Mechanical System Study

MECHANICAL SYSTEM STUDY

The existing mechanical system of Eight Tower Bridge employs a chilled water loop to cool the building through evaporative cooling. Evaporative cooling is a process by which moisture is added to air with a relative humidity less than 100% in order to reduce air temperature and increase relative humidity. The lower the relative humidity, the greater the cooling affect possible when moisture is added. The chilled water loop in Eight Tower Bridge is an example of indirect evaporative cooling. Indirect systems cool air without adding moisture. In operation, an indirect evaporative process cools air or water on one side of an impermeable heat-exchanger. The wet side cools the dry side without adding moisture to the air because there is no direct contact between the water and the air stream. They are more expensive and use more energy than direct systems, but they can provide energy efficiency in applications where direct evaporative cooling may not be practical.

The system in Eight Tower Bridge currently takes water pulled from the water main and pumps it through a loop to the rooftop, where heat is removed by two cooling towers. The water is then sent through a chilled water pump back down the building where it meets a heat exchanger within the "package" air handling units found on each floor. These air handling units use the chilled water to indirectly cool return air that is being circulated throughout each floor. Each of these units has a cooling capacity of 80 tons and can take 160 GPM of chilled water. Fresh air is provided to the spaces through rooftop louvers capable of taking in 475 CFM/ft length of louver.

Eight Tower Bridge is located directly next to the Schuylkill River; a body of water that maintains an average winter temperature of 31 ˚F and a summer temp of 72 ˚F. A feasibility study was conducted regarding the practicality of using a Ground source heat pump as the primary heating and cooling source for this loop, eliminating the need for rooftop cooling towers.

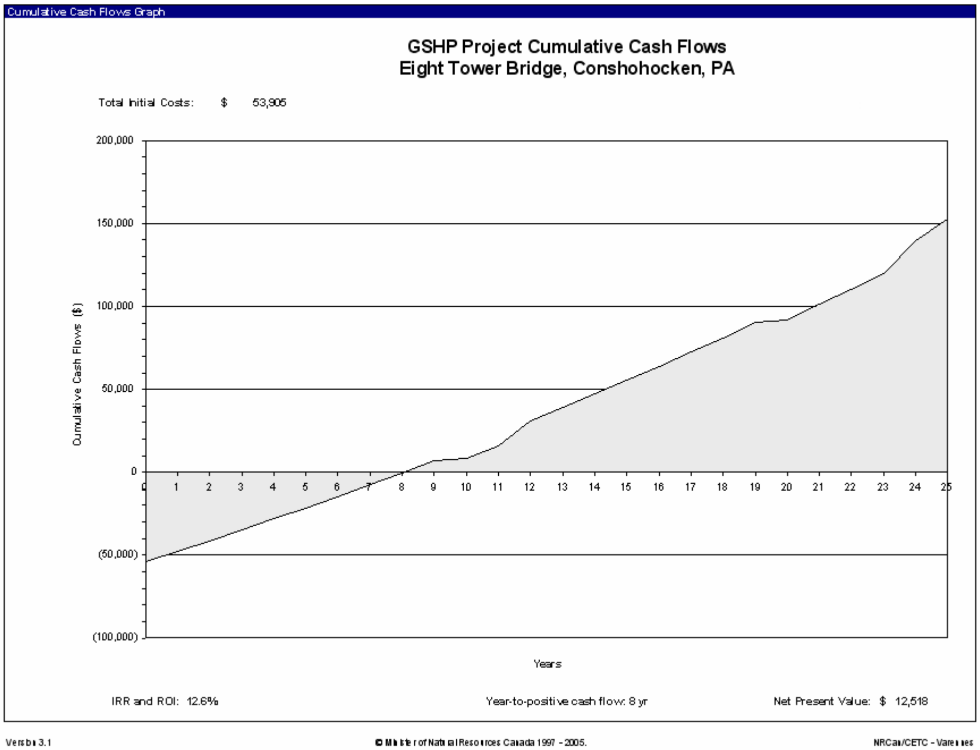
Ground source heat pumps use the heat in the ground as a thermal reservoir to take heat from in the heating case or discharge heat to in a cooling case. Water or refrigerant is pumped through a series of tubes bored into the ground. The refrigerant gains heat from the ground and is then pumped through the same loop described up above. The process is run in reverse for cooling, using the ground as a discharge for heat extracted from the building.

Heat pumps have generally been found to be very efficient, and can cut heating and cooling costs by nearly 40% given the right set of characteristics. The life of the system is generally longer than conventional systems because the units are housed indoors (in most applications) and the pipe work used for heat exchanging is buried underground. There are generally fewer components involved in a heat pump system, making installation easier and less prone to failure. However, these are an added start up costs (boring hundreds of holes on site) as well as the units themselves. The goal is to have a system that pays for itself in energy savings over the shortest time period.

The feasibility of installing a ground source heat pump as a cooling source for water or refrigerant in the chilled water loop described above was carried out using a ground source heat pump project model obtained through RETscreen International. This model allows the user to enter the desired location characteristics, average earth temperatures, equipment specifications and building size. Initial costs and payback periods for the system are then calculated.

The project model was run for both heating and cooling cycles. It was assumed that there would be a 200'x200' (3,176 m^2) space available to bore holes for the piping involved in heating exchanging for the heat pump. The temperature date was obtained from NASA's Surface Meteorology and Solar Energy Data site. Finally, the equipment selected for this Trane model was a high efficiency vertical WPVJ060 heat pump with a standard heating COP of 3.2 and standard cooling COP of 4.5. More specifications on this equipment can be found in Appendix F.

The model was run with the above assumptions and equipment selection. Below is the cumulative cash flow graph for the heating cycle.

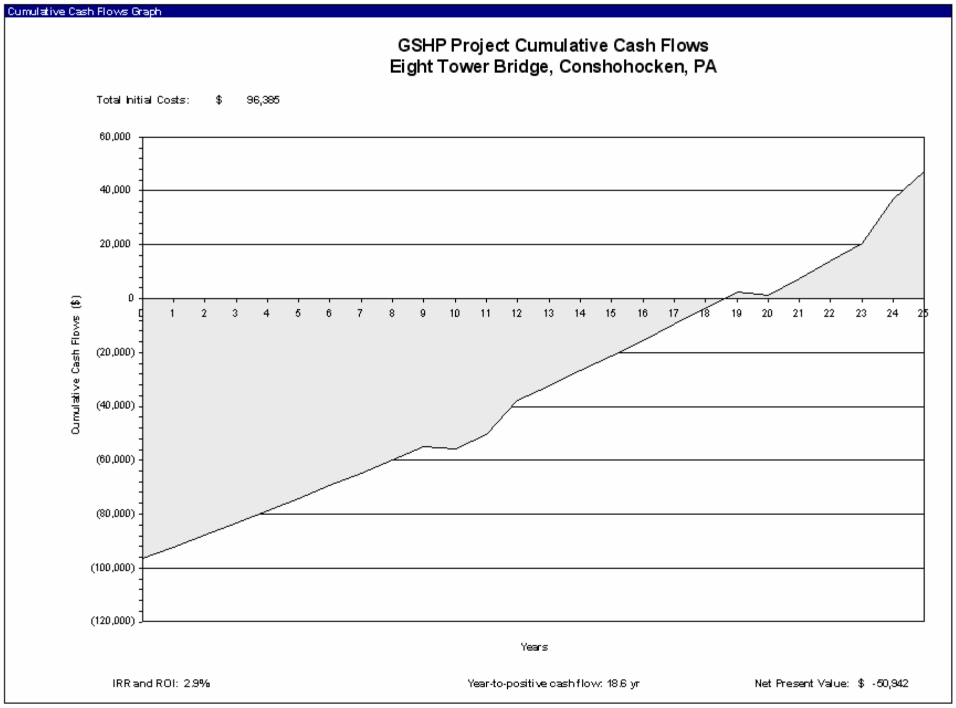


The initial cost of this system is $53,905 with a "year-to-positive" cash flow of 8 years. This cash flow does not take into account taxes. The system will see an annual life cycle savings of $1,379 dollars. A yearly cash flow for the system in heating can be seen to the right. Please refer to Appendix F for the full model report.

Yearly Cash Flows

Year #	Pre-tax $	After-tax $	Cumulative $
0	(53,905)	(53,905)	(53,905)
1	6,238	6,238	(47,666)
2	6,363	6,363	(41,304)
3	6,490	6,490	(34,813)
4	6,620	6,620	(28,193)
5	6,752	6,752	(21,441)
6	6,887	6,887	(14,554)
7	7,025	7,025	(7,529)
8	7,166	7,166	(363)
9	7,309	7,309	6,946
10	1,360	1,360	8,306
11	7,604	7,604	15,910
12	15,366	15,366	31,276
13	7,911	7,911	39,188
14	8,070	8,070	47,257
15	8,231	8,231	55,488
16	8,396	8,396	63,884
17	8,564	8,564	72,448
18	8,735	8,735	81,182
19	8,910	8,910	90,092
20	1,658	1,658	91,750
21	9,270	9,270	101,020
22	9,455	9,455	110,474
23	9,644	9,644	120,118
24	19,488	19,488	139,606
25	13,315	13,315	152,921

As previously mentioned, the ground source heat pump model was also run for the system in cooling to see what the cost of the system would be under cooling conditions. The same heat pump model was selected and all assumptions were kept the same. Below is the cash flow graph for the same system in cooling.



The initial cost of the system used for cooling would be $96,385 with a payback period of 18.6 years. The additional costs stem from the total depth of boring holes required, which nearly tripled under the cooling condition. A full report for the cooling model can be found in Appendix F.

It is important to mention that the effects of having a large body of water like the Schuylkill River next to a ground source heat pump reduce the average ground temperature that is reported for the area. This could add considerable efficiency to the system in cooling. A more accurate model including these affects could be created using ground temperature data collected on site.

Using a ground source heat pump to heat the building in cooler months appears to be a feasible mechanical system option. Although the payback period was determined to be a little over eight years, it still falls on the fringe of the acceptable return on investment time. However, when the system was run for cooling loads, it was found that the initial investment to employ this system is not worth the nearly 19 year return period, a period considerably higher than the ideal 3 to 4 year period. Therefore, it is suggested that the existing system be used over a possibly more expensive, yet more efficient system.