

Geothermal HVAC – Exceeding ASHRAE Standards at Lowest Life Cycle Cost

By Grant Morrison
Director
Geothermal India, Chennai

and **Parwez Ahmed**
Operations Manager
Geothermal India, Chennai

A Plate Heat Exchanger installed in the open, outside the Trac office in Hyderabad, in which thermal properties of moat water are exchanged with the properties of water entering the condensers of the Heat Pumps inside the offices. The rocky terrain of Hyderabad is visible in the background.

In this second article on Geothermal HVAC, we seek to explain how using Geothermal HVAC solutions can deliver a solution that exceeds ASHRAE Standards without exceeding the budget compared to other popular HVAC solutions. The first article appeared in the Oct-Dec 2010 issue.

We will focus on the ASHRAE Standards most relevant for a commercial office, namely:

- ASHRAE Standard 55-2004 Thermal Comfort
- ASHRAE Standard 62.1-2010 Ventilation
- ASHRAE Standard 90.1-2007 Energy Efficiency

As a refresher from our last article, Geothermal HVAC utilizes one or more Geothermal Heat Pumps to pump heat to and/or from the ground or groundwater:

1. As a thermal energy to heat a

structure or

2. As a thermal energy sink to cool a structure.

The Heat Pumps are either:

1. Water-to-water: a device producing chilled or heated water depending upon the requirement
2. Water-to-air: a unitary device containing the condenser and blower to produce cool or warm air depending upon requirements.

The ground or groundwater component of the Geothermal HVAC solution is known as a Ground Heat Exchange. Ground Heat Exchanges can be either:

1. Lake/Pond Closed Loops: Utilizing a series of pipes placed in bodies of water;
2. Open Loops: Utilizing groundwater in an aquifer or body of water;
3. Vertical/Horizontal Closed Loops: Utilizing a series of underground

pipes bored into small wells or laid into trenches.

Our article will illustrate how each ASHRAE Standard was exceeded in the context of a recently completed Geothermal HVAC project for a small commercial office in Hyderabad.

The Project

As the HVAC designer and provider of the HVAC solution also known as Geothermal Heat Pumps or Ground Source

About the Authors

Grant Morrison has over 20 years experience in a broad range of operations and finance roles in the logistics, construction and finance industries across Australia, Asia and Europe. With a degree in Business from UTS, Australia, he has previously worked with Barclays Bank in the UK and ING, Australia.

Parwez Ahmed has 10 years of HVAC experience in India and is a mechanical engineer from RJIT. He is responsible for overseeing design and installation of both geothermal and water-source heat pump technology projects in India.

Heat Pumps (GSHP) for a new commercial office of Trac India Private Limited (Trac), that was intended to be their office during the construction phase and subsequent management of a Night Safari Park and Hotel in Hyderabad. The building is aiming for Platinum LEED Certification under Indian Green Building Council Guidelines.

In the first step, we needed to assess which ground heat Exchange would maximize the efficiency of the HVAC solution at the lowest cost. Hyderabad is well known for its rocky terrain. When considering a rocky terrain, the Geothermal HVAC designer needs to balance the higher thermal conductivity offered by rock compared to sandy soil against the higher bore drilling costs. Horizontal and vertical Closed Loops were ruled out due to the higher costs. Fortunately, the client was willing to use a moat (a trench filled with water) surrounding the building for the Open Loop Ground Heat Exchange.

This is the first Open Loop Ground Heat Exchange in India. Water from the moat is pumped to a plate heat exchanger. There the thermal properties of the moat water are exchanged with the thermal properties of the water in the building loop. The building loop is a closed loop of pipes connected to each of the Geothermal Heat Pumps placed within the conditioned space of the building. The building loop pumps cooler water into each Geothermal Heat Pump, then pumps hotter water containing heat waste from the conditioned space away from the Geothermal Heat Pumps. As the building loop passes the plate heat exchanger again, the thermal property of the hotter water is transferred back into the moat.

The water in the moat averages 25°C and this in turn becomes the entering water temperature for the Geothermal Heat Pumps. It is worth repeating here that the water from the moat does not enter the building loop and subsequently the Geothermal Heat Pumps. Only the thermal properties of the water enter the building loop. And rather than the terrain being a hindrance to Geothermal HVAC, we incorporated the largest boulder on the site to assist with heat dissipation. The moat water containing the heat waste is sprayed onto the large boulder before the moat water circulates back to the plate heat exchanger. The boulder and moat acts like a natural cooling tower – allowing for heat waste to escape through natural evaporation.

Table 1 shows a summary of each of the conditioned spaces and the Geothermal Heat Pump used:

The Methodology

Originally Trac was set to install a VRF (VRV) solution. The task for for us was to convince the client that a Geothermal HVAC Solution coupled with an Open Loop Ground Heat Exchange could better the VRF solution in the following criteria:

1. ASHRAE Standard & LEED Credits
2. Energy Efficiency
3. Life Cycle Cost – equipment acquisition/installation/

Table 1 Summary of spaces in Trac office and heat pumps used.

Space	Area (sqf)	Occupancy	OA cfm	Nominal TR	EER	ClimateMaster Model
Server Room	95	0	0	1.5	24.8	TSV018BVG29ARTS
CBRE Workstation	733	15	134	5	23.2	TSH060AUG29ARBS
Night Safari	748	12	137	5.8	21.6	TSH070AUG29ARBS
GM Office	266	7	67	2.5	22.9	TSH030AUG29ARSS
Conference Room	490	15	135	4	23.3	TSH048AUG29ARSS
	2332			18.8		

operation/maintenance

The following methodology was followed to compare and contrast the different HVAC solutions which could possibly be used for the Trac office:

1. An Energy Model was built using the US Department of Energy eQUEST Building Simulation program to simulate and replicate the conventional HVAC for the office:

- a. Heat Loads – lighting, equipment and people
- b. Outside Air
- c. Building characteristics
- d. Energy Consumption

- e. ISHRAE Weather bin data for Hyderabad

2. This building simulation created:

- a. The baseline for comparative purposes and financial viability
- b. The building model to assess Geothermal Heat Pump performance

3. A design option for Geothermal Heat Pump HVAC was created:

- a. Assessed and sized the Tranquility 20 Single-Stage models of GSHP from ClimateMaster

Note: We followed the manufacturer's (ClimateMaster) recommendation to deliberately under-size the unit for the conditioned space. According to ClimateMaster, under-sizing the unit will result in better handling of dehumidification and result in longer life cycle of the equipment.

4. Benchmarked VRF system rated at 12 EER vs. Geothermal HVAC vs. Water-cooled Chiller/FCU

5. Created Lifecycle Cost Analysis model including:

- a. Design and Installation Costs
- b. Energy Consumption comparisons
- c. Initial and On-going Costs
- d. Pay-back Period

Benchmarking VRF HVAC Solutions Against Geothermal Heat Pumps

It was a challenge when it came to assessing the performance of VRF HVAC solutions within the Energy Model created in eQUEST. There are many types of HVAC solutions which have been loaded into eQUEST including Geothermal Heat Pumps. However, VRF HVAC is not available as an option. Therefore a proxy solution representing VRF was developed and applied.

We followed the methodology described by Dr. Xioabing Liu, formerly of ClimateMaster and currently with the Oak Ridge National Laboratory of the US Department of Energy. The key points to note in this methodology and research (with permission from ClimateMaster Inc, USA) are:

The major difference between VRF systems and conventional HVAC systems is that they adjust cooling/heating output by modulating the refrigerant flow continuously with variable speed compressor. VRF systems enable a single outdoor unit to be connected to dozens of indoor units of varying capacity and configuration throughout a building. It typically comprises of one or more centralized outdoor unit(s), which contains two or more air-cooled compressors, one of which is of variable speed. The indoor units contain electronic expansion valve, direct expansion coil, and fan. The outdoor and indoor units are connected with relatively long refrigerant line and require sophisticated control and refrigerant management. There are two types of VRF systems available: the “heat pump” (HP) type VRF, which provides either heating or cooling to the space, and the “heat recovery” (HR) type VRF, which provides heating and cooling simultaneously to different zones within a building.

The long refrigerant line may result in significant heat/cool loss and increased compressor power consumption. Third, some VRF systems require special “oil return” operation to get the lubricant oil back to the compressor, which consumes extra energy compared with conventional packaged air source heat pumps.

Compared with typical packaged GSHP units, VRF system usually has much longer refrigerant lines. The longer lines not only require larger system refrigerant charge, but also results in loss of heating/cooling capacity as well as increased compressor power consumption.

Length of refrigerant line significantly affects both the heating and cooling capacity of the simulated VRF system. It appears that the cooling capacity is more sensitive to this factor than the heating capacity. It may indicate that, in cooling mode, some refrigerant has been evaporated while transporting through the refrigerant line before entering into the indoor units.

Key finding – Comparison with Geothermal Heat Pump HVAC Solution

Geothermal Heat Pump HVAC solutions save 14% to 29% electricity compared with the “heat recovery” type VRF system with standard refrigerant line. More energy savings from GSHP system (up to 36%) could be expected if the “heat pump” type VRF system is compared and/or longer refrigerant line is used in the VRF system.

ASHRAE Standards

When designing a Geothermal HVAC solution, adherence to ASHRAE Standards is paramount. The ASHRAE Standards enable us to measure the effectiveness and efficiency of our design. The EQUEST Building Simulation Software tool produces a range of reports which allow the designer to check against the applicable ASHRAE Standard.

ASHRAE Standard 55-2004 Thermal Comfort

This standard provides the thermal environmental conditions

for human occupancy.

a. *Humidity limits:* Systems designed to control humidity shall be able to maintain a humidity ratio at or below 0.012, which corresponds to a water vapor pressure of 1.910 kPa (0.277 psi) at standard pressure or a dew point temperature of 16.8°C (62.2°F).

There are no established lower humidity limits for thermal comfort; and consequently, this standard does not specify a minimum humidity level. However, non-thermal comfort factors such as skin drying, irritation of mucus membranes, dryness of the eyes, and static electricity generation may place limits on the acceptability of very low humidity environments.

b. *Operative Temperature:* For given values of humidity, air speed, metabolic rate, and clothing insulation, a comfort zone may be determined. The comfort zone is defined in terms of a range of operative temperatures that provides acceptable thermal environmental conditions or in terms of the combinations of air temperature and mean radiant temperature that people find thermally acceptable.

Methodology used to adhere to ASHRAE Standard 55

A preliminary Geothermal HVAC design was created for the Hyderabad office to assess within the eQUEST Building Simulation model. We were able to access reports on space temperature and relative humidity for each conditioned space across all hours of operation for a year.

If space temperature or relative humidity is too high, we increased the tonnage of the Geothermal Heat Pump for any specific conditioned space. eQUEST has simulated that the Geothermal Heat Pump design for the Hyderabad office will produce:

1. Space temperature between 21-24°C (70-75°F) for 3,150 of 3,756 operational hours of the building. The space temperature is higher for the remaining hours. During this time, the conditioned space is unoccupied; the Geothermal Heat Pumps are in start-up at the beginning of the working day and cool down the space before the occupants arrive.
2. Relative humidity is lower than 65% for 3,545 of 3,756 operational hours. As per space temperature, humidity is only above 65% for 6% of the time during the cool down period prior to building occupants arriving.

The occupants have control over the Geothermal Heat Pumps within each conditioned space as each unit is connected to its own thermostat. The user can change the space temperature to their desired level of thermal comfort through a simple temperature change on the thermostat.

Geothermal Heat Pumps combat humidity within the conditioned space through slightly under-sizing the solution. ClimateMaster, the Tranquility 20 Single-Stage Geothermal Heat Pump manufacturer, recommends under-sizing the unit, as humidity control because it will allow the compressor to run on full capacity for maximum time. This ensures maximum cooling on evaporator which allows maximum dehumidification of

continued on page 86

continued from page 84

supply air (due to condensation).

ASHRAE Standard 62.1-2010 Ventilation

This standard sets minimum ventilation rates for indoor or enclosed areas that have human occupants, and assumes that the outside air is free of “unusual” contaminants. Human comfort is not considered; for example, humidity levels that are uncomfortable aren’t a problem unless they encourage the growth of mold.

Maximum humidity is 65%, provided there is a method to dehumidify. This is not a level designed for comfort; rather it is a point where condensation on cooler surfaces and subsequent mould growth is a possibility.

Definition of “acceptable indoor air quality” provide as “air in which there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction.”

Furthermore, ASHRAE Standard 62.1 recommends calculating Outside Air using the combined method for minimum ventilation rates:

- a. 0.06 cfm per square foot.
- b. 5 cfm per occupant (for standard office space).

The methodology used to adhere to ASHRAE Standard 62

The outside air requirement for each of the conditioned spaces within the Trac office was calculated using the combined method above plus increasing the minimum by 30% to gain additional LEED Credits. Table 2 show the rates:

Table 2 : Summary of spaces in Trac office and fresh air cfm.

Space	Area (sqf)	Occupancy	OA cfm
Server Room	95	0	0
CBRE Workstation	733	15	134
Night Safari	748	12	137
GM Office	266	7	67
Conference Room	490	15	135

The applicable OA cfm rate to each conditioned space was entered during the design phase of the eQUEST Building Simulation. An Air Side Report from eQUEST confirms the OA rate has been included in the design to guide the Geothermal Heat Pump sizing and subsequent performance of the HVAC solution.

To implement the ASHRAE Standard and LEED credit requirements into our design, we opted to draw in the outside air into a plenum box to mix with the return air.

The fan (or the blower) of the Geothermal Heat Pump sucks the hot return air from the room and blows it over the cooling coil, cools it and sends it to the room to be air conditioned. There are two possible arrangements of the fans in air handling units:

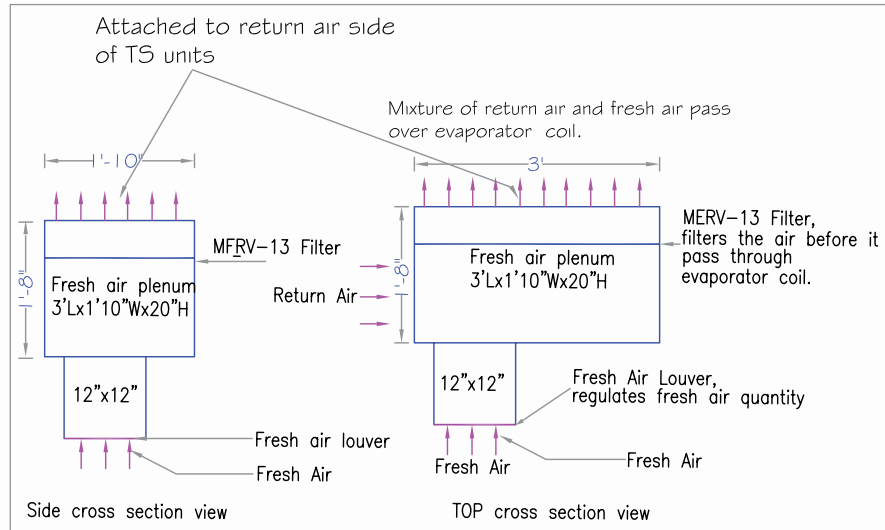


Diagram 1: Plenum design for return and fresh air at the Trac office.

1. Draw-through arrangement and
2. Blow-through arrangement.

In the draw-through arrangement, the fan sucks the return air through the filter and the cooling coil. As the air passes over the cooling coil its gets chilled, and is then passed to the rooms to be cooled. In case of the blow-through arrangement the fan absorbs the return air and blows it over the air filter and the cooling coil. The air then flows to the rooms to be air conditioned. The draw-through arrangement is used more commonly due to its compactness. The fans are of centrifugal types.

Outdoor air and return air mixes in a plenum box, which is attached to evaporator side of Geothermal Heat Pump. Return air opening is located inside false ceiling plenum and outside air louver is located on outside wall of building. The mixture of outside air and return air is induced in plenum box due to vacuum created by blower as per first type of arrangement. In this arrangement there is no separate need of dedicated blower for outside air, thereby saving energy. The quantity of the outside air is controlled by a louver, opening of which is regulated by CO Sensor.

Diagram 1 is a representation of this design for the Trac office.

Additionally, MERV 13 filters were installed which filter both the outside and return air before it enters the conditioned space.

ASHRAE Standard 90.1-2007 Energy Efficiency

The ASHRAE Standard 90.1-2007 benchmark for a Geothermal Heat Pump is 13.4 EER (Energy Efficiency Ratio) where entering water temperature is 25°C (77°F).

The methodology used to adhere to ASHRAE Standard 90

To ensure that the Geothermal HVAC solution design exceeded ASHRAE Standard 90 and gained maximum LEED credits for energy efficiency, a ClimateMaster Geothermal Heat Pump with a high energy efficiency rating under AHRI/ASHRAE/ISO 13256-1 conditions was selected Table 3 is the energy efficiency rating for each Geothermal Heat Pump used in the Trac building.

continued on page 88

continued from page 86

The data is abstracted from ClimateMaster’s Submittal Data where:

- a. Entering water temperature is 25°C
- b. Flow is 3 GPM/TR

Table 3: Summary of EER for spaces in Trac office.

Space	Model	EER @ EWT 25°C	Above ASHRAE 90.1
Server Room	TSV018BVG29ARTS	16.89	26%
CBRE Workstation	TSH060AUG29ARBS	17.09	28%
Night Safari	TSH070AUG29ARBS	16.79	25%
GM Office	TSH030AUG29ARSS	17.67	32%
Conference Room	TSH048AUG29ARSS	16.48	23%

The next step was to run the eQUEST Building Simulation model for the Trac building following the methodology outlined earlier in this article. ClimateMaster has developed a product library which integrates to eQUEST to enable Heat Pump unit selection and performance assessment. A number of iterations are made to the model to ensure adherence to ASHRAE Standards.

An Energy Consumption report is produced from eQUEST which breaks down all components of the HVAC solution into:

- a. Space Cooling
- b. Heat Rejection
- c. Fans & Ventilation
- d. Pumps & Ancillary

Table 4 compares the energy consumption of three contrasting HVAC solutions:

1. Geothermal Heat Pumps – as per the methods described above and then adjusted for actual performance measured at site.
2. VRF – as per the method described by Dr. Liu and rated at 12 EER
3. Central Chiller Plant rated at 0.7kW/TR with Fan Coil Units

Table 4: Comparison of energy consumption for three different solutions

Annual Energy Requirement	Geothermal	VRF	Chiller/FCU
Space Cooling	25,440	49,120	46,730
Heat Rejection	-	-	2,040
Ventilation Fans	16,050	15,530	28,890
Pumps & Auxiliary	7,930	-	9,210
Total kWh	49,420	64,650	86,870
Energy Rate per kWh	5.0	5.0	5.0
Annual Energy Expenditure	247,100	323,250	434,350
TR	20	19	20
Project Square Feet	2,497	2,497	2,497
System kW	0.66	0.91	1.16
System EER	18.2	13.2	10.4
Running Hours	3,756	3,756	3,756

The key observations from this table are:

- Geothermal Heat Pumps are found to be about 24% more efficient than VRF. This result is in line with the research conducted by Dr. Liu.
- Geothermal Heat Pumps are found to be about 43% more efficient than a higher-end chiller coupled with fan coil units.
- When comparing HVAC solutions, one must assess all components of the solution from a model of the actual building with an hourly weather file representing the local conditions (available from ISHRAE)

Why are Geothermal Heat Pumps Proven to be the Most Energy Efficient HVAC Solution?

In India our experience has been that HVAC consultants and customers are all pursuing a water-cooled chiller with the lowest kW rating. We believe this approach is incorrect as it ignores:

- All other components of the HVAC solution. As seen in the Energy Consumption Table above, the Space Cooling component (or the Chiller aspect) is only 50% of the Total Energy Consumption of the entire HVAC solution.
- The quoted kW rating is usually under test conditions which may vary remarkably with the local conditions at the building in terms of weather, heat loads and diversity factors.
- The unscrupulous amongst us in the industry may increase total tonnage in order to deliver a low kWh/TR number. It just goes to prove, how seemingly important this number is to the HVAC industry.

To further highlight why site conditions including HVAC solution design may impact and further enhance the case for Geothermal Heat Pumps, one needs to further explain each component of Energy Consumption.

Space Cooling

The number one site condition factor contributing to Space Cooling for any given HVAC solution is the temperature of the refrigerant as it enters the condenser.

Geothermal Heat Pumps take advantage of the lower and relatively more constant temperature of the earth or groundwater to transfer the thermal properties into the entering water temperature and therefore increase efficiency of the condenser.

A VRF solution relies on the ambient air temperature to lower the temperature of the refrigerant entering the condenser.

A water-cooled chiller relies on a cooling tower to lower the entering water temperature. The cooling tower performance, like the VRF solution, is subjected to ambient air temperatures.

In hot climates like India, where the predominance is for cooling during day time office hours, it is more efficient water cooled condenser than air cooled condenser because of thermal property of water. Water has higher heat capacity than air and therefore it reduces the volume of medium to extract heat from condenser and it can absorb more heat than air.

continued on page 90

continued from page 88

Heat Rejection

Neither Geothermal Heat Pumps nor VRF solutions generate heat rejection energy consumption. This is a function of the cooling tower.

Pumps and Ancillary

VRF does not require pump energy. A Geothermal Heat Pump requires two circulation pumps. One for the Open Loop Ground Heat Exchange and one for the building loop as per the Trac office HVAC design.

Fans & Ventilation

Fans and ventilation consumption can be as high as 50% of the total energy consumption for the HVAC solution.

The reasons why water-to-air Geothermal Heat Pumps have very low fans and ventilation energy consumption are due to their placement within the cooled space and the relatively large air coil face area.

For the Trac office

- Return Ducting: Geothermal Heat Pumps do not have return air ducting requirements since unit is inside the space itself. As such there is no static pressure for return ducting. Whereas AHU will require return ducting. Our design utilizing direct return saves 3000 kWh annually.
- Low External Static Pressure (ESP): Supply-side duct work for Geothermal Heat Pumps is very short compared to AHU because the unit is in the conditioned space. Therefore ESP is very low compare to AHU which may be installed remotely to the conditioned space. With less duct work there is lower cfm loss in the duct and negligible heat gain through the duct.
The ESP for the Geothermal HVAC solution is only 0.059 inches of wg. The ESP for an AHU to provide conditioned air for the same space would be a much higher 1.1456 inches of wg due to longer duct run and higher cfm.
As the ESP for AHU system is much higher than the geothermal heat Pump, the HP of the blower will be much greater and consumer more energy.
- Air coil face area: Face area (evaporator) of the Geothermal Heat Pump unit is 56% more than face area of conventional AHU. The higher the face area, the higher the efficiency for fans and ventilation energy consumption because:
 - a. High face area results in better contact factor due to low velocity of return air passing over evaporator coil. This results in better heat transfer between air and refrigerants.
 - b. High coil area reduces the pressure drop across evaporator coil, which in turn helps in reducing ESP for blower.

In conclusion, Geothermal Heat Pumps offer massive energy consumption savings compared to VRF and conventional water-cooled chillers with AHU or FCU.

Due to the fact a large proportion of the energy savings are derived from the high efficiency of the built in fans (blowers)

of the water-to-air Geothermal Heat Pumps, we believe it is sheer folly to connect a water-cooled chiller to a Ground Heat Exchange. Whilst there will be energy savings in the Space Cooling aspect for the water-cooled chiller, there will still be large inefficiencies in the energy consumption for fans & ventilation component.

Life Cycle Cost Analysis

We have just proven why Geothermal Heat Pumps are the most efficient HVAC solution available in India today and this is reflected in the operational cost component of the life cycle cost analysis.

But what does it cost to access technology?

Table 5 compares all the costs for the Trac office for the two competing HVAC solutions.

Table 5: Comparison of life cycle costs-Geothermal vs VRF

Annual Energy Requirement	Geothermal	VRF	
Total kWh	49,420	64,650	
Energy Rate per kWh	5.0	5.0	
Annual Energy Expenditure	247,100	323,250	
TR	20	19	
Project Square Feet	2,497	2,497	
System kW	0.66	0.91	
System EER	18.2	13.2	
Running Hours	3,756	3,756	
Acquisition & Installation Costs			
Installed TR	18.8	19	
Equipment Cost / Sqf (INR)	596	685	
Equipment Cost / TR (INR)	79,147	90,000	
Cost of Equipment	1,487,960	1,710,000	
Savings in INR	Geothermal	VRF	Compound Savings
Total Cost of Ownership Year 1	1,377,950	2,033,250	655,300
Total Cost of Ownership Year 2	1,625,050	2,356,500	731,450
Total Cost of Ownership Year 3	1,872,150	2,679,750	807,600
Total Cost of Ownership Year 4	2,119,250	3,003,000	883,750
Total Cost of Ownership Year 5	2,366,350	3,326,250	959,900
Total Cost of Ownership Year 6	2,366,370	3,649,500	1,283,130
Total Cost of Ownership Year 7	2,368,867	3,972,750	1,603,883
Total Cost of Ownership Year 8	2,368,867	4,296,000	1,927,133
Total Cost of Ownership Year 9	2,368,886	4,619,250	2,250,364
Total Cost of Ownership Year 10	2,372,642	4,942,500	2,569,858

The key points from the life cycle cost analysis:

- Initial capital costs are lower for Geothermal Heat Pumps compared to VRF.
- Geothermal Heat Pumps attract Government of India incentives such as 80% Accelerated Depreciation and waiving of normal excise duties.

continued on page 92

continued from page 90

- Geothermal Heat Pumps are easy to maintain and service.
- Geothermal Heat Pumps have a long life expectancy; often beyond 20 years.
- Geothermal Heat Pumps have been proven to consume less precious energy than other HVAC solutions available in India today.

Conclusion

By highlighting the ability of Geothermal heat Pumps to adhere or exceed ASHRAE Standards and breaking down the components of energy consumption of HVAC solutions, the authors have sought to confront and dispel each of these in turn. By playing our role in promoting geothermal HVAC we seek to promote the benefits of the technology to customers, HVAC/MEP Consultants and Engineers, Architects, Government and the wider community in India.

The main benefits of the Geothermal Heat Pumps are:

1. Financial Benefits:
 - 1.1. Operating Cost Savings
 - 1.1.1. Higher efficiency equates to lower energy consumption expenditure
 - 1.1.2. 100% conservation of water means make-up water is not required
 - 1.1.3. Distributed system means individual units can be turned off when not needed, saving energy consumption
 - 1.2. Capital Cost Savings

- 1.2.1. Make-up water tanks are not needed
- 1.2.2. Lower peak energy demand means less capital expenditure on sub-stations and DG sets
- 1.2.3. Distributed model means that if one unit is inoperable for maintenance all other units are still operational. Back-up units are not needed such as those needed by Chillers
- 1.2.4. Chilled water pipes with insulation are not needed
- 1.3. Other Financial Benefits
 - 1.3.1. 80% accelerated depreciation as per Income Tax Act of India for energy efficiency devices
 - 1.3.2. Waiver of normal Excise Duties as per 2010 Budget of Government of India
2. Benefits to Developers/Owners
 - 2.1. Up to 41 LEED certification points
 - 2.2. Space saving and re-allocation as AHU rooms are not needed
 - 2.3. The modular unit allows for ultimate scalability and flexibility
 - 2.4. Long life of Heat Pumps of over 20 years
 - 2.5. Flexibility to combine the Heat Pumps with Cooling Towers where geothermal applications are not viable
3. Corporate Social Responsibility
 - 3.1. 100% water conservation
 - 3.2. Lower energy demand for India where electricity is under-supplied
 - 3.3. Lower energy consumption equals lower carbon production

An Advt. appeared here