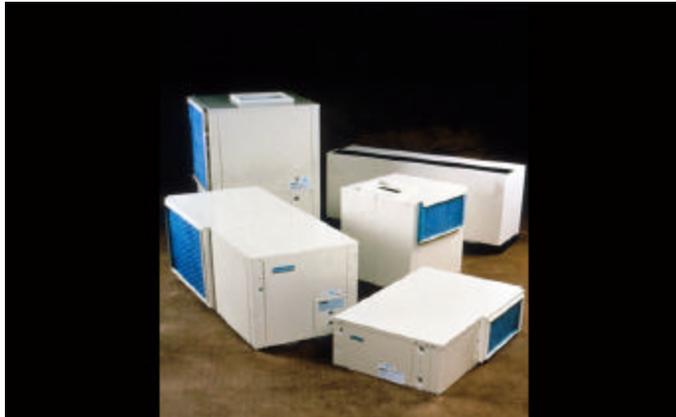
8



Modular approach to large systems



1980's and 1990's – heat pump styles to meet every need





Inherent Efficiencies of GHPs

- Geo is warmer than outside air when heating is required, cooler than air when cooling
- Water-source heat pumps more efficient than air-source
 - only moving air on one side
 - refrigerant-to-water heat exchanger
- No defrost cycles (often no electrical resistance heat) at low outdoor temperatures
- Recovered heat can be put to use
- Good part load performance of entire system

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11



Advantages of GHPs

- Reduced energy costs
 - Less consumption, improved pattern of use
- Reduced HVAC maintenance costs
 - 10-15 cents/SF-yr (rather than 20 or higher)
 - Underground (50 yr HDPE) or indoors (20 yr HPs)
 - Eliminates boiler/tower service
- Simple system – keeps on going
 - Low pressure constant volume air distribution
 - Complex controls not required
 - Decentralized, modular – i.e., reliable
- Requires less building space for equipment
- Lowest life-cycle cost in many applications

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12



Occupant/owner benefits of GHPs

- No central HVAC seasonal switchover discomfort
 - Each zone receives heating/cooling, on demand, year round
- Greater comfort — T-stats per zone, humidity control
- Improved comfort, IAQ ? productivity
- Recognition
 - Energy Star whole building
 - LEED (the 1st LEED platinum building had GHPs)
- If federal, progress toward EO 13123 goals
 - Site energy intensity reduction goal
 - Renewables goal
 - GHG reduction goal

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13



1998-present: Federal Energy Management Program (FEMP) – GHP Emphasis

- V □ Provide credible evidence of benefits to federal agency customers
- Provide expertise agencies can trust (core team)
- Solve universal access to \$ and infrastructure
 - GHP Super Energy Savings Performance Contracts
- Let industry, associations, providers do the selling
 - Support agencies cradle – to – grave (core team)
- Use project experience to advance applications technology

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14



Reasons GHP Use Is Growing

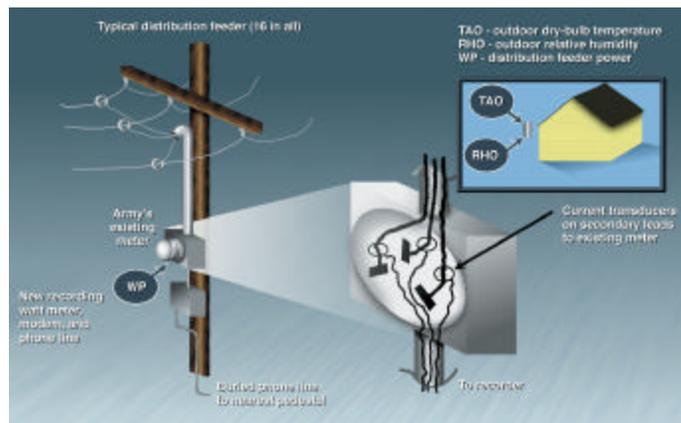
- Claims substantiated by 3rd parties
- Opinion leaders are choosing GHPs
- Comfort in numbers – shipment growth
- Applications technology is advancing
 - GHPs are being worked into the same kinds of tools already supporting conventional HVAC product applications

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15

Ft. Polk 3rd Party Evaluation – Before/After Data





Documented Benefits to Fort Polk

- Infrastructure renewal: new heating, cooling, and water-heating equipment, lighting, and low-flow shower heads
- No more maintenance headaches
- Electricity reductions
 - 33% less use, 43% lower demand, improved load factor 0.52 to 0.62
- Cost savings
 - \$345,000 annually during contract term
 - \$2.2 million annually after contract ends

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17



President Bush Chose GHPs



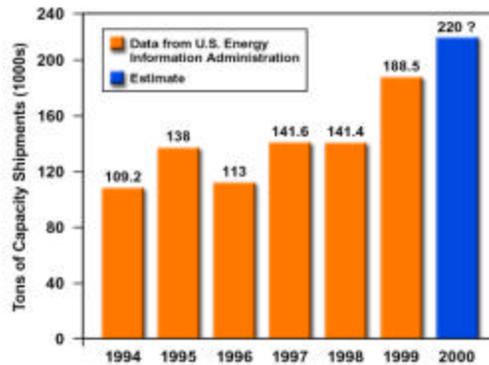
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18



Comfort in Numbers — Shipments Doubled Between 1994 and 2000



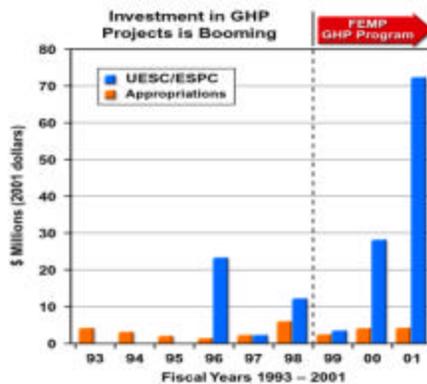
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19



Comfort in Numbers — Recent Burst of Federal GHP Projects



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20



The burst of projects is being used to advance applications technology

- GHPs are being worked into the same kinds of tools already supporting conventional HVAC product applications
 - Survey/audit stage
 - Feasibility/decision stage
 - Design stage
 - Implementation stage

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21

Projects have been closed loop – 95% vertical – so applications R&D is focused there





Survey/audit stage

- GHP survey guide & training
- Trained energy auditors



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23



Feasibility/decision stage

- Construction-cost-estimating guide
- Maintenance-cost-estimating guide
- Reliable software for estimating energy and cost savings
- GHP feasibility study guide & training
- Trained engineers



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24



Database will lead to inclusion of GHPs in cost estimating guides

Buildings Technology Center

HVAC

Construction and Maintenance Cost Survey

The HVAC construction and maintenance cost survey has been designed to collect recent, thorough information on new, retrofit, or replacement HVAC construction projects and HVAC maintenance costs. The database makes this information available to engineers in the public and private sectors to use as resources in developing projects and performing feasibility studies.

Log On to the HVAC Survey

If you have previously registered with us, please enter your User ID and Password below. If you have not registered and would like to participate in the survey, click here.

User ID:

Password:

The survey has the following features:

- It allows you to tailor it to accommodate the data that you are willing to provide. After you have provided certain types of required information on building and system characteristics, you may choose to provide information on construction costs or maintenance costs, or both. Likewise, you can provide total cost data or itemized cost data.
- At any time, you may review your input from the Survey Menu screen.
- Your participation is confidential. You will create a unique User ID and password, so that you may log, access, or modify your own data. All identifying information will remain private, and your

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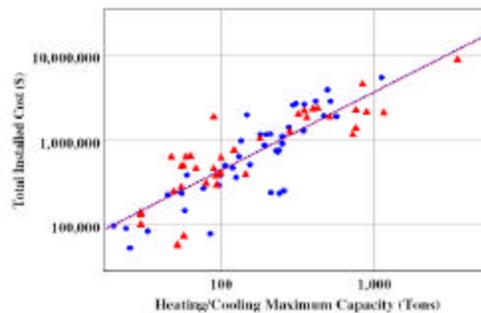
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DB supports fair & reasonable price determination ? R.S. Means

Vertical Bore GHP Systems



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26



DB supports estimates of maintenance cost savings ? ASHRAE

- ASHRAE funding a research project to adopt database as their own
 - Seed with conventional HVAC data
- It will become a key part of Chapter 35, Owning and Operating Costs
 - GHP included as a system type for 1st time
- DOE will be provided free access to anything ASHRAE develops
 - Better estimates of maintenance cost savings

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27



Evaluating software for estimating energy/cost savings

- Calculating energy use of GHPs is complicated by behavior of bore field
- A few programs model GHP behavior, some rather crudely
- Energy analysis also provides key inputs for vertical bore sizing
- Comparisons underway: TRNSYS calibrated to Lincoln school data versus ...
 - System Analyzer & Trace 700 (Trane)
 - Hourly Analysis Program (HAP) (Carrier)
 - DOE 2.1E & Equest (DOE-2.2) (J. Hirsch)
 - Market Manager (SRC)

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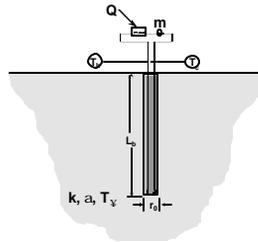
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28



Design stage

- Proven in-situ tests & analysis to determine soil/rock formation thermal properties
- Proven vertical ground heat exchanger design software
- Proven borehole completion methods
- GHP system design guide & training
- Trained engineers



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29



Heat exchanger design in vertical bore systems

- Bore field costs represent 1/3 to 1/2 of total cost, so it's important to get it right
- Short-looping may result in inadequate heating/cooling capacity and/or compressor lockout
- Design requires:
 - proven energy analysis software (and user)
 - accurate soil/rock & bore thermal properties
 - proven bore sizing software (and user)

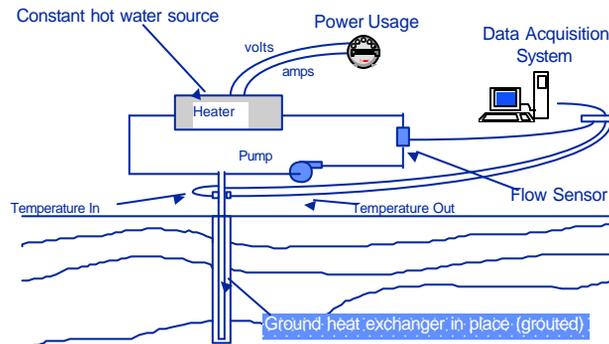
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30



In-situ test system schematic



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31



Effective in-situ test protocols & analysis are now available

- Soil/rock formation thermal properties
- Bore hole thermal resistance
 - Bore backfill material
 - Geometry (bore size, pipe size, etc.)
 - Pipe position (with or without spacer clips)
- ASHRAE TRP-1118 final report available
 - “Investigation of methods for determining soil formation thermal properties from short-term field tests” (Kavanaugh)

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32



Evaluating software for sizing vertical bores

- Comparisons completed: TRNSYS calibrated to Ft. Polk & Lincoln school data versus ...
 - GCHPCalc (Kavanaugh)
 - GLHEPro (IGSHPA/Spitler)
 - GS2000 (Caneta Research)
 - ECA Earth Coupled Pipe Loop Sizing (Elite)
 - Right-Loop (Wright Software)
 - Ground Loop Design (GaiaGeo/Peterson)
- Consistent inputs

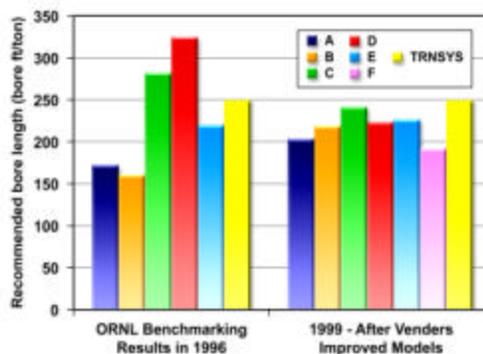
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33



Effective vertical bore sizing tools are now available



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34



Implementation stage

- GHP guide specifications
 - www.eren.doe.gov/femp/financing/esp/ghpresources.html
- GHP system commissioning, preventive maintenance, and trouble-shooting guide
 - Available from ASHRAE (SP-94 final report)
- Trained engineers and contractors



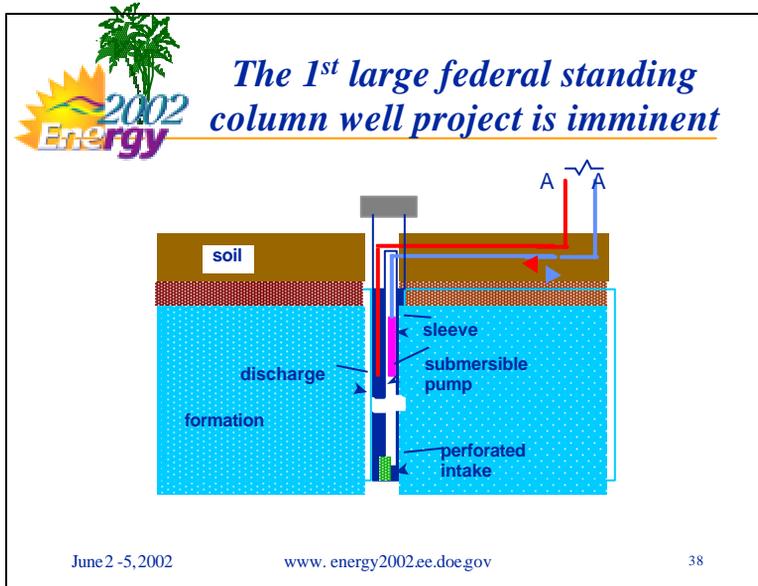
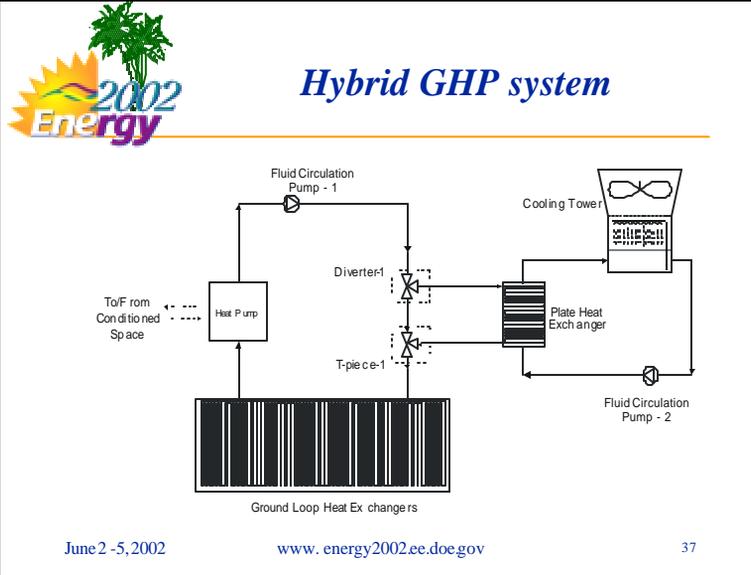
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35

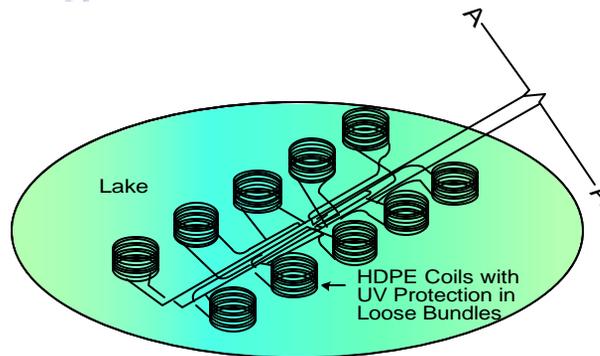
Future directions – hybrids, standing column wells, surface water loops







Surface water loops



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39



FEMP's Exit Strategy

- Goal is to make GHPs as easy to specify, procure, design and install as any other HVAC technology
- Through partnerships with industry and associations, develop standard tools of the trade so that in the future, FEMP can direct agencies to published resources and established training programs
- "Exit" is near for vertical bore hole systems

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40



GHP institutional resources

- International Ground Source Heat Pump Association (IGSHPA)
 - www.igshpa.okstate.edu
- Geothermal Heat Pump Consortium (GHPC)
 - www.geoexchange.org
- ASHRAE (TC's 6.8, 9.4, 1.8)
 - www.ashrae.org
- Oak Ridge National Laboratory (ORNL)
 - www.ornl.gov/femp

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41



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42