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Tech Talk - A Further Look at MS&T Geothermal

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Ah, the election is over! Those living outside the United States might not understand the relief, but as a minor example, we had six different phone calls urging us to support Todd Akin for the Senate in the 24-hours before our polling station closed. I am not sure that there will be much in the way of new information on Energy Policies out of Washington for a while as they debate the fiscal cliff, but one does wonder whether we might get a new Secretary of Energy. And so, with Iranian oil production very much a function of how effective sanctions remain, and with the new OPEC Monthly Oil Market Report due, I am going to return for a second week to discuss the geothermal operations at MS&T with a little more detail than last time, since some of the numbers might be of interest. (And I am grateful to Jim Packard at MS&T for providing the information).

Universities generally move very slowly. However, they are on occasion willing to accept new ideas to resolve a problem quickly. (We once had to build a small plant to recover explosive and repackage it – not something that was possible above ground, but by driving a new set of tunnels underground at the Experimental Mine, we could create space for the plant and then operate it for the required demonstration without needing any of the permissions required had we tried to build a facility on the surface. This was about 20 years ago, and we would likely still be moving the paperwork seeking permission to build above ground. Perhaps this is another argument for the accelerated use of underground space).

The case for a change in thinking, and perhaps a hint of its urgency, can be seen by looking at the energy balance before the new system is installed.

Breakdown of Steam Energy Use

Use Component	Steam Use Fraction	Energy (Therms)
Building Heat and Domestic Hot Water Heating Load	25% - 43%	565,000 -893,000
Absorption Chiller Energy	25% - 27%	576,000
Electric Cogeneration	4%	84,000
Power Plant Parasitic Loads	12% - 13%	265,000
Piping Heating Loss and Other Unaccounted Uses/Losses	13% - 35%	280,000 - 800,000
Boiler Output	100%	2,347,000
Boiler Fuel Input	126%	2,950,000

Figure 1. Comparison of the useful energy (upper circled numbers) to the input energy at the MST Power Plant. (MST)

Given that fuel costs will likely only continue to rise, that a new boiler was needed, and there was no obvious source of funds to pay for it, a number of options were considered. It is interesting to note in the following table, the costs of the current coal:wood system (60% coal) relative to those of the proposed water to water (WTW) heat pumps being proposed.

Comparison of Energy Cost from Various Sources	
Energy Source	**Cost of 100,000 BTU / (1 Therm)**
Steam Output From Coal/Wood Boilers	$1.10 - $1.20
Natural Gas Hot Water Boilers	$1.42 - $1.95
Electric WTW Heat Pumps	$0.75 - $0.82

Figure 2. Comparative Energy costs relative to the current system. (MST)

To digress a little, in addressing a similar problem, the University of Missouri at the Columbia campus is installing a bubbling fluidized bed boiler. The boiler will use biomass to displace about 25% of the coal use on campus. The $75 million project has just been completed. However, as I noted in an earlier post, there may be unrecognized processing costs for the biomass, which may eat into the campus savings. And while MS&T are looking for ways of handling the now unnecessary smokestacks, the biomass facility in Columbia has just added three 110-ft tall silos to handle the feed.

> The new boiler, which was retrofitted to the university's existing heating duct system, is expected to produce 150,000 pounds of steam per hour, increasing the 67-year-old power plant's steam output by 30,000 pounds per hour, and use an estimated 100,000 tons of in-state renewable energy sources such as chipped hardwoods and wood waste.

Back at MS&T the numbers for the heat pump came in part from a WTW heat recovery chiller that the campus had installed in October 2007, which saved the campus some $1,500 a day by allowing some of the recovered heat to be produced in useful form.

When the campus first looked at the potential, they also looked at the experiences of institutions such as the Richard Stockton College of New Jersey, which installed a system in 1996. Their installation pioneered many of the decisions made in subsequent operations.

> The wells are located on a grid and spaced roughly 15 feet apart. Within each four inch borehole, the installers placed two 1.25 inch diameter high density polyethylene pipes with a U-shaped coupling at the bottom.
>
> After the pipes were installed, the boreholes were backfilled with clay slurry to seal them and to enhance heat exchange. In total, the loop system includes 64 miles of heat exchange pipe. In addition, 18 observation wells were located in and around the well field for long-term observation of ground water conditions.
>
> The individual wells are connected to twenty 4-inch diameter lateral supply and return pipes. The laterals, in turn, run to a building at the edge of the field where they are

combined into 16-inch primary supply and return lines. These lines are connected to the heat pumps which serve Stockton's buildings. In the heating mode, the loop serves as a heat source and in the cooling mode, as a heat sink. The heat pumps range in size from 10 to 35 tons. All are equipped with air economizers. The equipment is controlled by a building management system using 3,500 data points. This allows the college to take advantage of energy-saving options such as duty cycling, night setback, and time of day scheduling. The building management system also identifies maintenance needs in the system. . .

The system immediately demonstrated that it could carry the entire planned heating load. In the first few years of operation, the average temperature of the well field has drifted upward by several degrees. This occurred because the buildings use more air conditioning than heating. . . . . .

Because of the constant changes to the system, and other energy conservation steps, it was difficult to verify energy savings exactly. Based on extensive monitoring, the predictions turned out to be quite accurate.

Figure 3. The polyethylene tubing and the metal end fixtures for insertion into the MS&T boreholes. (MST)

With this encouragement, there was an initial discussion of the system in mid-September 2010; the scheme was approved by the Board of Curators in November 2010, and 2011 was spent in bidding and awarding the contracts and pre-ordering materials. The first day of drilling was on June 4, 2012, just after the Spring semester. In order to complete the parking lots – to the degree possible – several drill rigs were used at once:

Figure 4. The use of multiple rigs to speed operations (how many?) (MST)

Once a well had been drilled, and the pipes installed, the holes were backfilled with a grout that included significant quantities of sand, to improve the heat transfer. And the two pipes were all that were left protruding.

Figure 5. After pipe installation (MST)

Trenches were then cut across the lot to allow the distribution and collection network of pipes to be installed. Once the field connections were fused together, the lines were connected to larger transport pipes at the end of the field, and set into a deeper trench.

Figure 6. The connections between the wells and the distribution network. (MST)

The larger pipes were used to carry the water from each field to the heat exchanger/chiller plant, with three plants being located around the campus. All that then remained was to backfill the trenches, tarmac the lots again, and the campus began to return to normal. The last well did not get drilled until half-way through this semester, but the lots are now coming back into use.

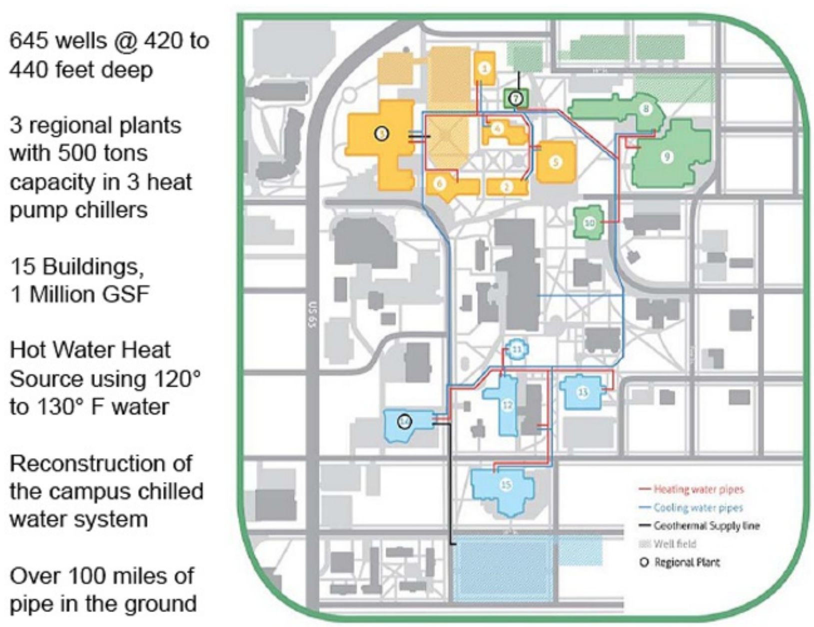

Figure 7. Overall layout of the three circuits being used on campus (MST)

With most of the work done on the fields, the remaining work involves the integration of the system into the existing infrastructure, and the necessary changes to the hardware in the various buildings to handle the different ways in which energy is used within them. Much of this change is required since the heating has been using steam lines in the past, and these have to be replaced now with the hot water circuit.