GEOTHERMAL INITIATIVE AT WEST CHESTER UNIVERSITY: SUSTAINABILITY FOR INSTITUTIONAL SUCCESS

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ABOUT WCU

- Regional comprehensive university located in suburban Philadelphia
- Largest institution of the Pennsylvania State System of Higher Education
- 15,800 students, 900 faculty, and 1,000 staff
- 4,000 students live on campus
- 3.5 million ft^2 of building space (1.8 M ft^2 on north campus)
- Established in the 1870s, WCU's physical plant includes a mixture of historic stone and contemporary, LEED-certified buildings (Figure 1).
- Signatory of the American College & University Presidents' Climate Commitment (ACUPCC)

Figure 1. West Chester University is faced with the challenge of heating and cooling a mixture of high-occupancy historic and contemporary buildings in a semi-urban environment.

WCU GEOTHERMAL SYSTEM

- Proposed in 2007 as a means of updating the 1960s-era coal-fired steam plant and electric chillers.
- The completed system will have a capacity of 16.1 MW including 1,400 152 m (500 ft) deep closed-loop geoexchange wells.
- Currently includes 12 buildings and 542 wells; approximately 38 percent of the completed system.
- The majority of buildings are connected to a *district* system. Thermal exchange fluid (water) is pumped between buildings and a central well field. Hundreds of 10 to 20 kW heat pumps exchange heat between the district fluid and building airspace. Advantages of this approach include:
  - Increased peak capacity - buildings require peak heating and cooling during different times of day, reducing the number of required wells (and cost) by 25 percent.
  - Increased efficiency - heat can be exchanged between buildings.
  - A centralized wellfield was placed at the perimeter of campus, under parking lots and open fields, in order to minimize disruption to the academic area and not impede future building development in the dense central core of campus.
  - A redundant system that allows multiple heat pumps, water pumps, wellfield sections, and even buildings to provide heating or cooling in the event of a partial system malfunction.

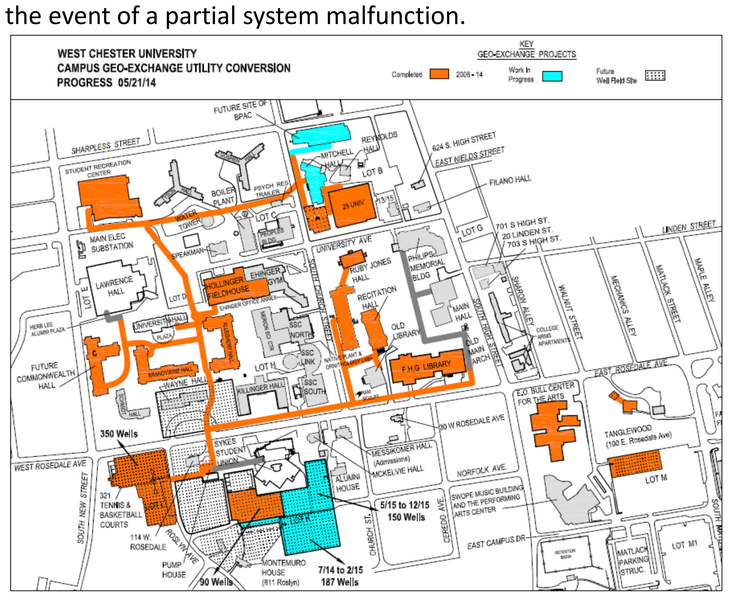

Figure 2. The WCU geothermal system currently includes 5 wellfields and 12 buildings.

SYSTEM PERFORMANCE

Geothermal (geoexchange) systems operate by exchanging heat between the ground and the building space (Figure 3). In the summer, heat is "pumped" from the building into the ground. In the winter, heat is transferred from the ground into the building. In a thermally-balanced system, summer heat remains stored in the ground to be used in winter and vice-versa, resulting in a highly efficient system. If more heat is placed into the ground than is removed each year, however, the ground will gradually heat up until the system is no longer efficient for cooling.

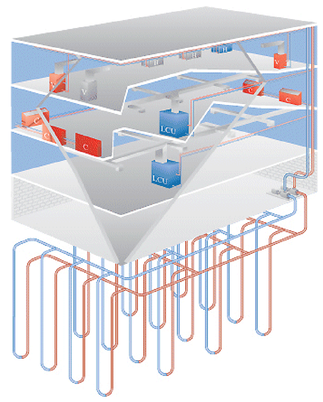

Figure 3. A typical closed-loop, commercial geoexchange system.

Figure 4. Daily mean ground temperature of the primary district wellfield from January 2011 to present.

- Ground temperature in the district wellfield oscillates 10 °C (18 °F) during a typical year (Figure 4).
- Temperature has increased from an ambient 12.8 °C (55 °F) in 2010 to a maximum of 34.5 °C (94 °F) during the summer of 2013.
- The temperature increase occurred because WCU requires twice as much cooling as heating every year due to high building occupancies (the average human produces 70 to 300 W of heat by metabolism).
- Typical heat pumps can handle supply temperatures up to 49 °C (120 °F), but should remain below 41 °C (106 °F) for reliable cooling performance.
- The addition of a second 88-well borefield in Nov 2013 and a subsequent cold winter returned ground temperature to 2011 levels.
- WCU is connecting an existing 736 kW cooling tower to release heat, mitigate the thermal imbalance, and increase sustainability.
- A consortium of faculty and students are working with WCU facilities to study system performance using an extensive data logger network and computer models (Figures 5 and 6). These tools will be used to predict future behavior and improve system efficiency.

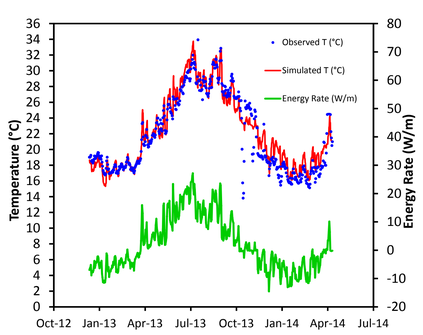

Figure 5. Computer-simulated (red) and observed (blue) daily ground temperature calculated from system heat flux (green) Dec 2012 to present.

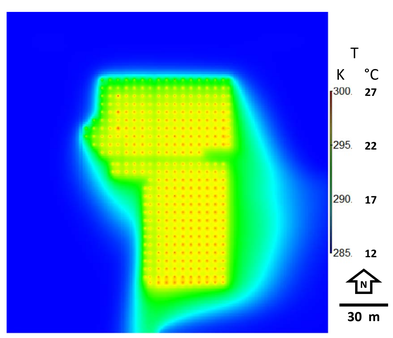

Figure 6. Three-dimensional heat distribution model of the wellfield in summer 2012 showing well-to-well interference and the influence of groundwater flow.

- The system is highly efficient, with a coefficient of performance (COP) of 3.4 for heating and 4.8 for cooling (i.e. the system derives 3.4/4.8 units of heating/cooling for every unit of electricity).
- The new system is 47 percent more efficient than the previous system.
- The current geothermal system produces 37 percent less CO_2, 73 percent less SO_2, and 71 percent less NO_x than the previous system. It also discharges no particulate pollution into the atmosphere.
- The coal-fired steam plant will be decommissioned this summer.

FINANCIAL INFORMATION

- The estimated cost for the completed system is $33M
- Sources of funding:
  - $5.1M Phase 1 Funding through a Housing Initiative
  - $6M PA DGS allocated for replacing old steam and condensate lines
  - $252k Pennsylvania Energy Harvest grant
  - $300k Congressionally-directed grant via Congressman Sestak
  - $558k DOE ARRA grant
  - $4.142M DOE FY2010 appropriations grant
  - $1.5M West Chester University funds
  - $15.1M Pennsylvania DGS funds awarded in 2012
- $14.26M have been spent to date. When complete, we estimate WCU will save $1M/year, with a projected payback of 29 years.

Figure 7. WCU's geothermal infrastructure—a financial investment for a sustainable future.

CONCLUSIONS

- The WCU geothermal initiative has made a profound and positive impact on our institution's infrastructure.
- The system is 47 percent more efficient than the previous system
- We estimate the system will save $1M/yr when complete with payback in 29 years.
- The current geothermal system reduces CO_2, SO_2, and NO_x emissions by 37, 73, and 71 percent, respectively. No particulate pollution.
- Wellfield temperature is increasing due to the cooling demand from high building occupancy. Reconnection of an existing cooling tower will mitigate this effect.
- WCU's system provides students/faculty with an opportunity for world-class research on heat transport and energy sustainability.

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