AMERICA ATMOsphere business case natural refrigerants

June 18-19, 2014 - San Francisco

Natural Refrigerant, Enhanced Geothermal Heating & Cooling Solutions

Lalit Chordia, PhD, Marc Portnoff

TharGeothermal

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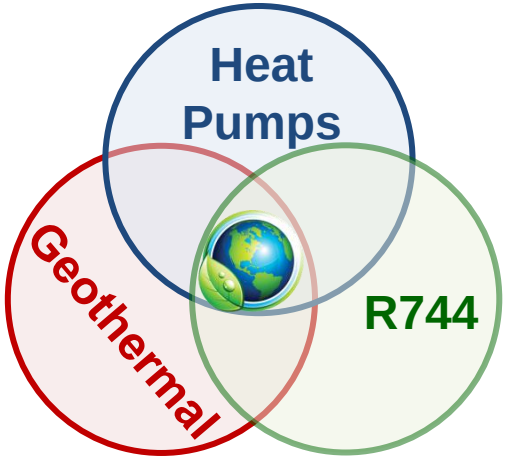
The Challenge: The Built Environment

Buildings accounted for
41% of the primary energy consumption &
40% of the carbon emissions
in the USA in 2010

(2011 Buildings Energy Data Book, buildingsdatabook.eren.doe.gov).

The Opportunity:

To improve HVAC & R system performance



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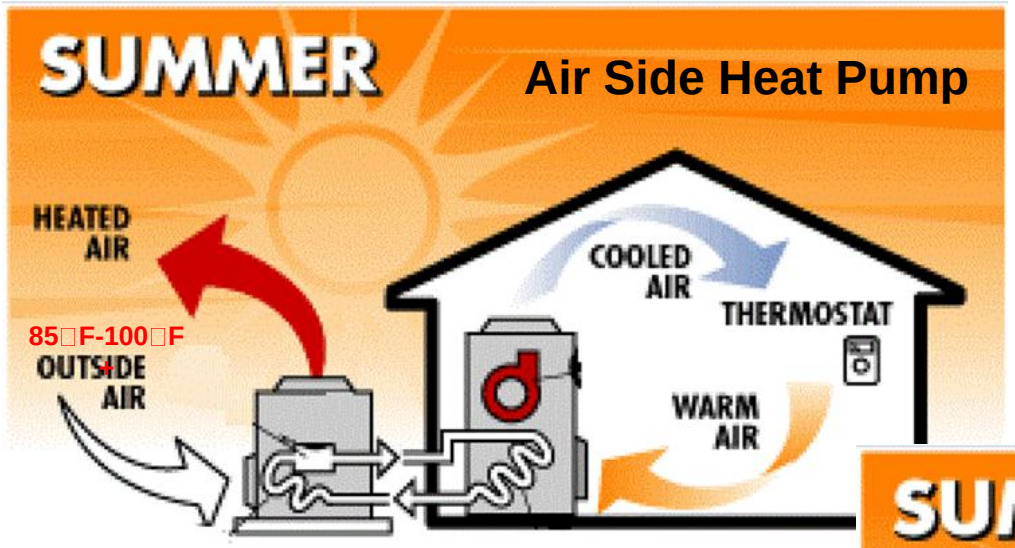

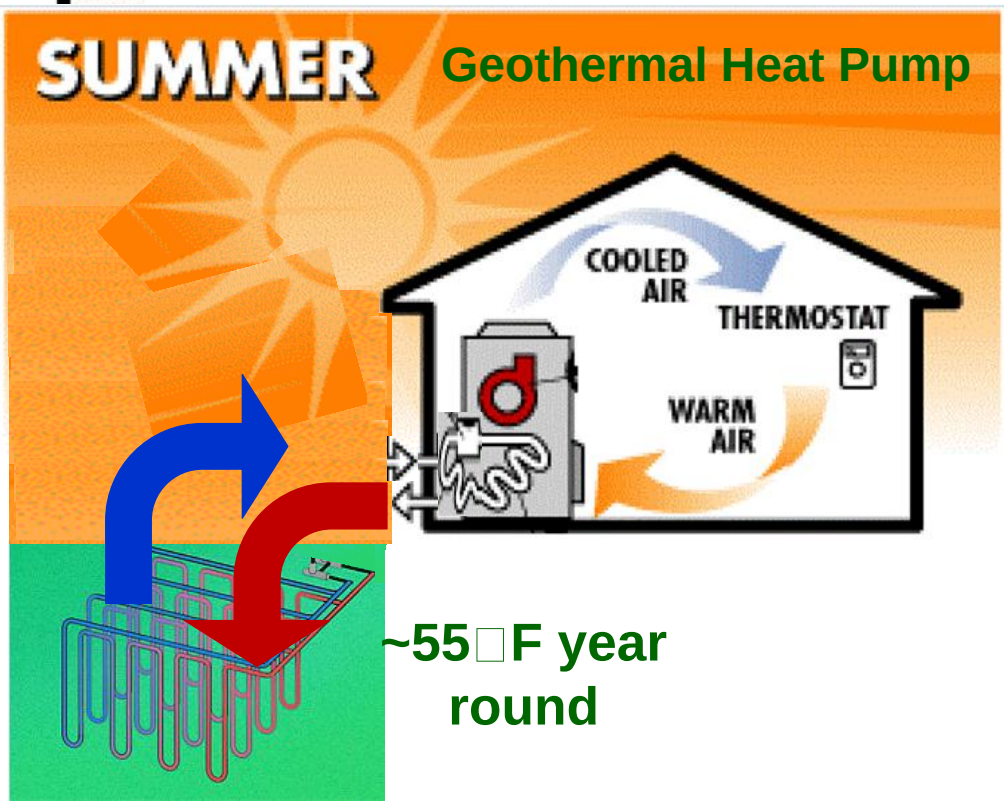

It takes less energy & $$ to transfer heat to the Cool earth than the Hot summer air

~55□F year round

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Geothermal Ground Source Heat Pump System Components

Terminals: Means for space heating and cooling

- Ducts
- Fan coils
- Radiant floor
- Radiant beam

Heat Pump Loop: Hot/cold refrigerant heats/cools the:

- Air
- Water (i.e. hydronics) which then heats/cools the air
- Domestic Hot Water (optional): uses heat pump capacity for simultaneous heating and cooling to heat water when space cooling

Ground Heat Exchanger (Ground or Earth Loop):

- Transfers energy from hot/cold refrigerant into or out of the ground

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"Ground Source Geothermal is the most energy-efficient, environmentally clean and cost effective space conditioning systems available today."

US EPA Space Conditioning: The Next Frontier. Office of Air and Radiation, 430-R-93-004, 4/93

"Ground Source Heat Pumps reduce Greenhouse Gas by up to 40% over convention HVAC systems." US EPA

DiEnna, J., **Geothermal, The Energy Under Our Feet**, International Ground Source Heat Pump Association, 26th Annual Conference, October 8-9, 2013, Las Vegas, NV

"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." *US DOE*

DiEnna, J., **Geothermal, The Energy Under Our Feet**, International Ground Source Heat Pump Association, 26th Annual Conference, October 8-9, 2013, Las Vegas, NV

Renewable Energy
Available 24/7/365

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Ground Source Geothermal Heat Pump Systems

Tangible Benefits

- Superior comfort in cooling and heating modes
- More energy efficient, saving fuel and lowering HVAC costs
- Reliable operation
- Safe & Clean
- Reduced local pollution
- Elimination of outdoor equipment
- For commercial systems: eliminates cooling tower fresh water use

With all these benefits,
why is Geothermal limited to 1-2% of the HVAC market?

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Market Barriers confronting Conventional Geo Systems

1) **High cost of ground heat exchanger (GHX) installation; ~50-75% of total system**

2) **Degree of disruption associated with GHX installation**

3) **Cost and difficulty of evaluating the suitability of individual installation sites**

Hughes, P., Geothermal (Ground-Source) Heat Pumps: Market Status, Barriers to Adoption, and Actions to Overcome Barriers, EERE Geothermal Technologies Program, U.S. Department of Energy, December 2008, ORNL/TM-2008/232

How can Thar Geothermal solutions confront these market barriers?

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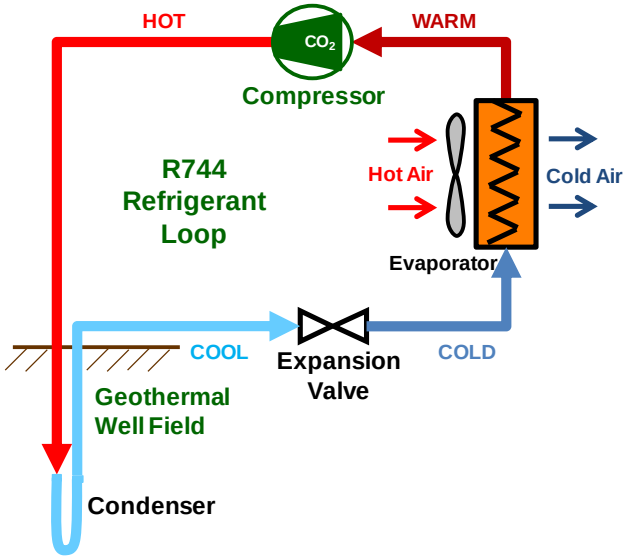
What differentiates Thar Geothermal from other commercial geothermal systems?

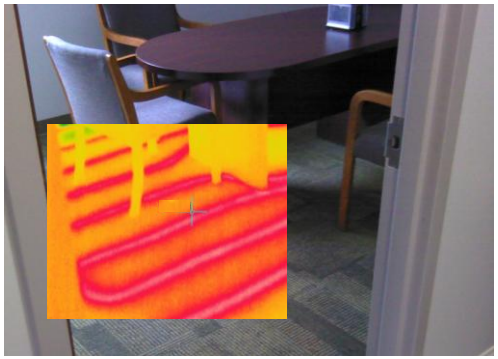
Recycled Carbon Dioxide CO_2
R744 the Safe & Natural Refrigerant

Commercial Scale, *Direct Exchange* Design



Successful Demonstrations 2012-2013

- *Enhanced Energy Efficiency*
- *Reduced Environmental Footprint*



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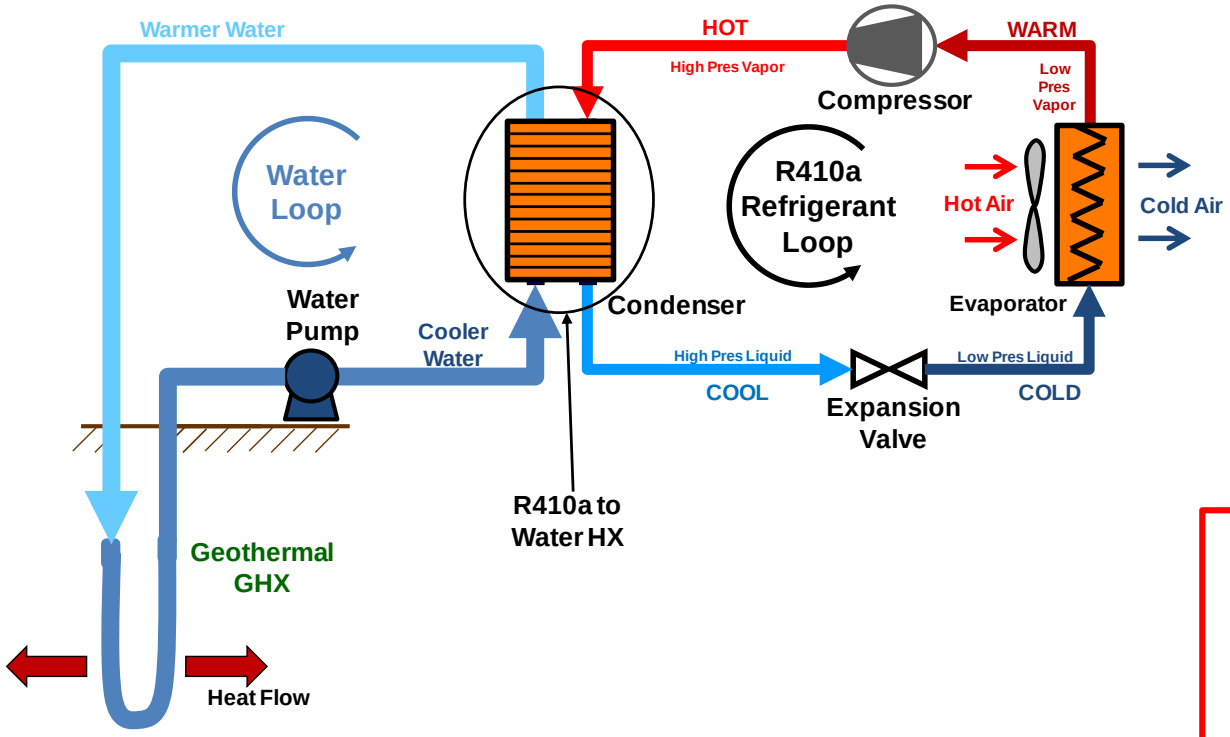
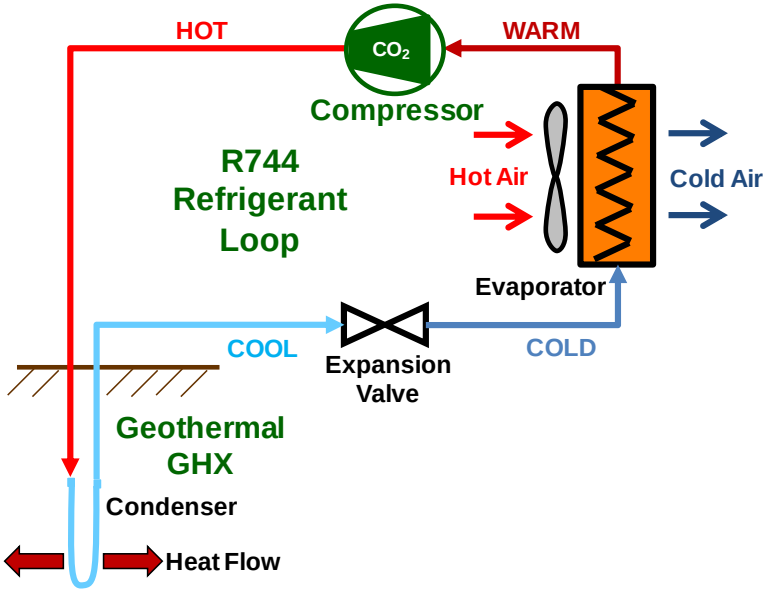
Comparison: Direct & Indirect Exchange Geothermal
COOLING MODE

Water Indirect Exchange



R744 Direct Exchange



DX - Simpler Design with Fewer Components

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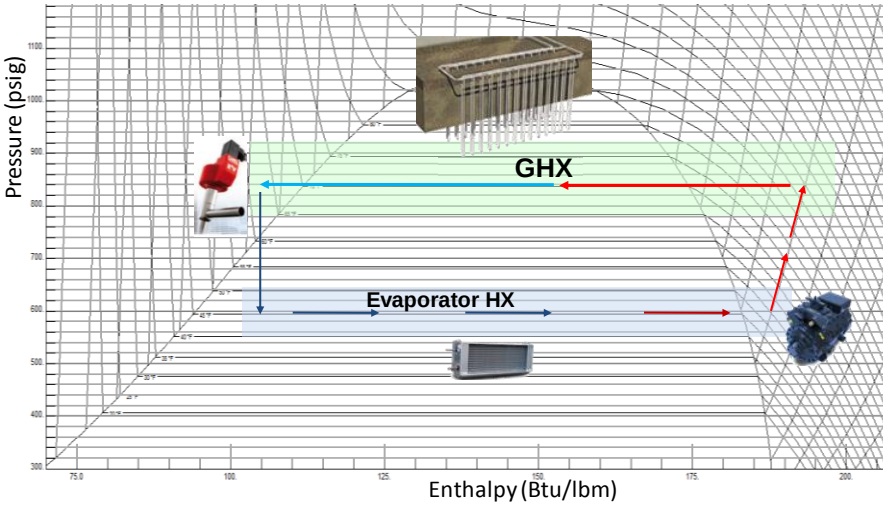
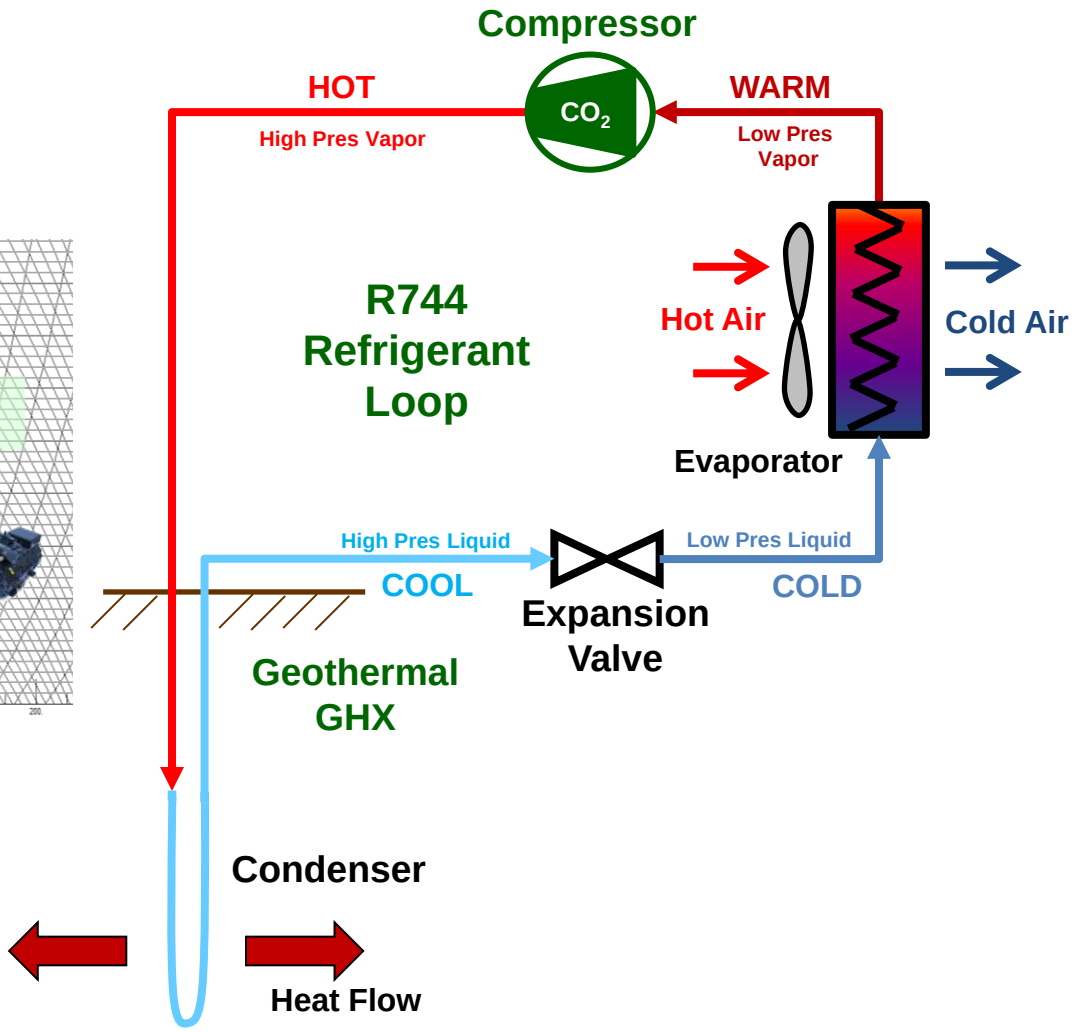
Thar All 744 DIRECT EXCHANGE Ground Source Geothermal - COOLING MODE





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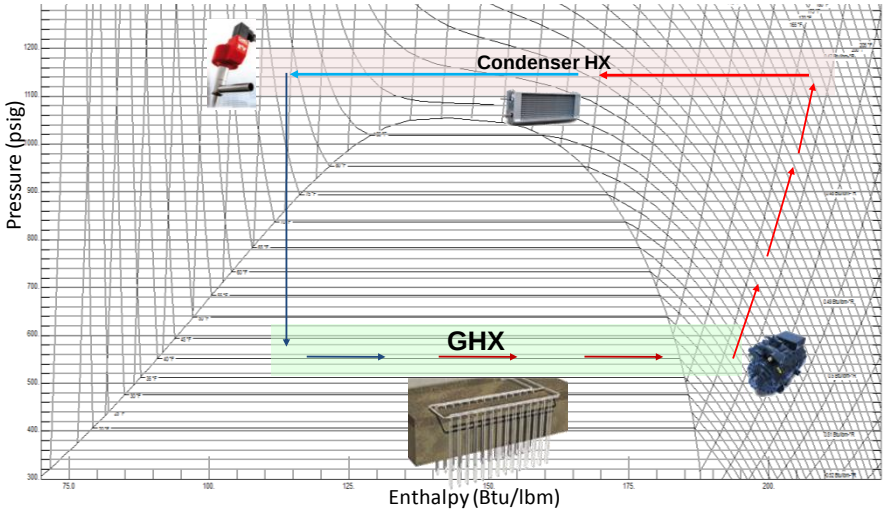
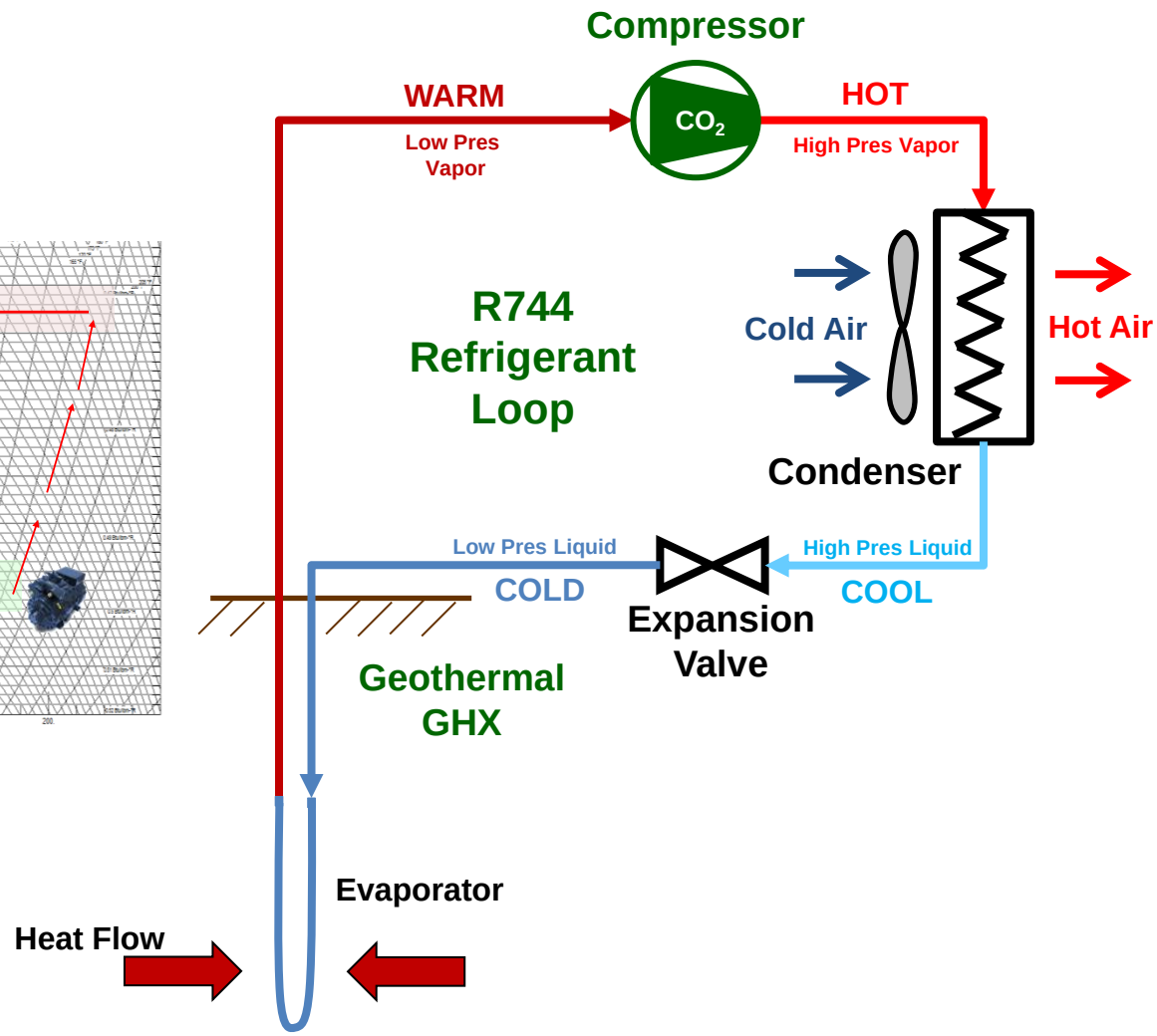
Thar Geo R744 DIRECT EXCHANGE Ground Source Geothermal – HEATING MODE





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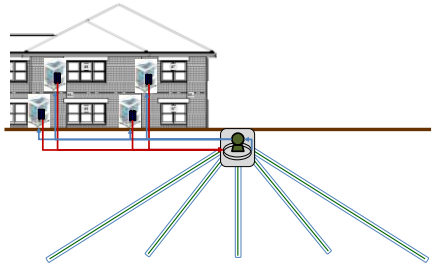
How does R744 refrigerant expand opportunity?

- **R744** is **safe, low cost, and environmentally friendly** enables **Direct Exchange Geothermal** design at the commercial scale

- **R744** enables the design of **smaller diameter ground loops (Geo-loops)**
  - Ground heat exchanger design flexibility
    - Horizontal, Radial, Vertical, Shallow Earth



Established Supply Chain

Temprite
DORIN innovation
CAREL
SWEP A DOVER COMPANY
BLISSFIELD MANUFACTURING CO
LUVATA
BAC BALTIMORE AIRCOIL COMPANY

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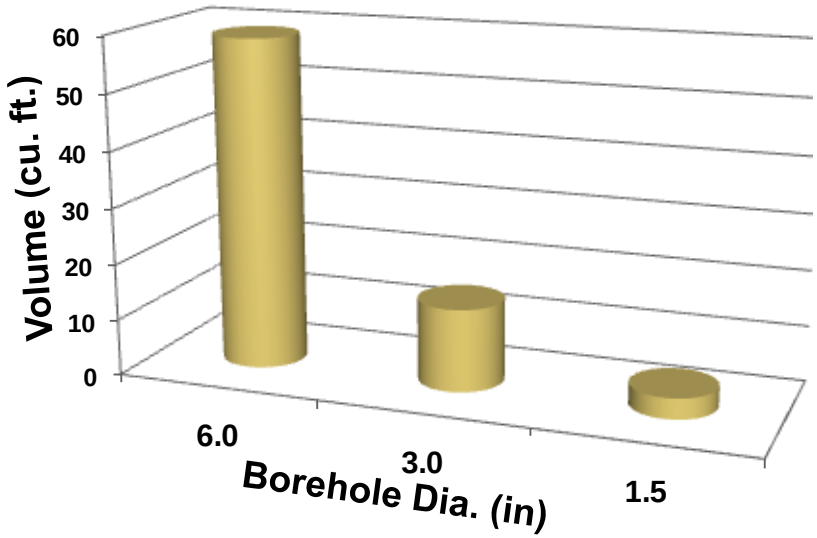
R744 Smaller Geo-loops can *reduce* Environmental Footprint & Cost

➢ Smaller Boreholes

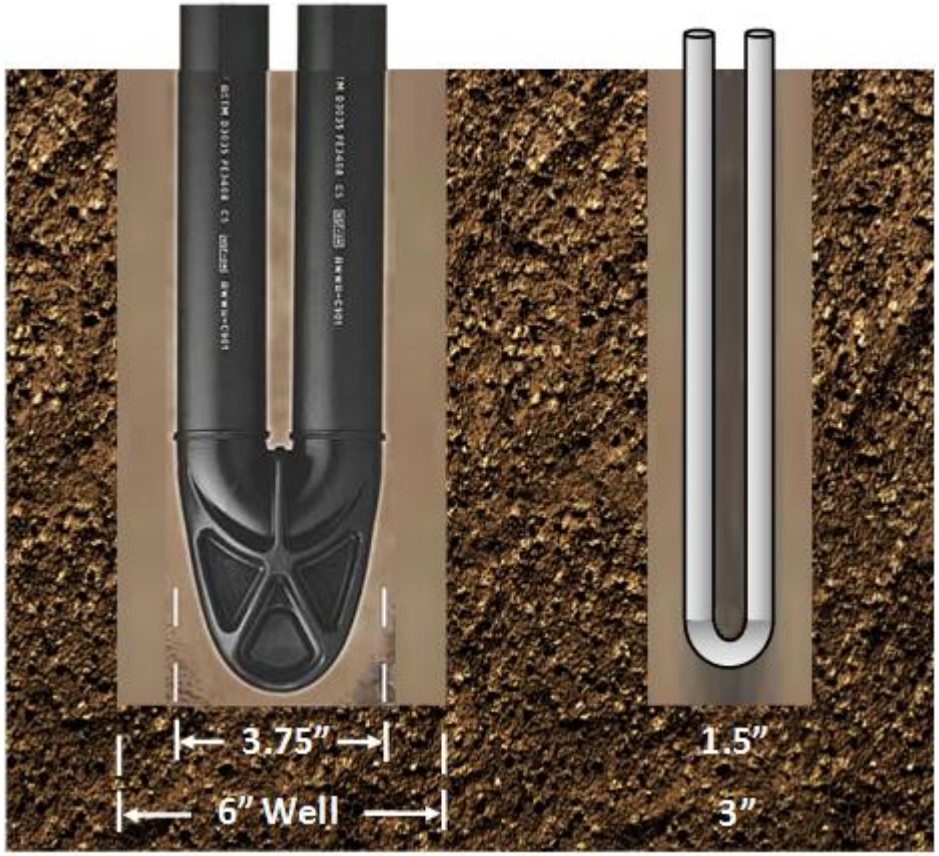
- ❖ Less earth removed
- ❖ Less waste – lower disposal $
- ❖ Less grout
- ❖ Smaller equipment
- ❖ Lower mobilization cost

Volume of 300 ft Borehole



Conventional
1.25” Pipe (1.66” O.D.)
HDPE

Thar Geothermal
Stainless
Steel



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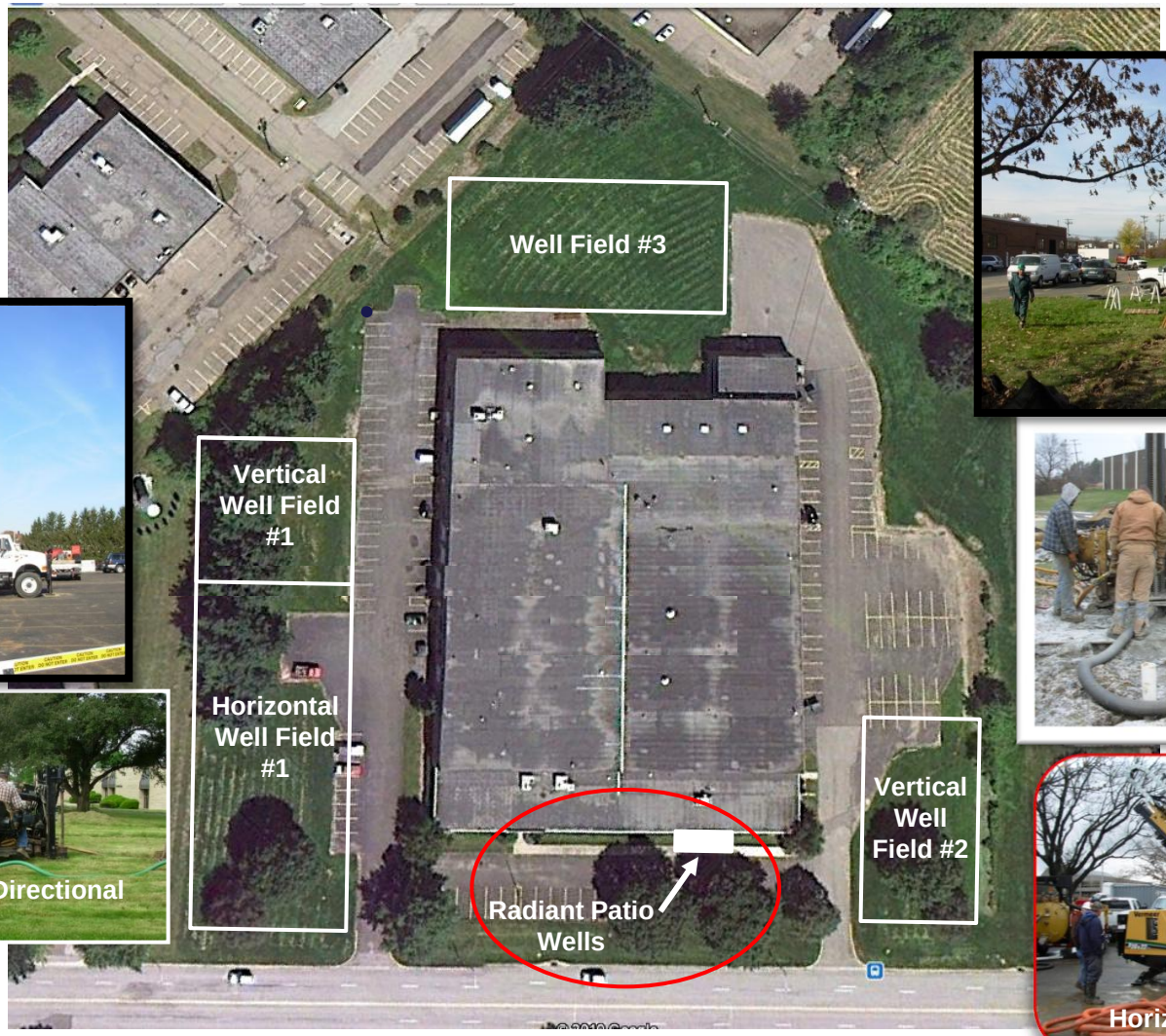
Thar R744 Geothermal Facility, Pittsburgh, PA
Well Field Development



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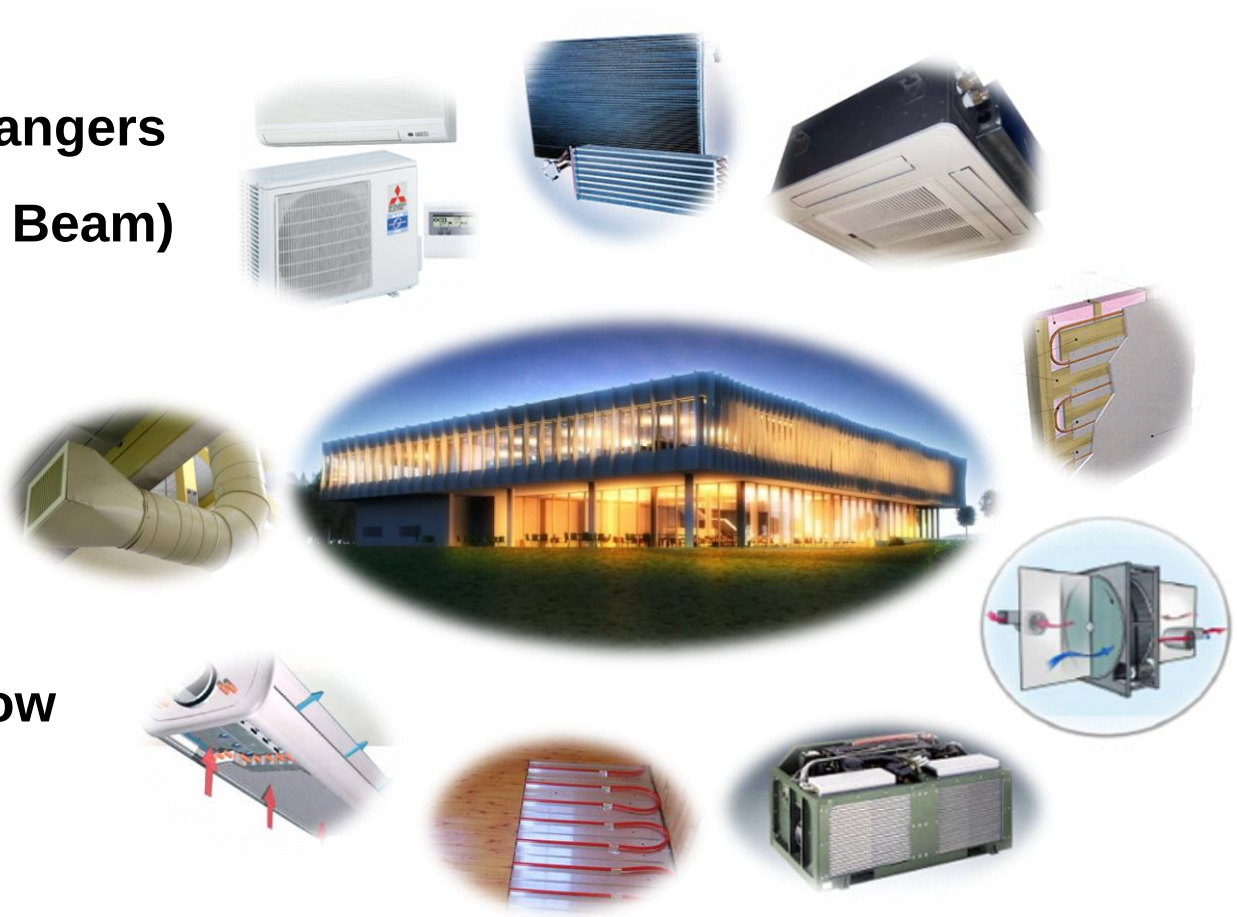
Thar Geothermal systems are versatile and can integrate with all types of standard HVAC systems

- Central or Distributed
- Air or Water Heat Exchangers
- Active Radiant (Chilled Beam)
- Passive Radiant
- Cassette
- Wall Mount
- Mini Air Handling Unit
- Variable Refrigerant Flow



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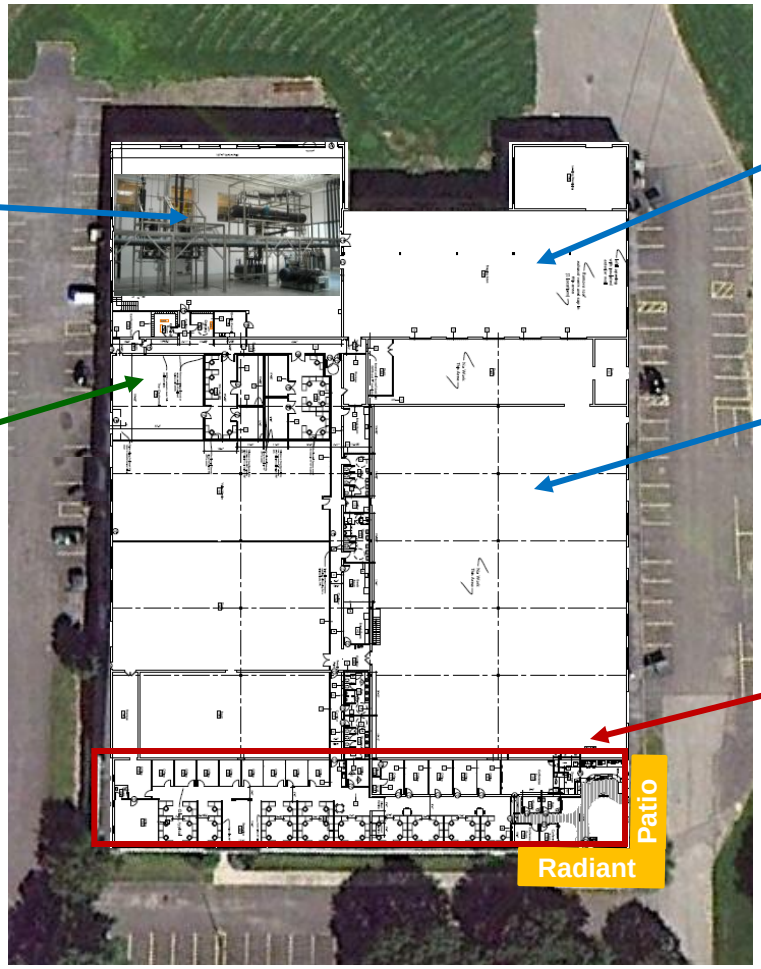
Thar R744 Geothermal Facility, Pittsburgh, PA
System Integration & Development

Toll Process Space
Cooling & Heating
Air Handling Units

Geothermal Lab & Workshop



Shipping & Receiving
Cooling & Heating
Air Handling Units

Manufacturing & Warehouse Space
Cooling & Heating
Air Handling Units

Front Offices Radiant Floor

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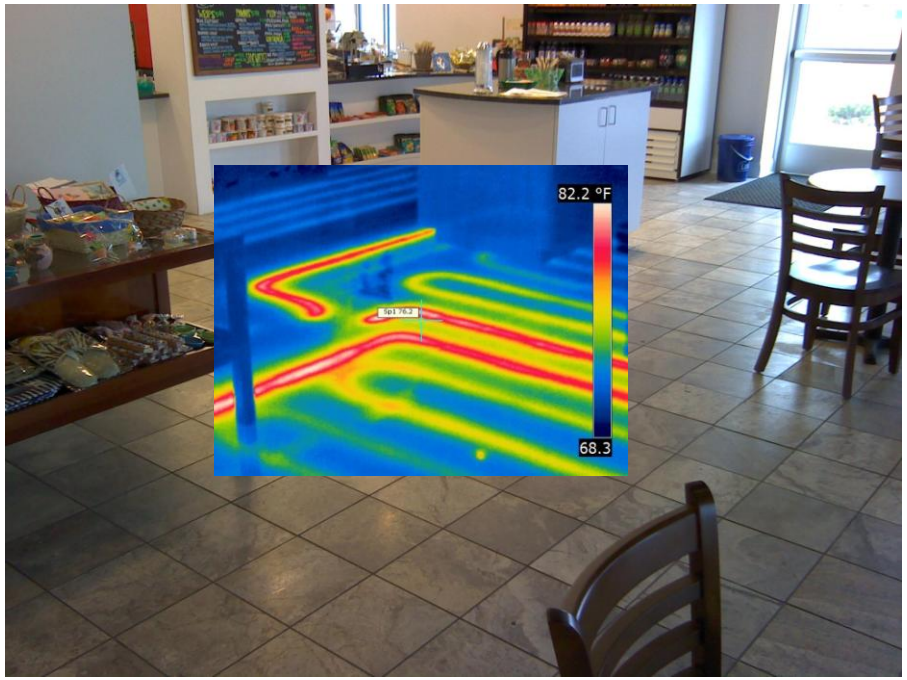
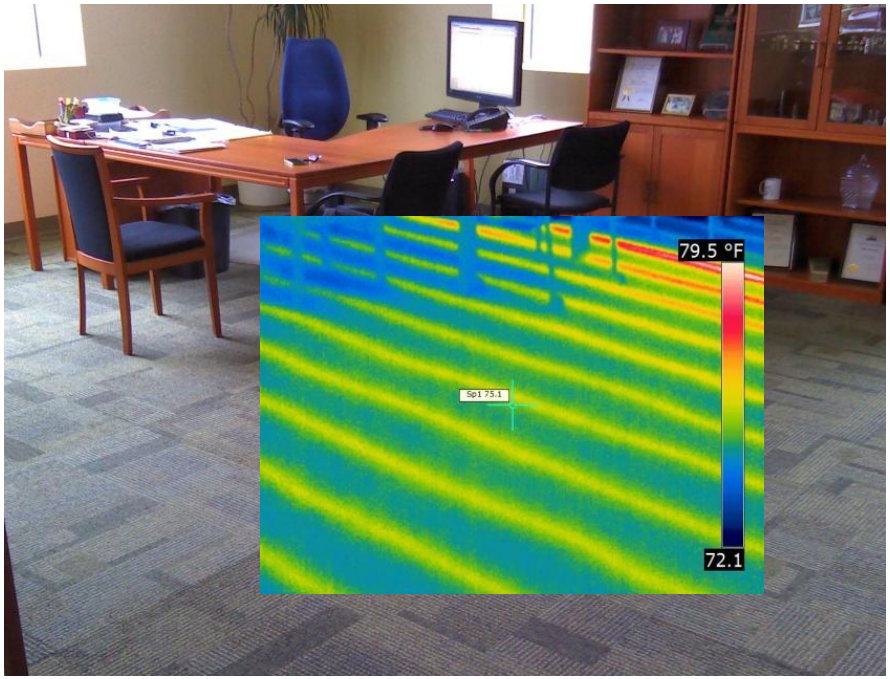
R744 Radiant Floor Thermal Image Overlay

Café



Office



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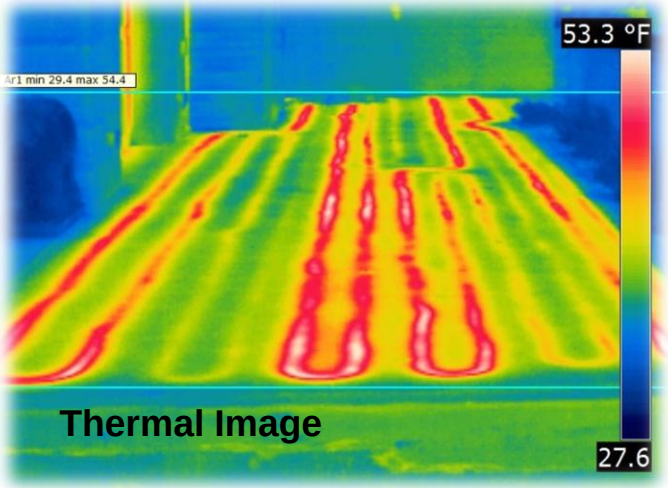
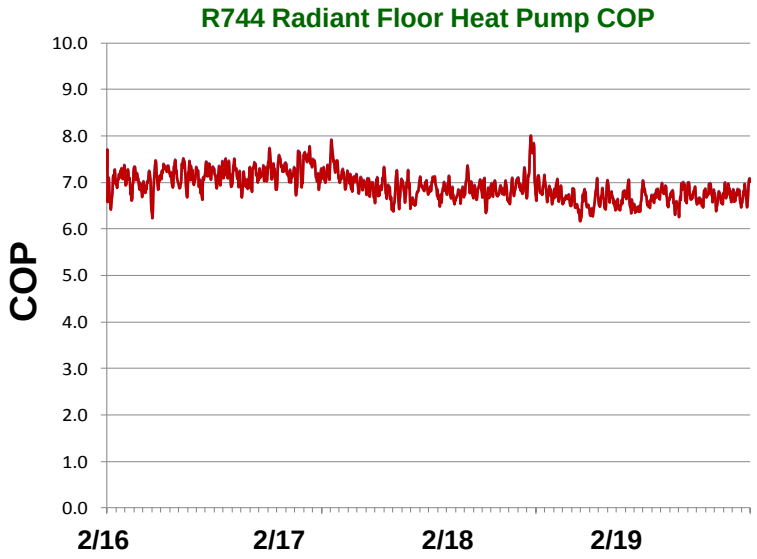
R744 Radiant Patio – Snow Melt





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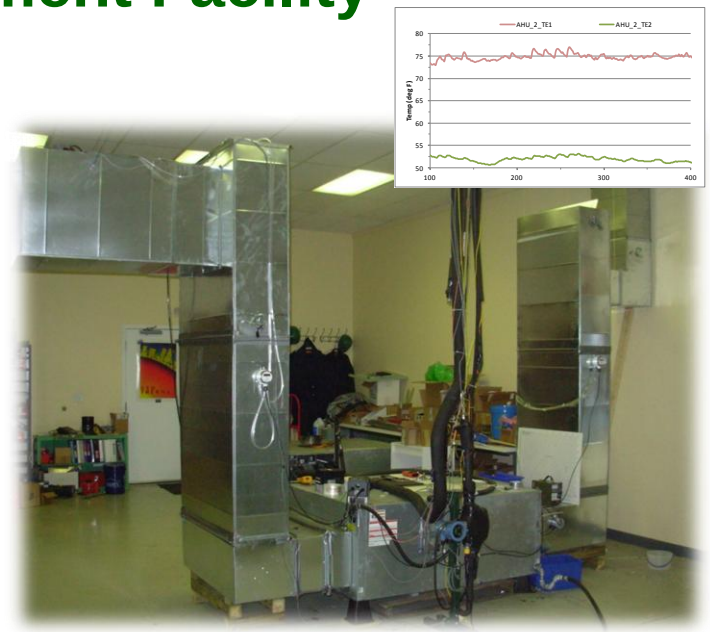
Thar Geothermal Development Facility

- **Validate R744 DX heat pump cycle**



- **Component Testing and Evaluation**
  - **Microchannel Heat Exchanger Designs**
  - **Electronic Expansion Valves**
  - **Oil Management Systems**
  - **Control Software/Hardwares**

- **Demonstration at commercial scale geothermal system (15-20 ton)**
  - **Air Side Heat Exchangers (heating and cooling)**
  - **Radiant Floor & Panels (heating and cooling)**

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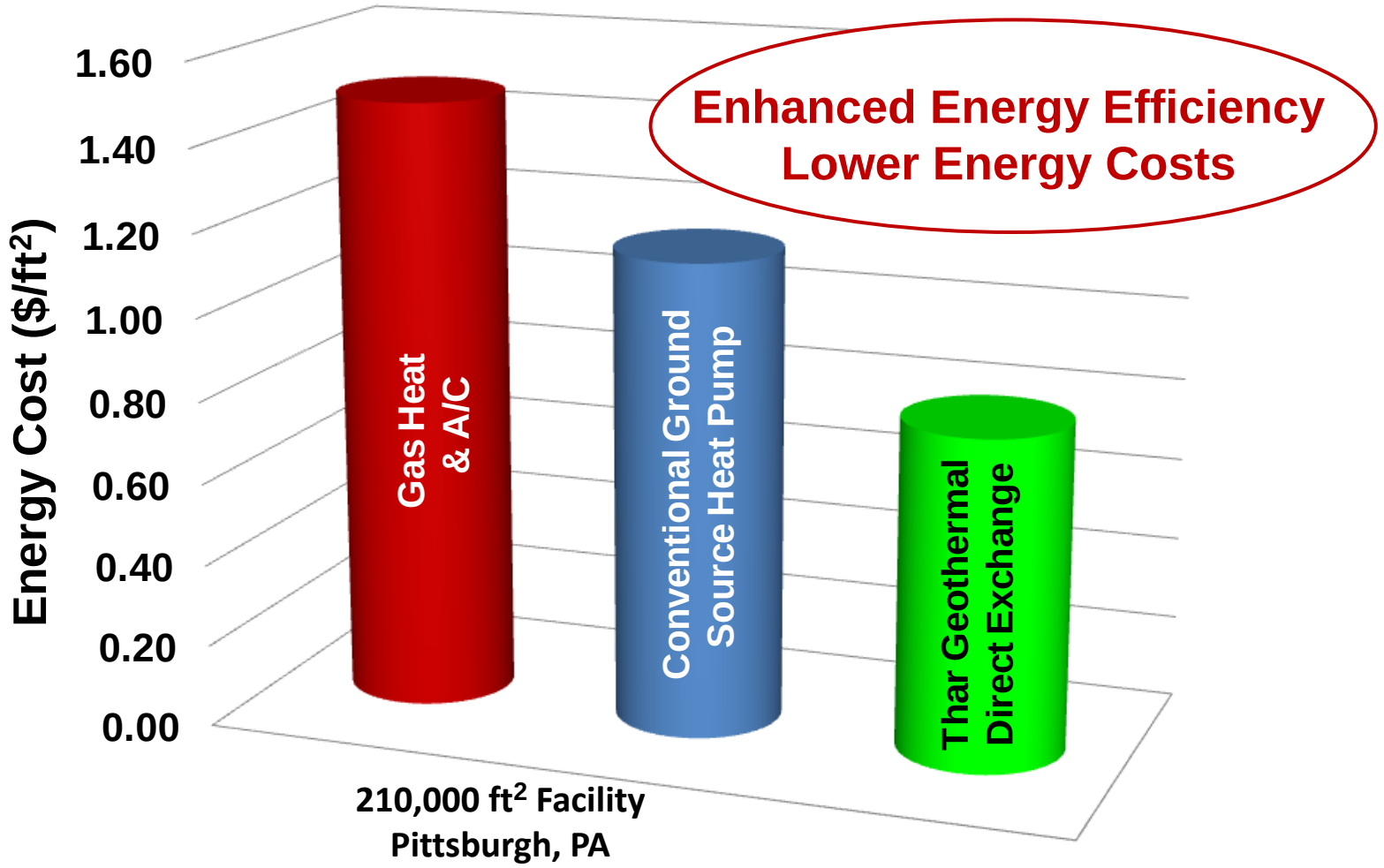
ECO_2 Efficient



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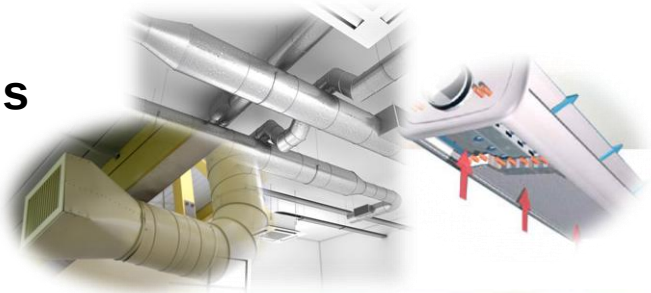
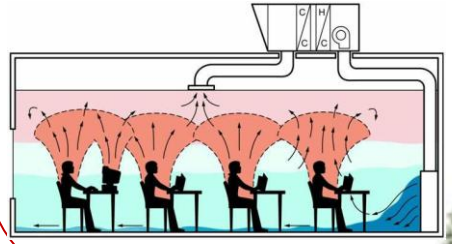
The Approach

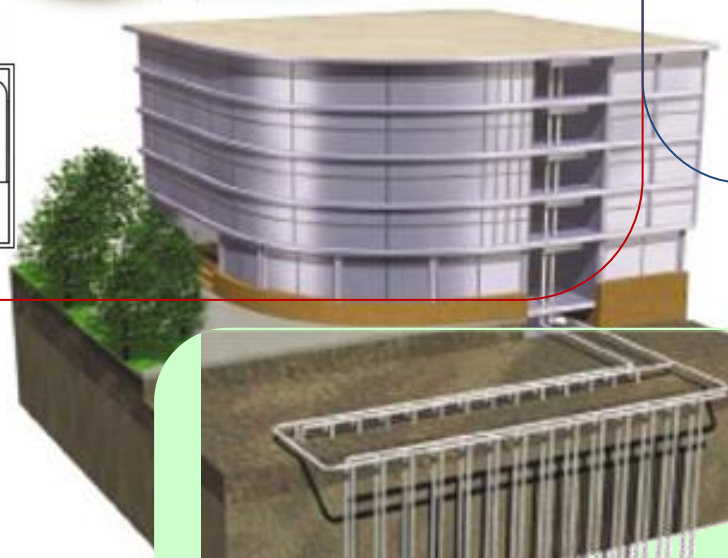
Conventional HVAC Delivery Systems

Comfort Controls

Temperature
Relative Humidity
Indoor Air Quality







Above Ground Mechanical Room

R744

Below Ground

R744

DX Geothermal GHX

Geology- Drilling- Geo-Loop Installation-Grouting

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Conclusions

- **Thar Geothermal Solutions are the next generation in Ground Source Heat Pump Systems providing *Enhanced Economic & Environmental Value***
- **Natural, Safe & Non-toxic R744 (recycled CO_2) Refrigerant**
  - **Less expensive, Promotes ease of maintenance**
- **Direct Exchange Design More Efficient**
- **Improved Return on Investment**
  - **Reduced Operating Costs**
  - **Reduced Maintenance Costs**
  - **Same or Lower Capital Costs**
- **Reduced Environmental Impact**

Nature's CO₂MFORT ADVANTAGE