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Role of Earth Air tunnel systems to reduce the building Air-conditioner load: A Case study analysis validating with simulation approach

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Abstract – Any buildings under Ground can possesses high heat capacity and the temperature is constat throughout the year. by using this phenomenon at sufficient depth, the HVAC load of the building can be optimized.

Site measurement and building thermal load requirement are key for planning an Earth Air tunnels system along with velocity and mass flow rate of the air through tunnel, soil nature & material of the pipe, cross-section of the pipe. These analyses are helpful for passive energy technologies which are an important feature for Green buildings. These technologies are in early stage in India and more standardization is required for economical operation. In this paper, an analysis has been done to how to plan for a Geothermal based Earth Air tunnel system for green buildings

Key Words: Geothermal power, EAT systems, Green buildings, RETScreen.

1.INTRODUCTION

Geothermal energy, that is the lengthy term accessibility and the large range of heat checked in the Earth's interior, usually considered as fresh and renewable sources on the timescales of technological system is record extensively used worldwide as an effective source for a justifiable supply of energy for the reason that the recovery of high-enthalpy reservoirs would fully get well to its pre-exploitation state after an extended stoppage period or even at the identical site from which the fluid or heat is extracted in not quite all geothermal projects worldwide. Additionally, the environmental powers of geothermal power generation and through use are generally insignificant controllable or negligible.

Geothermal resources take in dry steam, hot water, hot dry rock, magma, and ambient minced heat Steam and water resources have been settled commercially for power generation and ambient ground heat is castoff commercially in geothermal heat pumps; systems of tapping the other possessions are being studied.

Research centers on let down costs, improving methods for finding and illustrating reservoirs, and tapping broader assets.

Geothermal heat pumps do not cause electricity, but they reduce the depletion of electricity by using heat exchangers and the perpetual temperature of the earth several feet further down the ground to heat or cool indoor air.

RETScreen can consider the potential ground-source heat pump projects consuming the RETScreen International Clean Energy Project Analysis Software, including a machinery background and a detailed description of the algorithms institute in the RETScreen Software.

Keeping a comfortable temperature inside a building can involve a significant amount of energy. Dispersed heating and cooling systems are often hand-me-down to conserve the desired air temperature, and the energy vital to operate these systems generally comes from electricity, fossil fuels, or biomass. Bearing in mind that 46% of sun's energy is immersed by the earth, another option is to use this profuse energy to heat and cool a building. In contrast to several other sources of heating and cooling energy which need to be transported over long distances, Earth Energy is existing on-site, and in massive quantities.

For the reason that the ground passages heat slowly and has a high heat storage capacity, its temperature changes sluggishly—on the order of months or even years, reliant on the depth of the measurement. As a moment of this low thermal conductivity, the soil can allocation some heat from the cooling season to the heating season; heat riveted by the earth during the summer well gets used in the winter. This annually, continuous cycle between the air and the soil temperature grades in a thermal energy potential that can be harnessed to support heat or cool a building.
Added thermal characteristic of the ground is that a few meters of surface soil protect the earth and groundwater below, curtailing the amplitude of the variation in soil temperature in evaluation with the temperature in the air above the ground. This thermal resistivity fluxes further helps in fluctuating the heating or cooling load to the season where it is required. The earth is warmer than the ambient air in the winter and cooler than the ambient air in the summer.

This deep earth and groundwater lower the surface provides a able renewable source of energy that can straightforwardly provide plenty energy year-round to heat and cool an typical suburban residential home, for sample. A Ground-Source Heat Pump (GSHP) transmutes this Earth Energy into useful energy to heat and cool buildings. It affords low temperature heat by mining it from the ground or a body of water and runs cooling by reversing this development. Its principal submission is space heating and cooling, though various also supply hot water, such as for domestic use. It can uniform be used to continue the integrity of building foundations in permafrost environments, by keeping them frozen complete the summer.

A heat pump is cast-off to concentrate or upgrade this free heat energy from the ground previously distributing it in a building through conventional ducts. It activates much as a refrigerator or straight air conditioning system in that it relies on an outdoor source of energy - typically electricity - to quintessence the heat and shift the temperature. Naturally, each kilowatt (kW) of electricity used to run a GSHP system enticements more than 3 kW of renewable energy beginning the ground. Heat pumps normally range from 3.5 to 35 kW in cooling capacity (round 1 to 10 refrigeration tons), and a single unit is generally sufficient for a house or a slight commercial building. For higher commercial, institutional or industrial buildings, several heat pumps units will often be employed.

2. Description of Ground-Source Heat Pump Systems:
A ground-source heat pump (GSHP) arrangement has three major machineries: a heat pump, an earth connection and an interior heating or cooling spreading system as shown in fig. 4.1. These three foremost components, organized with the different earth connection conformations of a typical GSHP installation, are explicated in the following sections.

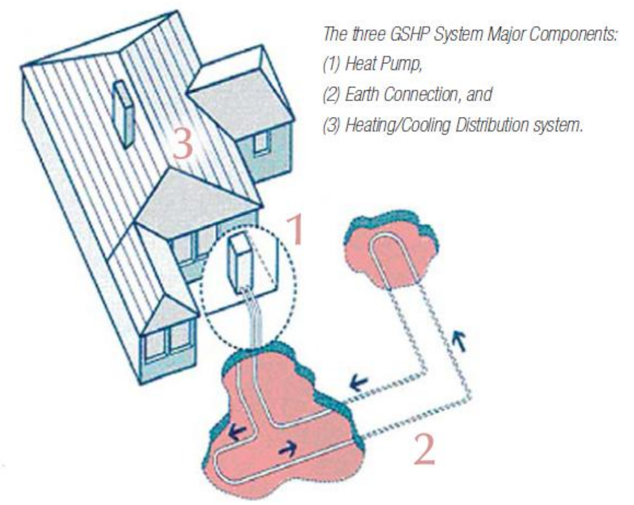


Fig. 1: Arrangement of Ground source heat pump

The heat pump allocations the heat amongst the heating/cooling distribution system and the earth construction. It is the basic edifice block of the GSHP system. The most joint type of heat pump used with GSHP systems is a "water-to-air" unit vacillating in size from 3.5 kW to 35 kW of cooling capacity. The water-to-air term shows that the fluid carrying heat to and from the earth linking is water or a water/antifreeze mix and that the heat distribution system secret the building relies on hot or cold air. The heat pump may be an long range unit, allowing lower toward the inside fluid temperatures in heating mode and higher inward bound fluid temperatures in cooling mode.
All the workings of this type of heat pump are in one enclosure: the compressor, an earth connection-to-refrigerant heat exchanger, panels, and an air distribution system comprehending the air handler, duct fan, filter, refrigerant-to-air heat exchanger, and condensate deletion system for air conditioning. A distinctive packaged heat pump unit is illustrated in fig. .2

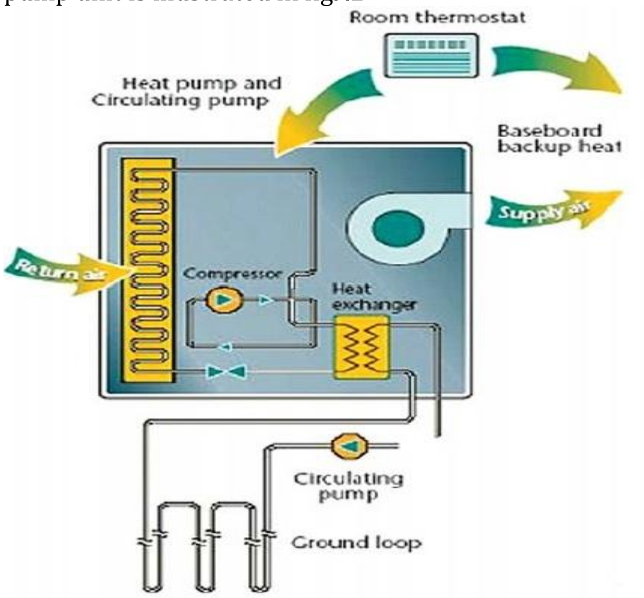


Fig. .2: Typical heat pump unit

3 Simulation analysis

RETScreen software will gives respectable results to test the technical likelihood of a Earth air tunnel system to test the EAT feasibility in a certain site.

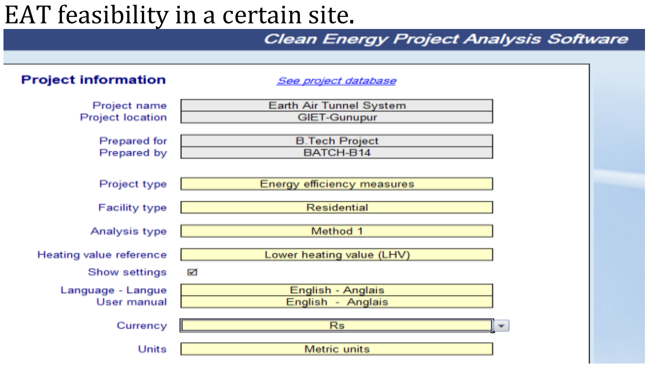


Fig 3: Home screen of the RETScreen Software

Fig. 3 is the home screen of the RETScreen Software. All the situations are to be pass in according to the site environments.

Fig. 4.shows the Weather settings of the project site. Air disease and Ground temperature clearly prosecuting the temperature transformations of the project site.
The malleability of the software is it can find from the NASA database and by taking into contemplation of the air temperature and earth temperature.

Month	Air temperature	Relative humidity	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days	Cooling degree-days
	°C	%	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	21.7	56.7%	4.73	99.1	2.8	23.3	0	363
February	24.0	60.4%	5.43	99.0	3.0	26.5	0	391
March	26.9	58.8%	5.97	98.7	3.6	30.2	0	525
April	28.2	64.5%	6.36	98.4	3.9	30.9	0	545
May	28.8	70.0%	6.15	98.0	3.6	31.1	0	583
June	28.3	78.0%	4.30	97.8	3.8	29.4	0	549
July	27.4	81.0%	3.75	97.8	4.0	28.1	0	540
August	27.1	81.4%	3.68	97.9	3.8	27.7	0	530
September	26.8	80.5%	4.10	98.2	2.9	27.7	0	503
October	25.7	74.9%	4.49	98.6	2.9	26.7	0	485
November	24.0	60.3%	4.44	99.0	3.5	24.8	0	419
December	22.0	52.5%	4.48	99.2	3.2	23.0	0	371
Annual	25.9	68.3%	4.82	98.5	3.4	27.4	0	5,803
Measured at m					10.0	0.0		

Fig. 4 : Air & Ground Temperatures at Gunupur

Cooling project	Unit		
Base case cooling system	Single building - space cooling		
Cooled floor area for building	m²	250	
Fuel type		Electricity	
Coefficient of performance - seasonal		3.00	
Cooling load calculation			
Cooling load for building	W/m²	28.4	
Non-weather dependant cooling	%	0%	
Total cooling	MWh	45	
Total peak cooling load	kW	7.1	
Fuel consumption - annual	MWh	15	
Fuel rate	Rs/kWh	6.000	
Fuel cost		Rs	89,980
Proposed case energy efficiency measures			
End-use energy efficiency measures	%	80%	
Net peak cooling load	kW	1.4	
Net cooling	MWh	9	

Fig. 5 : cooling project requirement

Base case load characteristics		
Month	**Cooling average load kW**	**Heating average load kW**
January	4	0
February	4	0
March	5	0
April	6	0
May	6	0
June	6	0
July	6	0
August	5	0
September	5	0
October	5	0
November	4	0
December	4	0
Peak load - annual	7	5

Fig. 6 : Base load characteristics

From Fig, 5 and 6 the assessment has shown flanked by the base load appearances and proposed load appearances.
Fir 4.6 and 4.7 display the yearly cooling load demand of the base case and projected case

Hence, by espousing the EAT systems there is much improvement the thermal relief of the building and the demand on the Air-conditioners are also tumbling greatly.

Proposed case load characteristics		
Month	**Cooling system load kW**	**Heating net average load kW**
January	1	0
February	1	0
March	1	0
April	1	0
May	1	0
June	1	0
July	1	0
August	1	0
September	1	0
October	1	0
November	1	0
December	1	0
Peak load - annual	1	1

Fig. 7: Proposed load characteristics

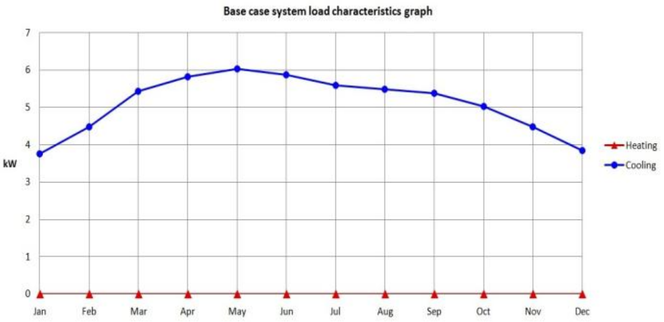
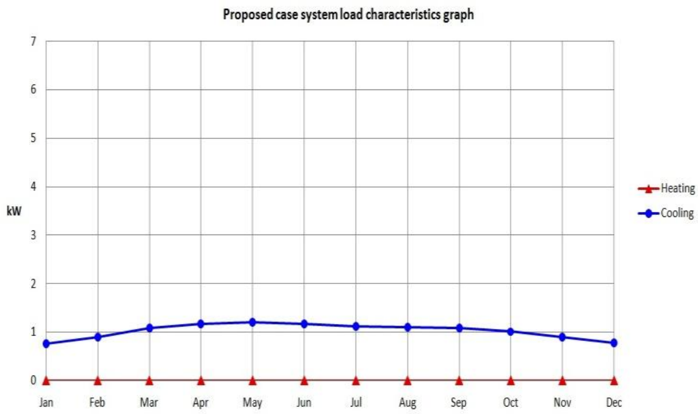


Fig. 8: Yearly cooling load demand (Base case)



Fig, 9: Yearly load demand (Proposed case)

Financial parameters			
Inflation rate	%	2.0%	
Project life	yr	25	
Debt ratio	%	40%	
Debt interest rate	%	9.00%	
Debt term	yr	25	
Initial costs			
Heating system	Rs	100,000	24.5%
Cooling system	Rs	300,000	73.5%
Other	Rs	7,987	2.0%
Total initial costs	Rs	407,987	100.0%
Incentives and grants	Rs		0.0%
Annual costs and debt payments			
O&M (savings) costs	Rs		
Fuel cost - proposed case	Rs	20	
Debt payments - 25 yrs	Rs	16,614	
	Rs		
Total annual costs	Rs	16,635	
Annual savings and income			
Fuel cost - base case	Rs	95,030	
	Rs		
Total annual savings and income	Rs	95,030	
Financial viability			
Pre-tax IRR - equity	%	35.2%	
Pre-tax IRR - assets	%	21.8%	
Simple payback	yr	4.3	
Equity payback	yr	3.0	

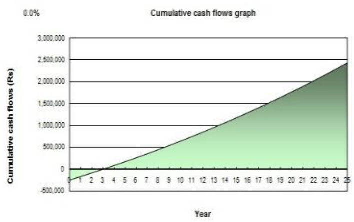


Fig. 10 : Financial analysis of the Project
Hereafter by relating the base and wished-for cases; of 9and 10 with the combination of EAT system with heat pump the cooling load mandate decreased considerably.

From Fig. 10; the payback historical of the project is from place to place is 4.3 years.

4 Conclusion

Ground possesses high heat capacity as well as its insulation potential so, at a sufficient depth, the ground temperature is constant. It is found that throughout the year the high temperature of earth remainders almost continual at a depth of 4m. This temperature is initiate to be sophisticated than that of the outside air in winter and vice versa in summer. By fixing on various designing restrictions of Earth air tunnel heat exchanger for room conditioning thereby employing the clean energy.

Site quantity and building thermal load necessity are key for planning an Earth Air tunnels system lengthwise with velocity and mass flow rate of the air concluded tunnel, soil nature & material of the pipe, cross-section of the pipe. These evaluates are helpful for passive energy knowledge which are an important feature for Green buildings. These technologies are in primary stage in India and more regulation is required for economical procedure.

A building unified with Earth Air tunnel system will progress the energy efficiency and it will ease the power consumption of the Air conditioners. In this venture the results are impressive and clearly indicating from Fig. 4.5 and 4.6; the power consumption of a building with EAT systems will cuts to a margin of 10%

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