Geothermal: The Genius Renewable

Live at Groundwater Week in partnership with NGWA

Las Vegas, NV
December 5-7, 2023
HOW TO GET A MECHANICAL ENGINEER EXCITED ABOUT SPECIFYING GEOTHERMAL

Aran Winn | Room N202
YOUR PRESENTER TODAY

Aran Winn
Western Commercial Sales Manager
Climate Control Group

• More than 20 years HVAC Experience

• Mechanical Engineer experienced in heating, ventilation, and air conditioning equipment consulting and sales.

• Commercial and applied HVAC equipment knowledge, specifically Geothermal, water chillers, air handlers, and commercial rooftop units.
What Are Water Source Heat Pump Systems?

- Water Source Heat Pump (WSHP)
- Water Loop Piping
- Water Loop Circulating Pump
- Heat Source
- Heat Sink
- Building and Room controllers
Benefits of Water Source Heat Pumps

High Efficiency Operation
Heat pumps operate at extremely high efficiencies
No part-load degradation of central systems
No reheat required
Low fan power

Independent Zone Comfort Control
Zones can heat or cool on demand, during or after hours, regardless of season, regardless of what other zones are doing. Individual units can serve zones from 200 to 10,000 square feet in size.

Heat Recovery
Heat is recovered in the closed-loop. Water loop recovers, stores, and recycles wasted energy

Flexible
Units can be easily moved to accommodate changing requirements

Units can be Individually Metered
Each tenant pays for what is used

Defer Construction Costs
Can install most zone units when space is finalized during tenant finish

Simple 1 or 2-pipe Water Loop
Usually does not require insulation, 1-pipe applications increasing

Long Equipment Life
Factory-sealed systems, Indoor installation and Moderate loading versus ASHP

Simple Controls
Can be as simple as a basic thermostat per unit
Easily adapts to cloud-based EMS or BMS control

Self-Contained Compact Units
Can be hidden within ceilings, installed in closets, or floor mounted
Quiet operation even in exposed applications

Small Mechanical Rooms
Maximizes rentable space

No Chillers, Large Central Station AHUs, RTUs, Condensing Units
No operating engineer required
Improves architectural aesthetics and radiated sound

Redundancy
Failure or maintenance activity on one unit does not affect any others

Simple Maintenance
Uncomplicated units are easy to service or remove and exchange if required

Low Installation Costs
4-pipe performance at 2-pipe costs. Easier to design and less complicated to commission

Simple Low-Pressure Duct Systems
Air is not mixed between zones

Can Utilize Geothermal Energy
Heat pumps operate at extremely high efficiencies
No fossil fuel input
No sound and vibration control concerns
No water consumption, chemical treatment, legionella concerns

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Key Advantages of Water Source Heat Pumps

✓ Unaffected by Outdoor Weather Conditions

✓ Water Side Heat Recovery Efficiency

✓ Independent Zone Control, Service, and Energy Metering

✓ Packaged Systems With Small Refrigerant Charge

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Ground Source Loop Heat Pump

✓ Eliminate Cooling Towers
✓ Fossil Fuel Free Heating
✓ Ultra-Efficient Cooling and Heating Solution
✓ Eligible for 2022 IRA Federal Tax Credits (up to 50%+ of total GHP system cost*)

*Per details in 2022 Inflation Reduction Act, Section 48(1)
Changes in Refrigerant

- Future refrigerant options will most likely be Flammability Class 2L which will result in lower maximum charge limitations and changes in equipment internal components.

- A2L Refrigerants will require different risk mitigation methods for refrigerant leaks.

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Water. It’s Good for you.

- As refrigerant regulations change in the future it may become more difficult to service or replace systems with large distributed refrigerant piping in walls and ceilings.

- Low refrigerant charge, packaged systems using water as a distribution system can switch refrigerants more easily with fewer changes to building structure.
WSHP System Heat Recovery Operation

- Building core zones will require cooling due to internal heat gains. These WSHPs will be in cooling mode.
- Perimeter building zones will require heating. These WSHPs will be in heating mode.
- Heat is being simultaneously rejected into and extracted from the water loop.

Energy Recovery within the water loop minimizes boiler and heat rejector operation and provides maximum efficiency.
Air Source Heat Pump Challenges

Cold temperature heating design days can strain the capacity of most air source heat pumps and reduce capacity and efficiency when they are needed most.
WSHP Comfort Year-Round!

Outdoor Air Temperature: 115°F

Outdoor Air Temperature: -5°F

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So, Why Not Ground Source Heat Pumps?

3 Strategies for making a ground source heat pump system fit the budget.
Ground-Source Hybrid Systems

Cost Saving Strategy for Ground-Source Heat Pump Systems #1
Ground-Source Hybrid System

- Reduces the size of the Ground-Source Loop
  - When paired with Cooling Tower (Cooling Dominated Buildings)
  - When paired with Boiler (Heating dominated buildings)

- Ground Source Loop is designed to meet the smaller load.

- First cost of the ground-source loop is significantly reduced

- In many commercial applications, the building requirements are cooling dominated 365 days / year.
  - People, Computers, Lighting, Solar

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Ground-Source Hybrid System

**Summer Operation**

- **In Summer:** rejecting heat to the geo loop and the cooling tower.

**Winter Operation**

- **In Winter:** geo loop is our source of FREE heat. The cooling tower is off.
Hybrid Dry Cooler for Load Balancing

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Real World Example - Tulsa Oil Company

Required Geothermal System
- 200,000 SQFT Building
- 750 Tons of HVAC Required
- $4.5 Million HVAC System
- 500 Bore Holes Required @ 300 Ft Deep
  - One (1) 300 Ft deep bore hole provides 1.5 tons of heat rejection.
  - Well field Cost - $1.2 Million

Due to cooling being the dominated load for Tulsa Oil Company building and to save on up front installation cost, a Hybrid Geothermal System was the perfect solution.
- Sized geothermal loop for HEATING load only
- Installed a closed loop cooling tower to cover the COOLING loads beyond what the ground loop could handle.
- Reduced bore holes from 500 down to 150 by adding the cooling tower.
Real World Example - Tulsa Oil Company

INSTALLATION COST SAVINGS

Reduced Geo Loop (150 wells) $ 360,000
Cooling tower costs $ 150,000
Geo/Hybrid system (150 wells w/Tower) $ 510,000

Original Geo Loop (500 wells) $ 1,200,000
Geo/Hybrid system (150 wells w/Tower) $ 510,000

SAVINGS with Geo/Hybrid Loop: $ 690,000

Federal Tax Credit Also Received!
What is a “Single-Pipe” Design?

Traditional Water Source Heat Pump Piping Design

Single-Pipe WSHP Design
What is a “Single-Pipe” Design?

- Manufacturer internal pump pulls water into WSHP when operating.
- Ball valves used for service.
- Flow controllers, water balancing valves, and test ports are eliminated.
- WSHP leaving will mix back with loop water.

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What Are The Advantages of Single Pipe?

- **Lower Material Cost.** Reduced pipe and flow controllers, water-balancing valves, and test ports are eliminated.
- **Reduced installation time with integrated pumping.** WSHP are self-balancing.
- **Smaller building loop pump horsepower due to lower system head (no control valves, balance valves, etc.).**
Simpler System Layout and Loop Control

Expansion Loop (as required) To Mechanical Room

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Simpler System Layout and Loop Control
Reduced Pump Head and Pumping Energy

✓ Smaller building loop pump horsepower due to lower system head.
❖ Eliminate control valves, balance valves, etc.

### EXAMPLE

<table>
<thead>
<tr>
<th></th>
<th>2-Pipe System</th>
<th>1-Pipe System</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary Loop</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat Source/Sink</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Pipe (100' x 3'/100')</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Multipurpose Valve</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Air Separator</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Suction Diffuser</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>Secondary House Loop</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipe (500' x 3'/100')</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td><strong>Subtotal Head (ft)</strong></td>
<td><strong>44</strong></td>
<td><strong>44</strong></td>
</tr>
<tr>
<td><strong>Tertiary Terminal Unit Loop</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WSHP Unit</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Control Valve (5 psi)</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>Balance Valve (2 psi)</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td><strong>Subtotal Heat (ft)</strong></td>
<td><strong>22</strong></td>
<td><strong>5</strong></td>
</tr>
<tr>
<td><strong>Total System Head (ft)</strong></td>
<td><strong>66</strong></td>
<td><strong>49</strong></td>
</tr>
</tbody>
</table>

System Head Reduced 26%!
<table>
<thead>
<tr>
<th>System</th>
<th>Days: 260</th>
<th>Hour/day: 8</th>
<th>Total hrs: 2080</th>
<th>Pump motor HP:</th>
<th>Pump motor efficiency:</th>
<th>Electrical cost / kwh:</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-pipe system</td>
<td></td>
<td></td>
<td></td>
<td>11.4</td>
<td>0.8</td>
<td>$0.10</td>
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<tr>
<td>$2,206.83</td>
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<tr>
<td>Annual energy cost</td>
<td></td>
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<td></td>
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<tr>
<td>1-pipe system</td>
<td></td>
<td></td>
<td></td>
<td>9.7</td>
<td>0.8</td>
<td>$0.10</td>
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<tr>
<td>$1,889.18</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Annual energy cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**14% Annual Savings!**
Single Pipe Design Keys

1. Use same common pipe size for all units on a single pipe loop (typ. 10-15 units per loop)

2. Size single pipe diameter for total GPM of all units on single pipe loop.

3. Temperature rise of single pipe loop will largely depend on loop flow.

4. Not all units will run at the same time, so there is diversity.
Loop Temperature Considerations

There will be a minor increase in water temperature along the loop based on the number of units operating but WSHP will compensate.
Loop Temperature Considerations

For larger loops, system water temperatures design for mixed water temperatures within WSHP operating window.

Table 12: Unit Operating Limits

<table>
<thead>
<tr>
<th>UNIT OPERATING LIMITS</th>
<th>ALL TSM MODELS</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMBIENT MIN - MAX DB</td>
<td>50-100 [10-30]</td>
</tr>
<tr>
<td>RETURN AIR MIN DB/WB</td>
<td>60/60 [10/15.5]</td>
</tr>
<tr>
<td>RETURN AIR MAX DB/WB</td>
<td>60/75 [35/24]</td>
</tr>
<tr>
<td>STANDARD UNIT ENTERING WATER MIN - MAX</td>
<td>50-120 [10-49]</td>
</tr>
<tr>
<td>EXTENDED RANGE STANDARD UNIT ENTERING WATER MIN - MAX</td>
<td>30-120 [-1-49]</td>
</tr>
<tr>
<td>vFlow® UNIT ENTERING WATER MIN - MAX</td>
<td>28-120 [-1-49]</td>
</tr>
</tbody>
</table>

- Requires optional insulation package when operating below the dew point.
- Operation below 50°F (10°C), EWT requires antifreeze, optional insulation package and jumper clipped.
The Inflation Reduction Act of 2022

Cost Saving Strategy for Ground-Source Heat Pump Systems #3
Inflation Reduction Act Political Drivers

**RISING ENERGY COSTS**
- Brent crude oil prices up 254% from 2020 to 2022 (EIA)
- Henry Hub natural gas prices up 239% from 2020 to 2022 (EIA)
- Electricity prices up 13% from 2020 to 2022 (EIA)

**ENERGY SECURITY CONCERNS**
- OPEC embargos of 1970s
- Middle East wars
- Hurricane Katrina
- Ukraine war

**ENVIRONMENTAL AND CLIMATE CONCERNS**
- Major oil spills
- Kyoto Protocol and Paris Agreement
- ANWR lease suspension
- Weather related events

**ELECTRIC GRID CONCERNS**
- Blackouts, aging infrastructure, threat of cyberattacks
- Renewable reliability, beneficial electrification, electric vehicles
- Loss of coal baseload plants

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Ground Source Heat Pump Political Drivers

**50 STATE TECHNOLOGY**
- Ground temperature resource is available everywhere
- GHP systems are operating in all 50 states

**DOMESTIC TECHNOLOGY & SYSTEM CONTENT**
- Widely, components for drill rigs, tools and GHPs are US made
- Growth of GHP driving local job creation at extreme rates

**ADDRESSES ONE OF THE LARGEST COMPONENTS OF US ENERGY CONSUMPTION**
- Building sector globally consumes more energy at 34% than transport sector at 27% or industry sector at 28%
- Globally, energy used for heating and cooling accounts for 50% of energy consumption and 39% of global greenhouse gas emissions

**PRODUCES MAXIMUM BENEFITS “ON PEAK”**
- Renewable kWh production, air-source heat pumps and electric vehicles stress grid at peak
- GHPs provide maximum demand reduction when running 100%

**BENEFICIAL ELECTRIFICATION**
- Electricity is becoming “cleaner” by the day – US CO2 per kWh is down nearly 40%
- Heat pumps are the best way to convert clean electricity into thermal energy

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RESIDENTIAL GHP Tax Incentives

Inflation Reduction Act

✓ Residential Clean Energy Credit – IRC Section 25D
✓ 30% of GHP system cost basis (26% 2033, 22% 2034)
✓ No cap on total credit amount
✓ Can be combined with solar and other credits
✓ Can be used in more than one year
✓ Can be used for more than one home
✓ Can be carried forward until used
✓ Exempt from AMT

✓ Home must be located in the US
✓ Includes houses, cooperatives, condos, mobile homes
✓ Does not have to be main home
✓ GHP must meet Energy Star requirements
✓ Placed in service before 12/31/2034

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Geothermal Tax Credit Incentives

- The IRA extends Section 48 under a two-tiered structure
- Increased from 10% prior to IRA
- A base rate of 6% (1/5 the bonus rate)
- A bonus rate of 30%
- 30% of total GHP system cost basis through 2032 (26% 2033, 22% 2034)

Bonus Rate Qualifiers

- A project with a maximum net output < 1MW of electrical thermal energy or
- Meet prevailing wage rate and apprenticeship requirements
- Projects commenced within 60 days of published rules
- All projects started in 2022 qualify for 30%

<table>
<thead>
<tr>
<th>GEOTHERMAL TAX CREDITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASE RATE</td>
</tr>
<tr>
<td>5X BONUS 2022</td>
</tr>
<tr>
<td>MADE IN USA 2023</td>
</tr>
<tr>
<td>ENERGY COMMUNITY 2023</td>
</tr>
<tr>
<td>INCENTIVE OPPORTUNITY</td>
</tr>
</tbody>
</table>
COMMERCIAL GHP Tax Incentives
Inflation Reduction Act Section 48

• Domestic Content Bonus
  ✓ Domestic content value (2% base rate or 10% bonus rate)
  ✓ 40% of the cost of iron, steel, or manufactured product must be produced in the United States
  ✓ Domestic content is an additive bonus
  ✓ 6% + 2% = 8% x 5 = 40%

• Energy Communities
  ✓ Energy community value (2% base rate or 10% bonus rate)
  ✓ Census tract or adjoining tract with coal mine closed since 2000, or
  ✓ Census tract or adjoining tract with coal plant closed since 2010, or
  ✓ Defined as "a brownfield site" by the EPA, or
  ✓ Area with 0.17% employment related to coal, oil or natural gas with higher-than-average unemployment, or
  ✓ Area with 25% tax revenue related to coal, oil, or natural gas with higher-than-average unemployment
  ✓ Energy Communities is also an additive bonus
  ✓ 6% + 2% = 8% x 5 = 40% + 10% domestic content = 50%

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COMMERCIAL  GHP Tax Incentives
Inflation Reduction Act Section 48

✓ 5-year MACR depreciation for GHP system cost basis (less 50% of tax credit)
✓ Eligible for bonus depreciation (80% 2023, 60% 2024, 40% 2025, 20% 2026)

ACCELERATED DEPRECIATION

✓ Building located in the U.S.
✓ Original use begins with taxpayer
✓ Project commenced before 12/31/2034
✓ At least 75% of energy from ground source
✓ Includes bore field, heat pump, and certain downstream items

ELIGIBILITY
COMMERCIAL GHP Tax Incentives

Inflation Reduction Act Section 48

- Direct rebate equal to credit for non-taxable entities
- Non-profits, state and local government, schools, tribes, electric cooperatives
- Placed in service after 12-31-22
- Maximum credit or rebate is not limited
- Exempt from AMT
- Can be carried back up to 3 years or forward
- Can be transferred or sold
- Placed in service after 12-31-22
- Can be used in more than one year
NEW ENERGY EFFICIENT HOME CREDIT

For Home Builders

- Home must meet or exceed most recent Energy Star criteria
- $2500 tax credit (up to $5000 credit if “zero-energy” ready)
- Home acquired before 1-1-2033

ENERGY EFFICIENT COMMERCIAL BUILDINGS DEDUCTION

For Commercial Buildings

- Must exceed ASHRAE 90.1 2007 requirements by 25%
- 0.50 to $1.00 per square foot (max based on 50% savings level)
- 2.50 to $5.00 per square foot if meets prevailing wage
- Can be assigned to design team for tax-exempt entities
- Placed in service after 12-31-22

UTILITY INCENTIVES

For GHPs

- Residential and Commercial rebates are available in many areas

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Thank You!

Let us know if you have any questions.

Scan to request a follow-up and get access to our Geo Economics Calculator.