Connecticut Community Geothermal Design Report (DRAFT)

During the beginning phases of this project, it was important to confirm with the local utility that there is sufficient grid capacity to accommodate an all-electric heat pump heating and cooling system in this area. Wallingford Electric has confirmed that there is sufficient grid capacity at Ulbrich Heights to proceed with a geothermal heat pump system for the community. As part of this project, electrical, telecom, water, and sewer interconnections will be required for the pump house facility which will contain the main system infrastructure equipment. Additional information about the pump house facility is indicated below.

The design for the Wallingford Housing-Ulbrich Heights Community Geothermal system utilized computer based energy modeling software and ground source heat exchanger modeling software to size the geothermal system and the heating and cooling equipment that will ultimately condition the housing complex.

The University of Connecticut (UConn) utilized TRNSYS EnergyPlus/Open Studio software to model the Ulbrich Heights housing complex buildings. The results of this energy modeling determined both the peak heating and cooling loads for the housing complex as well as the cumulative heating and cooling loads throughout the course of a calendar year.

Prior to completing the geothermal design, a geothermal well driller was hired to perform a Thermal Conductivity Test at Ulbrich Heights in an area that was identified as a possible location for a geothermal borehole field. The well driller installed closed-loop geothermal piping within a borehole that is filled with a thermally conductive grout. The well driller then set up testing equipment to measure the soil's thermal conductivity, thermal diffusivity, and the undisturbed ground temperature. This information enables more accurate modeling of the geothermal system using actual soil conditions and characteristics from the specific site. This testing is also useful to provide information about underground geology. The geology of each individual site varies, and the test well provides information regarding depth to bedrock and if there are areas of unstable soil that would make drilling more difficult. The depth to bedrock helps to understand how much casing is required for each borehole. Casing is typically steel pipe that is driven into bedrock to seal surface water and contaminants from entering the borehole and ultimately the ground water supply. The amount of casing that is required directly affects the cost to install the geothermal system.

L.N. Consulting utilized the load data generated by UConn and input that data into Ground Loop Design (GLD Gaia Geothermal) geothermal modeling software. The thermal conductivity, thermal diffusivity and undisturbed ground temperature were also input into the modeling software. Using the modeling software, we were able to determine that (90) 500-foot deep closed-loop boreholes (45,000 total vertical borehole feed) would be required to condition all of the buildings on the site while maintaining acceptable inlet and outlet water temperatures. A closed-loop geothermal system was selected to condition this complex due to the very minimal maintenance required compared to an open-loop geothermal system.

Conditioning for the facilities will be via Water-Source Heat Pumps (WSHPs). These heat pumps utilize the refrigeration cycle to exchange heat energy between a common water loop and the indoor air. The common water loop is a propylene glycol solution that is conditioned by the geothermal borehole field. Circulator pumps located within a pump house building circulate the propylene glycol solution through buried supply and return pipes to each individual building and ultimately to each individual zone heat pump. A second set of circulator pumps is utilized to pump the propylene glycol solution through the geothermal borehole field to be conditioned by the Earth. The Energy Model data that was provided by UConn was also used to size the individual zone level heat pumps. The pump house facility location was selected as being roughly centralized within the housing complex and in an open area between (2) buildings with relatively easy access from the main road (to ease future maintenance). Centrally locating the pump house reduces the size of the common loop piping mains since they can be split after leaving the pump house. By containing all of the main system pumps and equipment within a single building, the electrical and plumbing services required to support the facility are minimized compared to having multiple pump houses located throughout the site.

The preliminary layout for the pump house is for a building that is approximately 400 sq.ft to house the heat pump loop and geothermal loop circulator pumps along with containing the main geothermal borehole field manifold. All of the geothermal borehole field loops exit from the pump house and balance valves allow for balancing of each individual branch. The total calculated tonnage of capacity that is required to be provided by the geothermal field is approximately 250 tons of cooling and approximately 95 tons of heating. The energy model calculated building cooling load is approximately 180 tons, and the heating load is approximately 170 tons. The geothermal field loads are skewed more towards cooling due to the compressor waste heat generated by the heat pumps which is a benefit in heating mode (less heating required from the geothermal field) but increases the load on the geothermal system in cooling mode as this is additional heat that must be rejected by the geothermal field. The pump house building will also contain domestic water and sanitary waste systems for servicing and maintenance work along with adding water to the system as air is removed. Telecom will need to be provided to the facility for the Direct Digital Controls (DDC) system that will operate the equipment. We recommend providing a fire protection sprinkler system in the facility to protect the facility in case of a fire.

Using site plans of the Ulbrich Heights housing complex, a location for the geothermal borehole field was selected. There is a relatively large greenspace, approximately centrally located within the housing complex. This greenspace is also adjacent to the proposed pump house which minimizes underground piping that runs from the pump house to the borehole field. As indicated above, the results of the energy model and GLD software indicated that (90) boreholes were required to properly condition the housing complex. L.N. Consulting laid out the required quantity of boreholes in the available green space while maintaining approximately 20 feet spacing between boreholes.

Sizing of the underground supply and return common piping (heat pump loop piping) network is based on the connected load of all of the heat pumps served by individual main piping sections and branches to maintain a desired pressure drop through the piping system. As indicated above, the individual heat pump sizes were determined based on the load data provided by the UConn Energy Modeling results. For this project, we have elected to utilize console style heat pumps. The console heat pumps are ductless style units that are located within the space they serve. Currently, the apartments have hot water convectors located within each room. The console style heat pumps will replace the current hot water convectors which will allow for individual room zone control as well as eliminating the need to add ductwork for each heat pump unit which will reduce cost. The typical heat pumps are 0.5 to 1.0-ton units. The current basis of design are Daikin W-MHW console style units. All of the heat pumps within each apartment are 0.5 or 0.75-tons. The individual heat pumps must be sized based on individual space peak loads, which results in approximately 350-tons of total connected heat pump equipment on the system versus the peak, diversified cooling demand of the entire apartment complex of 180-tons. Although the final layout is subject to change as the project and design progress, the current design incorporates approximately 11,000 linear feet of horizontal heat pump loop piping and approximately 9,000 linear feet of horizontal piping serving the geothermal borehole field. The horizontal piping will be run at approximately 5 feet below finished grade with supply and return piping being spaced a minimum of 24" apart from each other.

Conclusion/Next Steps:

The mechanical, electrical and plumbing drawings that have been developed as part of this phase utilized the design information indicated above. These drawings can be utilized to obtain the services of an Architect and other necessary sub-consultants such as Civil Engineer(s), Structural Engineers, etc. The MEP engineers will need to work with the rest of the design team to generate a set of bid documents. Bid documents will be utilized to hire a General Contractor (GC) or Construction Manager (CM) to facilitate the installation of the project in accordance with the bid documents. The Architect will work with the contractors to obtain all necessary permits required for construction to begin and for the project to be completed.