Variable Refrigerant Flow Systems 
vs. 
Geothermal Water Source Heat Pump Systems

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Agenda

Section I: Case Study – Northern Illinois Food Bank
- NIFB challenge/goal
- System choices considered
- System choice selected
- Results/awards

Section II: Comparing VRF Systems to GSHP Systems
- Comparison of system components
- Advantages of VRF Systems
- Capturing first cost savings with VRF systems
- Conclusions

Section III: Northern Illinois Food Bank Building Tour
Section I: Case Study - NIFB

NIFB Challenge/Goal

The Challenge:
The Northern Illinois Food Bank needed a new facility to allow them to continue their mission of preparing and distributing food to over 60,000 hungry people each week.

The Goal:
Design and construct a cutting-edge, energy efficient building on time & in budget to meet the future needs of the communities the NIFB serves. The design team targeted LEED certification as an important requirement of the building’s design and construction process.

System Choices Considered

To meet the project's energy efficiency requirements, many systems were evaluated. The final two systems considered for the office area were:

- Geothermal water source heat pump (GSHP) system
- Air source variable refrigerant flow (VRF) system
Section I: Case Study - NIFB

System Choice Selected

After careful consideration, VRF was selected as the winning system choice. Three key advantages influenced the decision:

- Very little, if any, energy efficiency penalty to go with VRF
- Lower capital cost by approximately $400,000
- VRF system qualified for a grant from a clean energy foundation

Other innovative and efficiency systems were used elsewhere, including:

- White roof technology
- Motion controlled lighting
- High performance glass
- Warehouse heating via waste heat from cooler/freezer systems

Results/Awards

Project Milestones:
- July 2010: Ground breaking ceremony
- October 2011: Construction completed
- April 2012: Building is awarded LEED®-NC Gold certification
- April 2012: Building is awarded USGBC –Illinois Chapter Emerald Award

End Result:
The VRF system was a key component in helping the NIFB achieve their goals of constructing a cutting-edge, energy efficient facility on time & in budget. In addition, the sustainable features inherent in VRF systems contributed to the facility’s LEED®-NC Gold certification and Emerald Award.
Section II: VRF Systems vs. GSHP Systems

System Components - VRF

- Condensing unit(s) (compressors)
- Single piping system
- Individual controls in each zone
  - Temperature set points
  - Fan speed
  - Multiple operating modes
- Multiple indoor units
- Ventilation served by separate system

System Components - GSHP

- Bore field
  (may have boiler/tower in hybrid system)
- Circulating pump
- Single piping system
- Individual controls in each zone
  - Temperature set points
  - Fan speed
  - Multiple operating modes
- Multiple indoor units
- Ventilation served by separate system
Section II:  VRF Systems vs. GSHP Systems

System Components - Similarities

On the surface, VRF and GSHP look very similar:

- Heating & cooling via refrigerant based heat pump cycle
- Multiple terminal units located in, or near, occupied space
- High degree of zoning flexibility & individual temperature control
- Ventilation handled by separate DOAS system

UNDER CLOSER INSPECTION THERE ARE SIGNIFICANT DIFFERENCES

Section II:  VRF Systems vs. GSHP Systems

System Components - Differences

Despite the similarities, there are key differences:

- In VRF systems, compressors are centrally located in lieu of in/near the occupied space
- In VRF systems, compressors are variable speed in lieu of staged control
- In air source VRF systems, no circulating pumps are required
- In air source VRF systems, no bore field is required
- VRF systems have more flexibility regarding terminal unit appearance & location
- VRF systems are an integrated “self contained” control system. In many cases, no third party controls are required operate system. As compared with the many independent components (i.e pumps, GSHP units, boilers/towers (if used), etc.) needed in GSHP system.
Section II: VRF Systems vs. GSHP Systems

Advantages of VRF Systems

The previously discussed differences contribute to the following advantages of VRF systems as compared to GSHP systems:

- Improved maintenance/serviceability
- Improved system sound performance
- Improved dehumidification/temperature control
- Improved unit/system reliability
- Reduced capital cost
- Reduced life cycle cost

Advantages of VRF Systems: Improved Maintenance/Serviceability

- Most GSHP systems have multiple, small compressors scattered throughout the building. In large systems, the number of compressors can easily be in the 100-500+ range. This presents a significant challenge for maintenance/service personnel to properly maintain and service units.

- Most GSHP systems have terminal units located in ceiling space with extremely limited (if any) service access clearances. To minimize downtime, “spare chassis” concept is utilized.

- **VRF systems utilize centrally located compressors for ease of maintenance and service.**

- **EXAMPLE:** Regional Hospital located in Elgin, IL
  - 645,000 sq. ft. facility
  - 255 patient rooms in 6-story tower
  - 540 water-to-air heat pumps in building = **at least 540 compressors**
Advantages of VRF Systems: Improved System Sound Performance

- As previously stated, in GSHP systems the compressors are often located in the occupied space. Compressors can generate significant noise and vibration, especially in large tonnages.
- To minimize noise related issues, designers have trended towards specifying sound reduction packages/specialized vibration isolation mounting systems (*increased unit cost*) or remote location of the GSHP unit (*increased installation cost*).
- **VRF systems utilize centrally located compressors for ease of noise/vibration attenuation. By utilizing variable speed compressors and fans, VRF systems are inherently quiet; in many cases, they don’t require any special attenuation.**

<table>
<thead>
<tr>
<th>Nominal Tonnage</th>
<th>Premium GSHP (w/sound attenuation)</th>
<th>Ductless VRF Evaporator</th>
<th>Ducted VRF Evaporator</th>
</tr>
</thead>
<tbody>
<tr>
<td>2T</td>
<td>47</td>
<td>28-36</td>
<td>38-42</td>
</tr>
<tr>
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<td>52</td>
<td>31-38</td>
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<tr>
<td>4.0T</td>
<td>54</td>
<td>34-45</td>
<td>40-44</td>
</tr>
</tbody>
</table>

Advantages of VRF Systems: Improved Dehumidification/Temperature Control

- Most conventional GSHP heat pump systems utilized staged compressors for temperature control. Often, this results in wide swings in the space temperature and poor dehumidification.
- To combat excessive humidity build-up that can be problematic in GSHP systems, complex DOAS systems are utilized to treat the humidity at the source.
- **By utilizing variable speed compressors & electronic expansion valves, VRF systems provide precise space temperature and humidity control. In some cases, only energy recovery ventilators are required in lieu of full DOAS systems.**

![Graph showing temperature set point over time]
Section II: VRF Systems vs. GSHP Systems

Advantages of VRF Systems:
Improved Unit/System Reliability
- As previously discussed, GSHP systems can be subjected to less than ideal maintenance and service conditions. Both maintenance and service are critical to system reliability.
- GSHP systems are usually comprised of many small refrigerant circuits scattered throughout the building. Although factory testing is completed on the units, experience has shown that the reliability of the units is less than desired.
- By utilizing easy to maintain and service, centrally located variable speed compressors, and rigorously tested and proven installation techniques, VRF systems have been shown to have exceptional system reliability. While VRF systems exhibit some characteristics of centralized systems, their modularity and design provide significant redundancy.

Advantages of VRF Systems:
Reduced Capital Costs
- GSHP systems require the land and labor/materials to drill bore holes into the earth. In many cases the land required is not available; furthermore at approximately $3,000/ton geothermal field construction can be too expensive.
- Most GSHP systems require a dedicated 20-30A power feed to each terminal unit, resulting in higher electrical installation costs.
- Most GSHP systems require a 3rd party Building Automation System (BAS) to coordinate all of the various system components, resulting in higher temperature control installation costs.
- By utilizing an air source heat pump VRF platform, there is no need for the land/expense required with a geothermal bore field. By centrally locating the compressors, a smaller number of larger power feeds are required, resulting in lower electrical installation costs. Finally, many VRF systems do not require a BAS to operate the system. VRF systems already include all necessary control devices to coordinate the various system components, resulting lower temperature control installation costs.
Section II: VRF Systems vs. GSHP Systems

Advantages of VRF Systems:
Reduced Capital Costs

80 Room Hotel
80 GSHP’s – 2 ton = 30 MOCP per unit
Power service requirements 30 amp X 80 = 2400 amp service for rooms

VRF System
20 – 8 ton VRF @ 42.7 amps – 20 X 50 amps = 1000amps
80 Fan Coils @ .5amps – 10 X 20 amps = 200amps
1200 amp service for rooms

Section II: VRF Systems vs. GSHP Systems

Advantages of VRF Systems:
Reduced Life Cycle Cost

High Efficiency + Reduced Maintenance + Sustainability = Lower Total Cost of Ownership
Section II: VRF Systems vs. GSHP Systems

Conclusions

- VRF systems are an excellent alternative to decentralized GSHP systems.
- Air source VRF systems can provide similar, or better, energy efficiency to GSHP systems without the expense of the geothermal bore field.
- VRF systems can provide better sound performance.
- VRF systems can provide better temperature/dehumidification control.
- VRF systems can be more reliable and are easier to maintain/service.
- VRF systems are not a magic bullet, they should be applied where best suited. Some buildings are good candidates for a “hybrid” approach integrating multiple system choices.

Section III: NIFB Building Tour

- Let's see some equipment in operation.
Section III: Summary

THANK YOU

Questions?

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