Shared Facility Helps Technology Grow

The Koffman Southern Tier Incubator provides labs and shared facilities for start-up companies. A hybrid ground source heat pump system is integrated with high performance hydronics for radiant heating and cooling.

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The new Koffman Southern Tier Incubator (KSTI), located in downtown Binghamton, N.Y., is a three-story, 38,000 gross ft^2 (32,500 net ft^2) facility that provides labs and shared facilities for start-up companies. The purpose of the facility is to provide resources and promote growth until these companies are strong enough to graduate from the incubator.

The facility features 10 wet labs, eight dry labs, one high space area, 22 offices, and common areas. Lab spaces represent 25% of net occupied space. Tenants have access to any available space, admission to all events hosted by the Incubator, and the ability to book the conference or event room.

The project's HVAC design parameters and corresponding design challenges are shown in *Table 1*.

HVAC System Description

Key design issues for facility and mechanical systems:

- Variability of users (tenant turnover);
- Reliably low operating costs (energy and maintenance);
- Security (protect proprietary research and development); and
- Occupant safety (students, public, due to wet lab operations).

The HVAC system has 100% individual zone control through the building management system (BMS) and is divided based on occupancy use. The system includes a hybrid ground source heat pump system (GSHP) pumped through a well field with water-to-water and water-to-air GSHPs. The labs and office spaces are served by water-to-water GSHPs coupled with moderate dual-temperature hydronics and induction chilled beams, with common and public spaces served by water-to-air GSHPs.

The well field is located under the adjacent parking lot directly south of the building. The well field comprises forty 400 ft (122 m) deep vertical bore wells on 20 ft (6 m) centers for a total capacity of 107 tons (376 kW) cooling or 1,170 MBH (343 kW) heating.

A test well was drilled on the site to confirm the thermal performance of the well field on site.

The project site is in an urban area and within a flood plain, and it was expected that drilling would yield ground water conditions, increasing the efficiency of the well field heat transfer ability. Water and silt on-site containment during the drilling process was required by the New York State Department of Environmental Conservation.

Wet labs are provided with low flow fume hoods with VAV exhaust and pressurization control. Ventilation and makeup air is provided from three dedicated outdoor air systems (DOAS). Each air-handling unit (AHU) has energy recovery and heating/cooling provided by the water-to-water GSHP system. Variable pumping is provided for the GSHP well field and all hydronic loops.

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The building orientation takes maximum advantage of solar orientation for daylighting and allows space for future building expansion. Lighting is LED with daylight control. Additionally, the building's south façade has an integrated solar wall for outside air preheat in winter conditions.

The mechanical systems (*Figure 1*) focus on a minimum distribution system and maximum energy performance, with variable air volume control, heat/energy recovery from exhaust, and very high efficiency heating and cooling equipment.

Energy Efficiency

At the time of design, energy code for KSTI was ANSI/ASHRAE/IESNA Standard 90.1-2007. eQuest v3.65 was used to evaluate energy savings relative to Standard 90.1-2007 Appendix G, *Performance Rating Method*. The building is in Climate Zone 6A and includes energy measures to reduce energy consumption in a heating-dominant climate. KSTI was operational in February 2017 with full occupancy achieved by June 2017. Between June 2017 and May 2018, the annual EUI was 71 kBtu/ft^2·yr (806 347 kJ/(m^2·yr) (*Table 2*).

TABLE 1 System issues and corresponding design challenges.

HVAC Design Parameters	Design Challenges
Comfort conditions (temperature and humidity control)	High ventilation volumes for wet labs, undefined requirements for high bay space
Low noise and good acoustical isolation	Gypsum ceilings and walls, lots of hard reflective surfaces
Wet lab fume hoods	Cost of fume hood exhaust, exhaust control and energy recovery
Good indoor air quality	Ventilation without introducing excess humidity
Individual zone control and sub-metering	Equipment to handle variability of occupancy and thermal loads
Aesthetics of exposed ductwork and system components	Equipment location, finishes and aesthetic quality
Energy efficiency (low utility cost)	Equipment and system efficiency
Lowest acceptable first cost	Balance first and life-cycle cost

Table 3 provides a comparison of Standard 90.1-2007 baseline and the proposed design energy savings parameters.

The actual utility consumption for KSTI is 43% better than the Standard 90.1-2007 baseline model. A

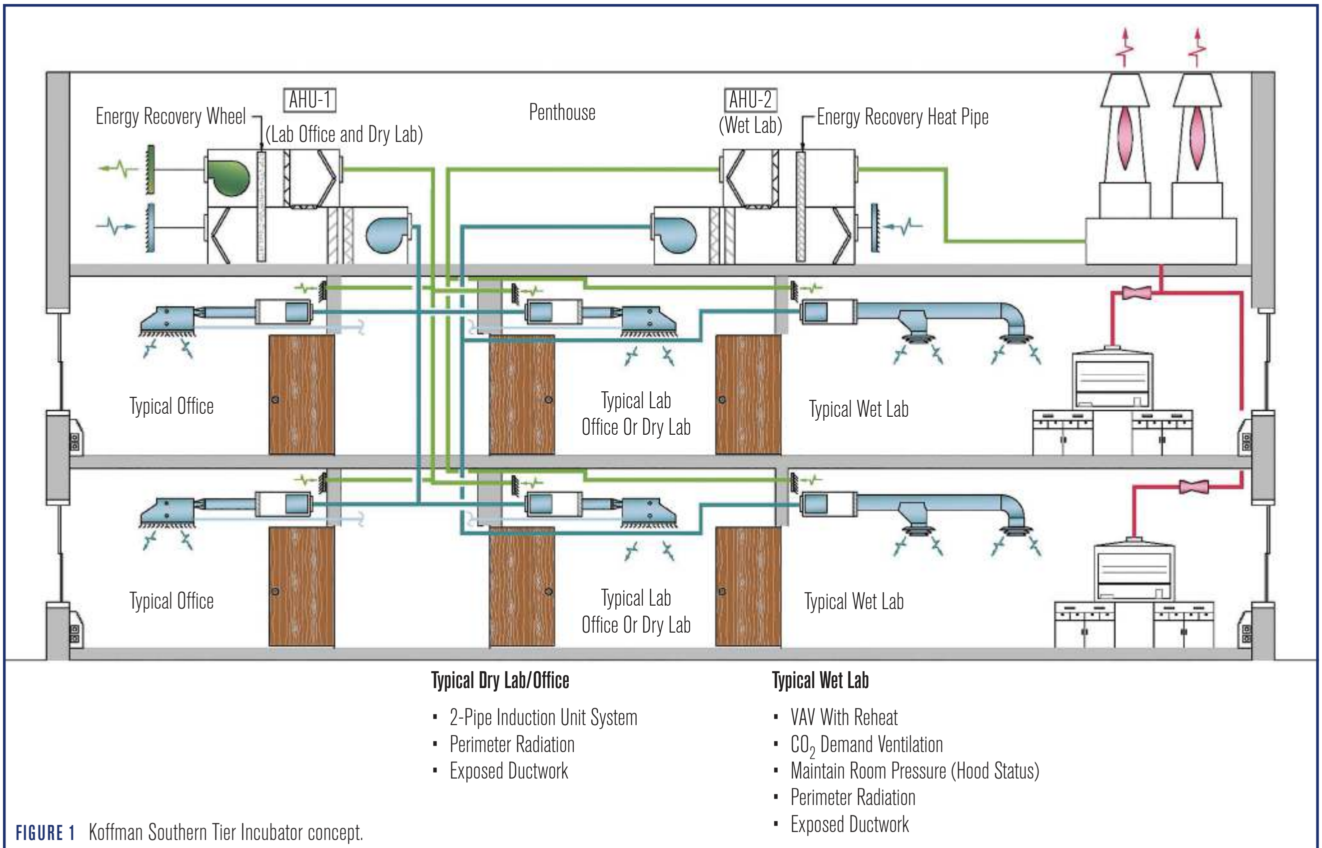

FIGURE 1 Koffman Southern Tier Incubator concept.

parametric analysis evaluated the impact of each energy conservation measure (*Figure 2*).

Indoor Air Quality/ Thermal Comfort

The design ensures good indoor air quality and meets or exceeds ANSI/ASHRAE Standard 62.1-2007. Compliance was calculated using a zone air distribution effectiveness of 0.80 and the Appendix A method for system ventilation efficiency with results of 0.69 for AHU-1 and 0.64 for AHUs 2 and 3. Additional IAQ measures included:

- Increased outside air in corridors and common spaces for lab and anteroom pressurization. This was specified in the control sequences and confirmed during commissioning.
- Ventilation air is measured and controlled to each zone via a VAV box and ducted to terminal devices.
- Demand control ventilation (DCV) is used with CO_2 control in all common, office and non-laboratory spaces.
- The design and construction included LEED materials and storage compliance for low/no VOC construction materials and furnishings.
- The building was purged using AHUs 1, 2 and 3 prior to occupancy as part of commissioning using LEED guidelines and MERV 13 temporary filters.
- As previously mentioned, the zoning strategy, energy recovery technology application and process exhaust system fan selection and location helped ensure good lab safety, ventilation system flexibility, and eliminate cross contamination from exhaust contaminants.

The design provides good thermal comfort and compliance with ANSI/ASHRAE Standard 55. The zoning strategy allows for thermal comfort under varied occupancy for the different spaces. All lab spaces and common areas are controlled independently with ±3°F (±1.7°C) temperature adjustment permitted for occupants. Ventilation air is delivered to the

TABLE 2 Annual energy consumption profile.

	Gas (Therms)	Electric (kWh)	EUI (kBtu/ft^2·yr)
Actual Utility Consumption	10,893	472,200	71
Standard 90.1-2007 Baseline, PRM*	19,280	821,401	123

* KSTI was enrolled in the NYSERDA New Construction program. NYSERDA Technical Assistance and energy model was provided by a third party, Erdman Anthony

TABLE 3 Standard 90.1-2007, Appendix G, *Performance Rating Method.*

Model Input Parameters	Standard 90.1-2007 Baseline	Proposed Design
Envelope	Roof: U-0.048 Walls:U-0.064 Windows: U-0.55, SHGC-0.4	Roof: U-0.021 Walls: U-0.064 Windows: U-0.36, SHGC-0.38 Exceptional Calc: Solar pre-heat wall
Lighting	Space-by-space method 36 kW, 0.95 W/ft^2	LED lighting: 22 kW, 0.58 W/ft^2 Additional savings: Daylighting, occupancy sensors and bi-level controls
HVAC system	System 5: Packaged variable air volume system with reheat (PVAVS). DX cooling with hot-water fossil fuel boiler	Hybrid GSHP with condensing hot water auxiliary boiler. Terminal water-to-air heat pumps and active chilled beams with demand controlled ventilation
Hot water loop	Constant volume, pump riding the curve, 80% boiler Et	Variable volume pump, 94% boiler Et
Heating COP	N/A	Water-to-water heat pump: Average 3.28 COP Water-to-air heat pump: Average 4.1 COP
Cooling EER	System 5 PVAVS: 9.3 EER	Water-to-water heat pump: Average 17.4 EER Water-to-air heat pump: Average 20.3 EER
Energy recovery	No	Yes

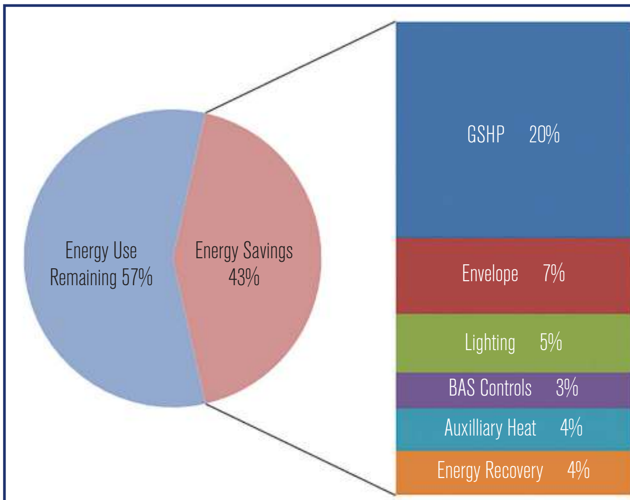

FIGURE 2 Koffman Southern Tier Incubator energy consumption savings summary. (Standard 90.1-2007, LEEDv3 Baseline)

space and induction units at 50 grains (3.24 g) or less to avoid condensation at the induction units. Only small offices were combined (maximum of four) to a common control zone by exposure for budgetary reasons. Perimeter radiation helps eliminate fenestration losses in the offices and labs with high glass/wall ratios used for daylighting and outside views. The use of radiant slabs in the main lobby at the curtain wall windows and cantilevered floor slabs also provides better comfort in the high-volume spaces.

TABLE 4 Cost-benefit analysis for KSTI ground source well-field.

HVAC System	Total Construction Cost	Annual Energy Costs			Energy Use Index
		Electric	Gas	Total	kBtu/ft^2·yr
Ground source heat pump (GSHP)	$7,433,300	$61,152	$1,098	$62,250	66
Air-cooled chiller with condensing boiler	$7,335,300	$63,625	$8,696	$72,321	101

TABLE 5 Greenhouse gas reductions.

Electricity Conservation ($MTCO_2e$)	Natural Gas Conservation ($MTCO_2e$)	Total ($MTCO_2e$)
213	45	258

Calculations based on EPA's Pollution Prevention (P2) Program GHG Calculator developed in 2015.

Innovation

The hybrid GSHP system is integrated with high performance hydronics for radiant heating and cooling. Lab HVAC systems, which represent 60% of the total building HVAC energy use, feature:

- 56% energy recovery via a heat pipe from exhaust (no cross contamination);
- 10 low flow fume hoods (60 fpm [0.31 m/s]);
- GSHP water-to-water integrated with moderate temperature, dual temperature hydronics and chilled beams;
- Active pressure control for safe negative relationships between public corridor and lab anterooms and anterooms to labs; and
- Visual color-coded lab safety pressure indicators in public corridors for occupant safety.

To enhance energy performance, this project integrates a large solar preheat system on the southern façade with the HVAC system, which includes energy recovery wheels in the DOAS air-handling units and the GSHP system. The collector is perforated with tiny holes and painted a dark color to absorb maximum solar radiation. Solar radiation heats the air in the plenum, as the air is drawn through the collector and into the plenum by the DOAS air-handling units.

On March 23, 2017 heating systems were being commissioned. At 9:30 a.m., the outside air temperature was 18°F (–8°C). The solar preheat wall raised the intake temperature to 29°F (–2°C) and the energy recovery wheel further raised incoming air to 58°F (14°C). Fan motor heat raised the discharge air to the space set point of 67°F (19°C). No additional energy was required to heat the building.

Ground source heat pump drilling.

Operation and Maintenance

The layout of the labs allows business to expand or reduce their space size in alignment with their needs. Co-working space on all three floors encourages networking and collaboration among start-up companies and partners. All major mechanical equipment is in indoor mechanical space for ease of maintenance.

GSHP benefits include:

- Smaller boiler dedicated to OA preheat;
- Reduced fossil fuel combustion and lower NO_x, SO_x, CO and CO_2 emissions;
- No cooling towers with chemical treatment, reducing water consumption;
- Lower operating costs and lower maintenance costs;
- No exposed at-grade cooling tower or chiller (security); and
- Increased central plant redundancy via multiple GSHPs.

Cost Effectiveness

The total project cost was $15,936,000. The HVAC system cost was analyzed during design development and indicated a simple payback of 10 years. Based on utility data from June 2017 – May 2018 the building is performing close to energy model predictions with an actual EUI of 71 kBtu·ft^2·yr (806 347 kJ/(m^2·yr), which is 50% better than a typical mixed-use laboratory and office building in Climate Zones 5A and 6A, according to Labs21 Benchmarking Tool.

The following cost-benefit analysis was prepared during early design for two systems considered: ground-source well-field with heat pumps (GSHP) and a conventional air-cooled chiller with condensing boilers. The predicted annual energy costs were then calculated using a design analysis software.

Although a GSHP was more expensive to install, with higher incremental cost of $98,000, the annual energy costs for the ground source heat pump are $10,071 less than the conventional air-cooled system. The GSHP system has a simple payback period of less than 10 years.

Environmental Impact

The GSHP system reduces fossil fuel use and provides low energy consumption. The smaller boiler is limited to extreme cold outside air preheat, resulting in lower fossil fuel consumption and emissions. No cooling tower or chemical treatment is required. In addition, to the high energy performance of the equipment, the GSHP refrigeration systems selected use R-410A a non-ozone depleting refrigerant. Chemicals are contained and removed from site. Ambient mechanical noise to the neighborhood was minimized by installing the ground source heat pump system, placing auxiliary mechanical equipment in a penthouse and providing screened exhaust fans.

All plumbing fixtures are low flow flush valves and automatic faucets for water conservation.

The total annual energy savings is equivalent to 258 metric tons of CO_2. ■