LABORATORIES FOR THE 21ST CENTURY: CASE STUDIES


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GEORGIA PUBLIC HEALTH LABORATORY, DECATUR, GEORGIA

Introduction

The Georgia Public Health Laboratory (GPHL) in Decatur is a very attractive example of a bright, comfortable, energy-efficient laboratory building. This state-run, 66,000-ft^2 clinical testing facility is located on the outskirts of Atlanta near other government facilities on a busy, multi-use street. More than 90 personnel conduct about 2.5 million tests each year on over a million specimens in the areas of virology, parasitology, bacteriology, mycology, and immunology. The GPHL was selected by *Research and Development Magazine* as the 1998 Laboratory of the Year.

This case study of the GPHL is geared toward architects and engineers who are familiar with laboratory buildings. It is one in a series produced by Laboratories for the 21st Century, a joint program of the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE). The case studies exemplify the "Labs 21" approach, which encourages the design, construction and operation of safe, sustainable, high-performance laboratories.

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The GPHL's energy efficiency can be attributed both to its many sustainable design features and to a strong retro-commissioning effort. Natural light and exterior views permeate the building, making even the innermost laboratories bright and spacious.

The innovative use of recycled materials and thoughtful siting enhance the GPHL's design. Design features that contribute to the building's energy savings include tight envelope construction; air handlers located on the floor directly above the chillers; closely grouped loads (such as low-temperature freezers); natural lighting; a heating, ventilating, and air-conditioning (HVAC) system that uses one-pass air in the laboratory and support spaces and recirculated air in administrative spaces; direct digital controls (DDC); and lower nighttime settings for supply and exhaust air. Also included are a reflective roof surface, sunscreens to control solar gains, and the use of low-emissivity (low-E) glazing. All these elements, combined with light, open work spaces and an attractive design, contribute to a building that ranks high in comfort and functionality and low in energy use and utility costs.

> *"Care was taken to create a work environment that is pleasing to work in, promotes interaction, and inspires pride."* Laboratory Director Elizabeth Franko

Project Description

The GPHL is a two-story building that measures 66,030 gross ft^2 and contains large, open Biosafety Level 2 (BL-2) laboratory areas and smaller BL-3 areas, as well as administrative offices, conference areas, and classrooms. BL-2 labs are suitable for work involving agents of moderate potential hazard to personnel and the environment. BL-3 areas are suitable for the study of airborne transmissible diseases.

The GPHL is the primary clinical testing laboratory for the state of Georgia. To safeguard the public's well being, the GPHL monitors and helps to control the spread of communicable diseases such as acquired immune deficiency syndrome (AIDS), tuberculosis, and hepatitis.

The building was designed by Lord, Aeck & Sargent Architects of Atlanta. Consultants included Stanley D. Lindsey & Associates (structural engineers), Delon Hampton & Associates (civil engineers), Thompson Engineers (mechanical/electrical engineers), and Carla S. Wertheimer (landscape). The general contractor was Beers Construction. The GPHL was completed in November 1997 at a cost of \$159/gross ft^2, including all fixed laboratory casework, environmental rooms, and equipment. Furniture, movable equipment, laboratory information systems, and other costs added another \$26.50/ft^2.

Laboratory personnel conduct about 2.5 million tests per year on more than a million clinical specimens. The testing is diverse and includes blood tests for all newborn babies in Georgia as well as parasitology, virology, and bacteriology tests of many kinds. The labs were designed for maximum flexibility, because the types of tests needed and the state's priorities can change rapidly. The space breakdown is shown in Table 1.

As part of a collaborative learning venture between the GPHL and the Centers for Disease Control (CDC) and Emory University's Rollins School of Public Health, the facility also includes a teaching laboratory. This was included in the design in response to Georgia's growing need to instruct scientists and technicians from various organizations on the proper use of laboratory facilities. The GPHL teaching laboratory includes both classrooms and conference facilities as well as a fully outfitted mini-laboratory with advanced BL-3 suites. The teaching lab allows students and teachers to discuss and practice specimen handling procedures and includes telecommunication capabilities for distance learning.

The first floor houses the main public areas of the building, including a two-story lobby, as well as receiving, warehousing, offices, classrooms, and conference facilities. A security separation between the lower floor and the second floor allows the public access to the first floor

Table 1. GPHL Space Breakdown

(In net ft^2, unless otherwise noted)

Function	Size (ft^2)	Percentage of Total(1)
Labs (BL-2)	20,260	46%
Labs (BL-3)	2,980	7%
Offices	9,220	21%
Other programmed spaces	12,030	27%
Total net ft^2	44,490	
Other (2)	21,540	
Total gross ft^2	66,030	

1. The percentage is for net ft^2 only; net ft2 equals gross ft^2 minus "other."
2. "Other" includes circulation, toilets, stairs, elevator shafts, mechanical and electrical rooms and shafts, and structural elements like columns. The net-to-gross ft^2 multiplier is 1.5.

while maintaining a safe environment for lab users and samples on the second floor. In addition, the second floor houses clerical spaces, offices, lab support spaces, and a service corridor. Taking advantage of the naturally sloping site, the rectangular second floor is larger than the first floor, extending on-grade much farther north than the first floor. This allowed many of the laboratory areas to be built on-grade, reducing vibrations where sensitive equipment is used.


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Figure 1. Vertical columns along the west facade of the building make elegant use of granite while providing shade. Also shown is the south-facing two-story lobby with its distinctive sunshade.

Design and Layout

A number of sustainable design features were incorporated into the building in addition to its energy-efficient design, building envelope, HVAC equipment, and control system. One of the most beautiful and functional elements is the exterior facade, which is made of salvaged granite scrap and recycled copper shingles. The durable granite is waste material from local tombstone crafting operations. Along the western facade, this granite forms tapered vertical piers that act as sunshades for west-facing windows. Shingles from recycled copper over structural metal studs cover the upper portion of exterior walls. These materials, though very attractive, cost no more than a standard brick wall. Figure 1 shows the elegant use of the granite in the vertical columns along the west facade.

The GPHL's layout was designed to minimize life-cycle costs, materials consumed, and remodeling time over the life of the building. It also encourages interdisciplinary collaboration. The light-filled design enhances productivity by increasing the staff's ability to work comfortably "at the bench" for longer periods of time.

The building streamlines workloads and processes by "flowing" along the logical path of a lab specimen. Deliveries arriving at a loading dock on the east side of the building are sent to a nearby receiving room. From there, supplies are diverted to a warehouse and stockroom, while specimens are transported to a second-floor accessioning laboratory; the second floor can be accessed only by using a key card. There, samples are checked within bio-safety cabinets for content and container integrity. After the samples are logged in, they are sent to either the BL-2 or BL-3 laboratory. Centralized checking and logging in of specimens greatly increase productivity, because they eliminate the need to perform those tasks at the bench. Thus, testing capacity is much greater than that of most conventional testing laboratory buildings.

The first floor has a double-height, south-facing public lobby with curtain wall glazing and a distinctive sunscreen of horizontal aluminum tubing, coated with copper-toned fluoropolymer. The sunscreen shades the south-facing glazing from direct sun. Offices line half of the west side of the first floor and the entire west side of the second floor. All have access to exterior views and natural light. Figure 2 shows the second-floor plan.

Laboratory Modules

The BL-2 area consists of 21 laboratory modules, each measuring 10 ft 8 in. wide and 42 ft long, including the dry desk but not the support labs. Each module has freestanding benches, and individual test groups are designated for a particular bench. Space needs are determined by the volume of incoming samples; staff can either downsize or expand a module by simply vacating a bench or assuming occupancy of an adjacent bench. For flexibility, all lab benches have the same infrastructure, including natural gas, vacuum, emergency power, and deionized water. A slightly larger than normal bench-to-bench spacing of 10 ft 8 in. enables staff to carry out an array of scientific operations side by side and accommodates large equipment.

The self-contained BL-3 laboratory is dedicated to tuberculosis testing. Developed in collaboration with the CDC, it is the first U.S. laboratory to meet current standards for this testing.

Utility Servicing

The layout of the HVAC system and utilities features a service corridor that runs along the eastern side of the north-south axis of the building. The service corridor has no ceiling and houses the largest exhaust air ducts. The ceiling plenum space begins just west of the service corridor and then decreases in height at the west facade, where less space is needed for air ducts. Figure 3 shows the sloping plenum space. The labs are on the west side of the service corridor; lab support spaces and the accessioning lab are to the east of the service corridor.

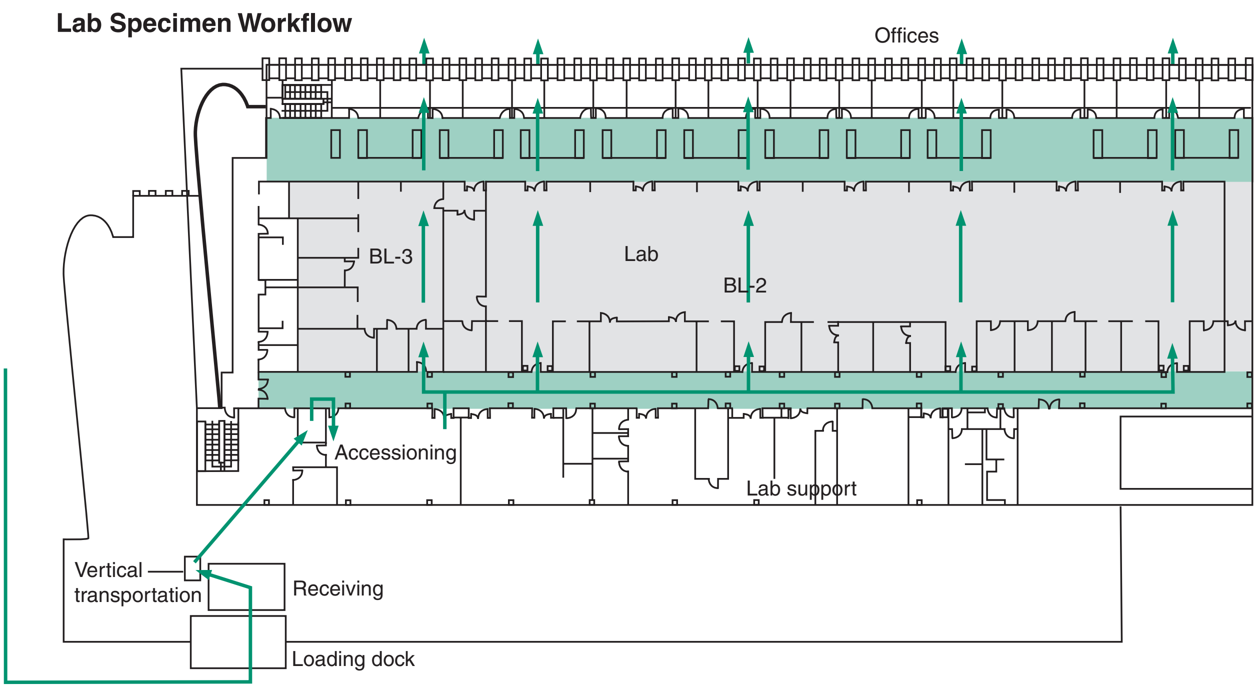

Figure 2. Second-floor plan of the Georgia Public Health Laboratory, showing the flow of specimens (Courtesy of Lord, Aeck and Sargent).

Directional airflow is a safety measure in this building. Air flows from areas of least hazard and is drawn toward areas of highest hazard, where it is then exhausted. Air supply ducts are located on the western side of the labs, and fume hoods and exhaust air ducts are on the east side of the labs, near the service corridor.

The system is zoned so that only the lab and lab support space use one-pass air; air from the administrative areas is returned to the air-handling unit. All the low-temperature freezers, which give off a significant amount of heat, are grouped together in one room to provide more efficient cooling.

There is no central specialty gas system feeding the lab modules. Where it is required, bottled gas is provided in the service corridor and piped to the benches. Labs have point-of-use deionized water systems at the benches rather than centralized deionized water. This has proved to be an easy system to maintain because, as lab equipment has become more sophisticated, the quality and type of the deionized water has increased. It has been easy to upgrade the system at the individual benches.

Most of the services are accessed from the adjacent service corridor and routed to benches via the ceiling plenum in the lab. At the benches, a set of umbilical columns extend into the plenum and function as utility chases.

Design Approach

To help create the most efficient design possible, the design team created a three-dimensional model of the building and examined the model with the aid of a "virtual reality" helmet. This technology allowed the team members (and the client) to "walk around" inside the building during the design phase and to adjust the dimensions of corridors, office areas, ceilings, and other areas to create the best possible environment at the least possible cost.

Two key goals of the design approach were functionality and flexibility. Since the laboratory has rigorous annual testing requirements, careful consideration was given to work-flow issues. The lab also has to be highly flexible to accommodate changes in public health priorities. And it has to function as a high-quality training facility, another important design goal.

The number one request from staff, however, was for a bright, spacious work area, preferably with views to the outside. Everyone wanted to have a sense of light and of the outdoors. Laboratory Director Elizabeth Franko said, "Care was taken to create a work environment that is pleasing to work in, promotes interaction, and inspires pride."

Therefore, the design team developed a curved, sloped ceiling at the second floor that begins at a low point at the east end of the open labs and gradually increases in height as it extends over the open office areas. Clerestory windows were added above office areas and at the laboratory walls; staff in interior spaces and offices can see treetops and sky through the clerestories. Windows were provided between the labs, offices, and office support areas to provide an open, "seamless" feel that allows light and views to be shared among these multiple areas.

Although the office windows and laboratory clerestories face west, glare from late-day sunlight is controlled by the vertical granite piers and a 12-foot-deep clerestory overhang. The evergreen trees along the building's west facade also help to screen the afternoon sun. Figure 3 illustrates the sloped ceiling and shows how light enters from the west.

To address the need for flexibility over time, the designers developed an open laboratory plan with benches slightly larger than normal. Offices were designed so they could be reconfigured later, if necessary. And lower level doors were strategically aligned so staff could replace chillers without having to demolish walls.

After several design iterations, the design team determined that it would be more sensitive to the site to locate the building on the north portion of the site and place parking areas on the southern portion. This allowed many trees to be retained and require a minimum of grading. Siting the building this way also permitted good interior views and daylighting to be incorporated into the design, as well as powerful views of the building from the street.

The building was oriented so that the southwest corner was the most dominant side when viewed from the road or from the entrance to the parking lot. To provide visual interest, the design team created a curve at the southwest corner, and carried the south horizontal sunscreen of the lobby around this curve to create the building's "front." This also brought more light into the open office area on the second floor.

The welcoming, glass-faced lobby area was designed specifically to bring light into the interior. The horizontal aluminum sunscreen was developed to help control the heat of the sun at the south facade inexpensively yet dramatically. Figure 1 shows the aluminum sunscreen.

Materials were chosen primarily for their durability, cost-effectiveness, and environmental qualities. Recycled granite and copper are used extensively on the exterior. Tile extends from the south plaza into the lobby space to reinforce a positive connection between the areas inside and outside the building. Sandblasted cement board, an inexpensive but attractive and durable wall surface, was selected for high-gloss interior surfaces.

Technologies Used

The building's energy-saving features and technologies include the following:

- A tight envelope construction
- An HVAC system that uses one-pass air in lab spaces and recirculated air in administrative spaces
- Efficient location of air handlers in relation to chillers
- Closely grouped loads, such as freezers grouped in one room, to manage heating and cooling more efficiently
- Direct digital controls
- Night setbacks that reduce the amount of supply and exhaust air needed
- Extensive use of natural lighting (daylighting).

Other features include the use of a reflective roof surface and sunscreens to control solar gains, and low-E glazing.

Envelope and HVAC

The building envelope is well insulated with R-19 wall insulation and R-21 roof insulation, and finished with materials that require little exterior maintenance. The roof, which is almost an acre in size, has a highly reflective surface to minimize heat gain. Low-e glazing optimizes the building's heating and cooling efficiency.

The HVAC equipment is a constant-volume system that moves air at 70,000 cubic feet per minute (cfm). The 11 fume hoods in the building are connected to a manifold exhaust system. Six high-induction Strobic Air™ exhaust air fans are on the roof directly above the service corridor. Exhaust stacks are 12 ft high above the roof line.

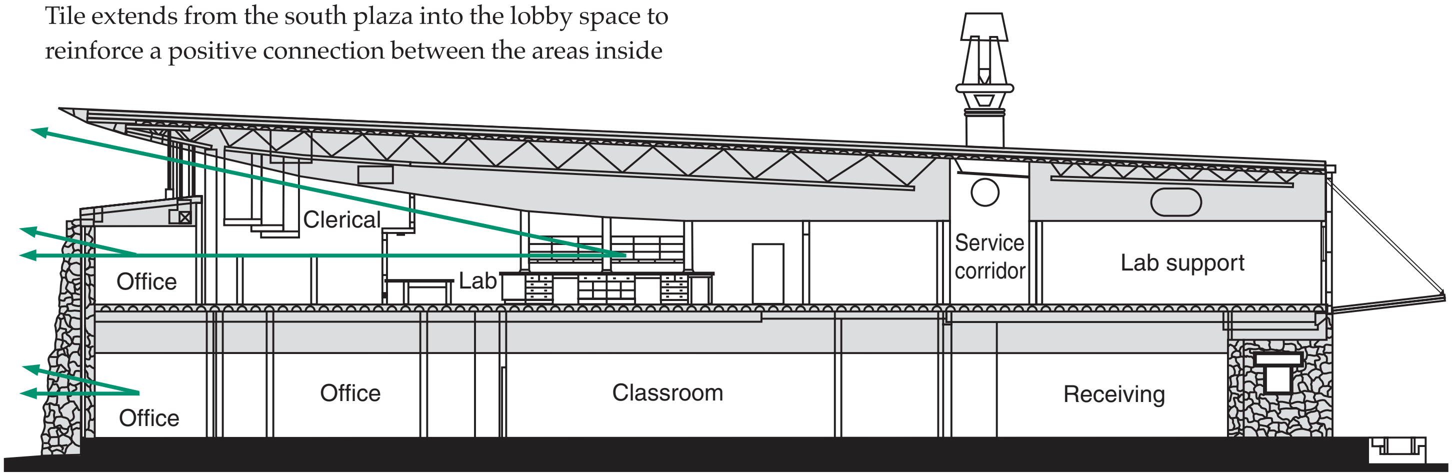

Figure 3. Building section, looking north (Courtesy of Lord, Aeck and Sargent).

Fans have variable-frequency drives and direct-drive motors to balance the air in the system. The motors are directly coupled to a fan and do not use belts. The air-handling unit is located on the second floor directly above the mechanical room, which contains the chillers and boilers. Inlet air is drawn from the north side of the building at ground level. A DDC system is used for equipment controls.

The pressure drop through the supply air system is low, at 1.7 in. water column. The lab areas and support spaces take up approximately 34%, or 22,906 gross ft^2, of the building and use 100% outside air. The remaining areas use 20% outside air with 80% recirculated air. In both the BL-2 and BL-3 labs, there are 10 air changes per hour (ACH); at night, setbacks drop this to 6 ACH.

Each of the two 200-ton chillers can provide enough cooling for the entire building. Heating is provided by two 125-boiler horsepower (BHP) gas-fired steam boilers. There are three shell-and-tube heat exchangers—one for domestic hot water, one for humidification, and one for reheat coils. Steam is used for sterilizers and glassware washers. Emergency power is provided by a 400-kW generator with a natural gas engine.

Daylighting and Other Lighting

The architects designed the west side of the building to provide the labs with natural light, or daylighting, and views. Normally, daylighting from the west side would have made it difficult to shade the glass from the western sun at low angles and prevent unwanted heat gain. However, the architect used both vertical shading (which is most effective for the east and west facades) in the form of the granite piers and a sweeping horizontal overhang to provide daylighting without adding heat. A line of evergreens also help block the low-angle western sun.


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Figure 4. Staff have a direct line of sight from the laboratories and offices to the outside; this view is from the north.

The south-facing public lobby uses horizontal overhangs made of copper tubing to block unwanted heat gain.

Offices are glazed with view windows, and recessed clerestory windows above the offices provide a direct line of sight to the outdoors from the labs and clerical spaces. The west interior wall of the labs is a fire-rated wall and has view and clerestory windows. The furniture in the clerical areas is designed to have low partition walls that do not block the direct line of sight from offices to labs and from the labs through offices to the outside. The result of this attention to detail is a clear line of sight to areas outside the building from almost anywhere inside, as indicated in Figure 4 and in the cover photo.

The ceiling space gently curves up toward the west facade to allow the added height needed for clerestory windows over offices and labs and thus access to views and daylight from the labs. In addition to the productivity benefits of daylight and views, the direct line of sight between the offices and the labs adds an element of safety; it allows people to see whether there's been an accident or a problem in a lab. The direct line of site to the labs also has managerial benefits; it allows scientists to determine, without leaving their desks, who is in a lab and whether tests are being run.

Labs and offices use direct/indirect lighting fixtures to supplement daylighting. Overall, laboratory staff are pleased with the lighting fixtures, which use T-8 lamps and electronic ballasts. Staff can turn off the lights manually in offices and clerical areas when there is sufficient daylighting. Automatic dimming controls were not incorporated into this design, but they could provide a means to increase the energy savings resulting from the use of natural lighting.

Commissioning Process

This project was completed before the State of Georgia had fully embraced building commissioning. By the time construction was finished, only traditional test and balance procedures and basic operational training were completed. Commissioning for this project is better described as startup and retro-commissioning during the first year of operation.

A short time after the building was occupied, Lord, Aeck and Sargent were selected for operation and maintenance of all the building's systems. During the winter of 1997, the owner began to notice that some systems were not operating as needed and there were some deficiencies in both the design and the construction. To address these problems, the owner formed a "retro-commissioning team." This team consisted of the owner's building manager; an independent test and balance firm; a mechanical maintenance firm; an electrical maintenance firm; the original controls subcontractor; a mechanical, electrical, and plumbing (MEP) engineering firm; and members of the architectural firm.

The team created an operational intent statement to describe how the systems should be operating. This is identical to the first step in a commissioning process, but it began several months after occupancy. In the first year and through the following winter, the team members identified and corrected several operational problems. They established how each system should work and confirmed or corrected each aspect of each system. By the end of the winter, the systems were corrected and tuned up, and operations were established so the building would function as intended. A lesson the team learned is that it is important from an economic and efficiency standpoint to start commissioning a building during the design and construction phases.

Measurement and Evaluation Approach

During the first few years, the GPHL tracked measurable indicators of performance, e.g., outside temperatures and how the building's systems responded internally. These were tracked initially to help GPHL understand how to optimize the building's performance.

Building Metrics

A review of the laboratory's energy bills indicated that the GPHL consumes about 358 kBtu / gross ft^2 of energy per year. Its energy use is thus comparable to the energy performance of other laboratories highlighted in the "Labs 21" case study series; those buildings are 30%–40% more energy efficient than they would have been if they were designed as conventional code-compliant laboratories. In this case, however, energy use was not modeled for a base case building—i.e., a building designed to meet energy code requirements without additional energy-efficient features. That data would be needed to compare energy use and savings for the (as-built) GPHL with a similar base case building.

Summary

The GPHL shows the advantages that can be gained by designing and building a laboratory with the staff's needs, as well as the building's energy efficiency, in mind. The designers took into consideration the requests of laboratory personnel in designing this comfortable, light-filled facility. It makes very good use of daylighting while providing direct views to the outdoors from almost anywhere in the building. To determine the placement of key areas of

Table 2. GPHL Building Metrics

System	Key Design Parameters	Annual Energy Use (based on design data)	Annual Energy Use (based on utility bills)
Ventilation (sum of wattage of all the supply and exhaust fans)	Supply = 2.1 W/cfm Exhaust = 1.8 W/cfm Total = 1.96 W/cfm (1) 2.2 cfm/net ft^2 (labs only) (2)	31.9 kWh/gross ft^2 (3) (47.85 kWh/net ft^2)	
Cooling plant	400 tons 0.65 kW/ton	6.0 kWh/gross ft^2 (4)	
Lighting	2 W/net ft^2	5.9 kWh/gross ft^2 (5)	
Process/plug	10 W/net ft^2 (receptacles)	27.8 kWh/grossft^2 (6)	
Heating plant	250 BHP heating plant capacity		195 kBtu/gross ft^2/yr
Total		71.6 kWh/gross ft^2/yr (estimate based on design data for electricity only) (256 kBtu/gross ft^2/yr for electricity only)	46.2 kWh/gross ft^2/yr for electricity only (158 kBtu/gross ft^2/yr for electricity only) 358 kBtu/gross ft^2 for electricity and gas Actual annual cost for electricity and gas equals \$4.5/gross ft^2/yr (based on 2001 utility bills)

Notes:

1. Supply = 2.1 W/cfm [200 hp (supply fans) x 746 W/hp divided by 71,650 cfm]; exhaust = 1.8 W/cfm [122 hp (exhaust fans) x 746 W/hp divided by 51,000 cfm].
2. Total cfm required for all floors is 71,650 cfm/66,030 gross ft^2 = 1.06 cfm/ gross ft^2; net lab-only cfm = 51,000 cfm/23,240/net ft^2 = 2.2 cfm/net ft^2 .
3. 1.96 W/cfm x 122,650 cfm x 8760 hours/1000 = 2,104,257 cfm, or 31.9 kWh/gross ft^2.
4. 0.65 kW/ton x 200 tons x 2890 hours/63,030 gross ft^2 = -6.0 kWh/gross ft^2 (assumes cooling runs 33% of the hours in a year; each chiller can provide all the buildings cooling needs so only one was included in the calculation).
5. 1.3 W/gross ft^2 x 4534 hours /1000 = 5.89 kWh/gross ft^2 - (2.0 W/net ft^2/1.5 = 1.3 W/gross ft^2). (Assumes lights are on 87.2 hours/week.)
6. 6.6 W/gross ft^2 (0.80) x 5256 hours/1000 = 27.8 kWh/gross ft^2. (10 W/net ft^2/1.5 = 6.6 W/ gross ft^2). (Assumes 80% of all equipment is operating 60% of the hours in a year.)

Note: Estimated data are presented in site Btu (1 kWh = 3412 Btu). To convert to source Btu, multiply site Btu for electricity by 3. Note: Atlanta has 3089 heating degree days and 1611 cooling degree days.

the facility, the designers also took into consideration the tests and other processes that would be carried out. The result is an increase in productivity and a more streamlined work process, as well as enhanced satisfaction with the laboratory on the part of its occupants.

The designers employed numerous energy-efficient materials and equipment to enhance the efficient design. As a result, the GPHL is more energy efficient than a comparable building using a more conventional design and equipment. Using some relatively inexpensive recycled materials in the facade, the designers also made sure that the building would be attractive.

Another lesson learned in the design and construction of the GPHL is the importance of commissioning a building as construction progresses and is completed. However, in this case, the commissioning was performed after the building was constructed and operating. The success of the retro-commissioning effort was due in large part to the thoroughness and expertise of the team that accomplished it.

Acknowledgements

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