Bob McMath School
Richmond, B.C., Canada

GeoExchange Heating Hybrid

The new Bob McMath Secondary School in historic Steveston (Richmond School District #38) will soon pioneer a significant innovation in GeoExchange heating, ventilating and air conditioning. The 1,000 student school south of Vancouver will be constructed with a heating hybrid: a central geothermal heat pump with a supplementary natural gas condensing boiler.

While the system has not been completed, it is expected to use 50 percent less purchased energy than a conventional system while being installed for 22 percent less than budget. Not only will it be lower cost, both to install and to operate, but it will allow cooling for far more floor area than in most Canadian schools, providing not only increased comfort but new possibilities for usage (and revenue) during the summer. Utility cost savings will be over $11,000 per year (all dollars Canadian). This remarkable system has been designed by Gordon Shymko, P.Eng. and Neil Caldwell, P.Eng. and their D.W. Thomson Ltd. colleagues.

This optimal configuration is of such interest that this case study was done to inform the design community *now, rather than in two or more years when annual energy data is available.*

Budget

The McMath High School total project budget was $20 million ($139/sf) for the approximately 150,000 square foot (13,900 sq. m.) gross floor area in two buildings.

The two story main building and separate gymnasium building are designed by Grant & Sinclair Architects Ltd. for eventual occupancy of 1,900 and are sited on a roughly 220 m(720') square lot totaling 12 acres.

In British Columbia, strict budgetary guidelines are set by the provincial Ministry of Education, which manages all school construction. The budget for the mechanical system was $3,095,900. The Ministry also limits mechanical cooling to administrative offices and high load spaces (such as computer classrooms) to a maximum of 15 percent of floor area to minimize costs.

> The design team exceeded expectations by providing a high quality and energy efficient mechanical system to cool the entire floor area, using half the energy of the conventional mechanical system. This was done at a cost 22 percent below the Ministry of Education's budget allowance.

The original Ministry design development brief proposed a Constant Volume Reheat (CVRH) air system. In this system, large central station air handlers supply each zone through medium velocity distribution ducts. Air is supplied at a temperature set by the Direct Digital Control (DDC) system to satisfy the warmest zone and reheated by hot water heating coils as required for the other zones. Cooling is by conventional chiller and 100 percent outside air "free cooling" when outdoor temperatures permit.

Phone: 202-508-5500 Fax: 202-508-5222 Toll Free: 1-888-ALL-4-GEO
Internet:http://www.geoexchange.org/ E-mail: info@ghpc.org
GHPC #CS-054 8/97

Economic Analysis

Before choosing the final configuration, the design team simulated the heating, cooling and ventilation needs of the school using DOE-2.1E software and their own large heat pump/ground source simulator module. A rigorous simulation of all options, including various sizes of heat pumps supplemented by gas boilers, showed an economically optimal configuration.

Using ASHRAE Standard 90.1 parameters such as glazed areas and lighting power density, a reference simulation was made of the Constant Volume Reheat (CVRH) system proposed by the Ministry of Education. Annually, consumption was 1,235,333 kWh of electricity and 1,804 GJ of natural gas at an annual energy cost of $79,078.

Fuel Price Assumptions

Natural Gas:
Schedule 3 - Commercial (over 2,000 GJ/year)

Basic Charge: $12.00/month
Energy Charge: Winter (Nov.-Mar.) $5.001/GJ
Summer (Apr.-Oct.) $4.120/GJ

Electricity:
Schedule 1200 - General, 35 kW and over/month

Basic Charge: $4.15/month

Demand Charge:

First 35 kW	Nil
Next 115 kW	$3.32/kW
Additional kW	$6.37/kW

Energy Charge:

First 10,000 kWh	$0.0650/kWh
Next 6,000 kWh	$0.0587/kWh
Additional kWh	$0.0312/kWh

Next, the performance of a four pipe fan-coil (FPFC) system was simulated. With this system, heating and cooling water supply and return piping would connect chiller and boilers to fan-coils for each room or zone. Outdoor ventilation air was supplied from central station constant volume air handlers ducted to the return air plenum of the fan-coils. The analysis showed that this system (with conventional chiller and boilers) saved $3000 annually in energy and $50,000 in first costs compared to the benchmark CVRH system.

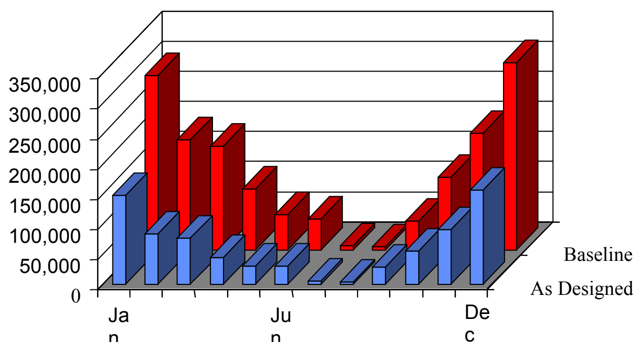
Final Design

Further analysis was completed, substituting various sizes of geothermal heat pumps for the chiller and base-load heating in the four pipe fan-coil (FPFC) system. This showed that an optimum sized 1126 MBH (108 ton) geothermal heat pump would minimize demand charges and pay back in less than four years compared to the conventional FPFC. The capital cost analysis proved to be conservative in that the heat pump fan-coil system tender cost was 22 percent below the budget.

The single 108 ton geothermal heat pump will satisfy approximately 80 percent of the school's heating needs, even though the heat pump was sized at only 30 percent of the design heat load. Supplementary heating is provided by high efficiency gas boilers.

Annual consumption of the final design was 1,001,333 kWh electricity and 2,269 GJ natural gas. The total annual energy cost is $67,926, an annual saving of $11,152 over the benchmark system. The final design also incorporated double pane tinted glazing , T8 light fixtures with electronic ballasts, photocell control of lighting in clerestory areas and occupancy sensor control of lighting in classrooms.

Total Energy Consumption (kWh)



SVEC Spiral GeoExchange Field

The McMath School design team, having considerable experience in hydronic systems, had few new challenges incorporating the heat pump itself in the design, even though only Gordon Shymko, the energy and mechanical design team leader, had extensive experience with GeoExchange. The new element to all was the design of the outside collector field. CSLM Associates of Kanata, Ontario was retained to advise the team.

The school's playing field will provide the needed heating energy and store the rejected heat from cooling. Buried four feet below the playing surface will be a Svec spiral heat exchanger (after the inventor Dr. Otto Svec of National Research Council Canada). Similar to, but claimed to be more efficient than the "slinky" design, each ton of capacity uses 500 feet of pipe in 75 feet of six foot trench. The two foot diameter horizontal “corkscrew” of 1.25 inch high density polyethylene pipe at the McMath School was buried in fill for the playing field, which cut installation costs.

The resulting 108 nominal ton field will be made up of 18 modules of 6 tons each. Each module is composed of two parallels, each of 3 one ton Svec spirals in series. The supply and return runouts are to be 1.5" (38 mm), teed to the two parallels. Pipe and fittings are to be PE3408 Series 125/SDR 13.5. Cost of pipe and fittings was estimated to be $25,000. All joints are to be by thermal fusion as per ASTM D2683 and others.

Burial in the playing field fill for the pipe spirals will be 6' (2 m) below finished grade, horizontally separated by 10' (3 m). Installation will follow CSA Standards C445 and C447. All pipe will be protected from rock or crushing by backfilling with sand or other unconsolidated material until the pipe is covered. Original material from the trench will be used for completion of the backfill to seal the sand fill. Supply and return runouts will be in separate trenches. Runouts entering the building will be insulated within one meter of the foundation and properly sleeved and waterproofed. Interior piping will be insulated against condensation.

Each module will be filled with water and pressure tested to 620 kPa (90 psi) for a period of 4 hours with a maximum acceptable drop of 5 psi. After tying in to the building headers, flushing, purging of air and backfilling, the pressure should be maintained for one hour with no drop. Each module will be properly flushed and purged by maintaining a flow of at least 20 USGPM at a 60' head for one hour in each direction.

Properly inhibited Methanol or Ethanol (subject to the approval of the Authorities having jurisdiction) should be added to provide a 15% by weight antifreeze mixture. Each module will be balanced to insure minimum operating flow exceeds 7.8 USGPM, a 4.6 m (15') head.

Conclusions

The Bob McMath secondary school is the first known installation of an advanced hybrid central ground coupled heat pump in British Columbia, and is expected to set a new standard for heating, cooling, and ventilating performance in new western Canadian schools.

As modern educators who teach respect for the environment and best use of natural resources, the B.C. Ministry of Education and Richmond School District #38 are to be commended for *practicing what they teach.*

Key Players

Energy and Mechanical Design and Simulation

Neil Caldwell P.Eng.
Tescor Pacific Energy Services Inc.
200-1985 W. Broadway
Vancouver, B.C. Canada V6J 1X9
Phone: 604-731-4984
Fax: 604-738-4420

GeoExchange Field Design

Cam McNeil P.Eng.
CSLM Associates Inc.
3 Sandwell Crescent
Kanata, Ontario, Canada K2K 1V2
Phone & Fax: 613-591-9116

Courtesy of Cam McNeil, CSLM Associates.