Outline

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The Challenge

• Biggest barrier to greater geothermal heat pump use

• High cost
• Large area
• Large & expensive equipment
The Solution

EarthSpar™

• 50% Cost Reduction
• Low landscape disruption
• Gets into small areas
• Fast installation
• High thermal performance

Patent Pending
Development Overview

Awarded US Dept. of Energy Grant - 2013

GOAL of Program:

To develop a ground loop heat exchanger that can be:

• **Expediently inserted** into the earth
• Via the use of **man-portable equipment**
• Resulting in **low cost, space efficient** ground loops for ground source heat pumps
• **Thermally testing** the heat exchanger
The Direct Insertion Ground Loop Heat Exchanger addresses key barriers to wider GSHP adoption by:

- Significantly reducing high installation costs for ground loops
- Reducing space requirements for ground coupling (slinky field or large drilling equipment in densely built areas)
- Greatly reducing ground cover disruption and providing a flexible grid structure for placement around obstacles
- Allows for angular ground loop placement enhancing under-structure installation or radial center point headering
Core Concept – Part A

Water Jets/Metal Driving Tip

- Loosening soil
- Lubricating insertion
- Dislodging rocks
- Displacement
- Hard soil erosion
- Deflection
The Technology

Core Concept – Part B

Concentric Tube Design

- Single Tube Heat Exchanger
- With same flow rate achieve laminar flow in down-flow
- Turbulent flow in up-flow
- Improved thermal performance
The Technology

Pressure Drop in 20ft. EarthSpar™ Coaxial Heat Exchanger

Flow Rate vs. Pres. Drop
Nominal 3/4" HDPE Pipe

Flow Rate vs. Pres. Drop
1 1/4 - 3/4" Annular

Same cross-sectional area
The Technology

Pressure Drop in 20ft. EarthSpar™ Coaxial Heat Exchanger

Combined Pressure Drop

Flow Rate gpm

Pres Drop psi

0 0.5 1 1.5 2 2.5

0 1 2 3 4 5 6
The Technology

Core Concept – Part C

Insertion Platform
Heat Exchanger Insertion

- Insertion into varying soil types
  - Sand, sandy loam
  - Gravel, cobble
  - Clay
  - Subsurface boulder field (Insertion halted)
- Insertion speed ~ 2 – 4 ft/min
- Insertion for 24, 30ft heat exchangers ~ 6 hours at 2 ft/min
  [700 ft] 3 hours at 4 ft/min
  (total insertion time, including equipment placement on targets, will be increased)
- Extraction of heat exchanger – straightforward and rapid
20’ EarthSpar™ Testing

- ASHRAE 1118-TRP
- Inline water heating device
- Precision Watt meter – energy-in
- Input power control
- Thermocouples – in-flow & out-flow temperatures
- Flow meter – in-line
- ~ 10°FΔT
- Wireless data acquisition
Thermal Testing

Test Data

\[ y = 2.2366 \ln(x) + 80.241 \]

Slope of Ave. Temp.

Time ~ 41.5 Hours
After 5 Hours Stabilization
Thermal Testing

Thermal conductivity: Line Source Method

\[ k = 3.412 \times \frac{P}{4\pi L \times Slope} \]

\[ k = 3.412 \times \frac{356W}{4\pi 17.8 ft \times 2.2366} = 2.249 \text{ Btu/hr-ft-°F} \]

- 20W/ft heat rate
- 17.8 ft of tested length – heat exchanger
- ~ 10°F ΔT (heated IN – earth cooled OUT)
- Thermal insulation between down-flow & up-flow concentric tubes for 67% of length
Effect of Ground Loop Heat Exchanger Thermal Conductivity on Loop Length

\[ y = 850.06x^{-0.473} \]

Performance Benefit

2.24 EarthSpar
System Flexibility

- Angular insertions
  - Under structures
  - Radial loop field
- Extraction - straightforward
- Shallow water wells
- Under structure races for utilities, communications lines, water lines
Technology Review

- Water-jet technology
- Soil displacement/insertion
- Tangential obstruction dodging
- One-step process
- Concentric - High thermal performance
- Agile insertion platform – tight areas
- Angular insertion
- Easily extract heat exchanger
Areas of Use

Where Drilling or Trenching May Be Superior

• Where bedrock is close to the surface
• Areas/soils with closely spaced large rocks
• Large commercial/industrial/institutional systems
  • Single source ground loop/non-distributed
  • Excavation already planned (i.e., Parking lot)
  • Capital equipment (i.e., Drilling rigs) on-site and can be amortized over many borings
• Limited space (tons/ft2) – drilling excels

EarthSpar™ will not replace existing ground loop methodologies

EarthSpar™ will be strong adjunct methodology in many applications
Cost Advantage

Estimated Ground Loop Cost Comparison

Standard Ground Loop $ vs. DIGLHE $
4 ton example (700’ Vertical)

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<th>DIGLHE</th>
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<td>Pipe</td>
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<td>Completion labor, etc.</td>
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Method Comparisons

EarthSpar™

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<th>High Performance</th>
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1. The EarthSpar™ concept is a viable technology
2. Core concepts were proven to work to drive pipe, displace soils and function even with obstructions (rocks)
3. Insertion times (> 2 ft/min) allow for rapid placement of GSHP ground loops
4. High thermal performance may lead to shorter lengths of heat sink in the ground than with conventional designs
5. Small, mobile insertion equipment allows for ground loops to be placed in space restrained areas
6. Capital costs associated with ground loops (bore drilling and large horizontal field processes) are greatly reduced
7. Project goals were met (rapid insertion & thermal testing)
8. Can reduce ground loop installation cost by 50%
9. Will expand GSHP market in residential & small commercial
Special thanks to the U.S. Department of Energy and Bahman Hebibzadeh (DOE Program Manager) for supporting the development of the EarthSpar™ Direct Insertion Ground Loop Heat Exchanger & Rex Ambs – Geofurnace LLC & IGSHPA