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PHARMACIA BUILDING Q, SKOKIE, ILLINOIS

Introduction

Building Q on Pharmacia Corporation's research campus in Skokie, Illinois, is designed to be a world-class facility for chemistry research. The building's architecture reflects its dedication to innovation, and interior spaces are filled with natural light. These bright spaces help to create a comfortable work environment that fosters the discovery of new pharmaceutical solutions. For its many efficient, sustainable design features, Building Q received a Gold certification through the U.S. Green Buildings Council Leadership in Energy and Environmental Design (LEED) rating system. It also received a special mention award as a 2001 Lab of the Year from *Research and Development Magazine*. This case study 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). Geared toward architects and engineers who are familiar with laboratory buildings, the case studies exemplify the "Labs 21" approach, which encourages the design, construction, and operation of safe, sustainable, high-performance laboratories.

EPA United States Environmental Protection Agency

United States Department of Energy FEMP FEDERAL ENERGY MANAGEMENT PROGRAM

A review of one year's worth of utility data indicated that Building Q's electricity consumption equals 150,000 Btu per gross square foot (ft^2)—much less than predicted. A number of design features contribute to this reduced energy use in comparison to that of a similar conventional, code-compliant laboratory building. These features include energy-efficient, variable-air-volume (VAV) fume hoods, used with a VAV supply and exhaust system; heat recovery; premium-efficiency motors for mechanical equipment applications; and extensive use of natural lighting. Also included are occupant sensors for lighting and ventilation setbacks; chillers and cooling towers, selected on the basis of life-cycle costs; and submetering of all utilities.

In addition to its low-energy design, the building incorporates many sustainable design features, such as the use of recycled materials and an innovative approach to "green housekeeping." All these features combine to make Building Q a good example of energy efficiency and sustainability.

"Our senior management saw that creating a green lab would be consistent with our reputation as a responsible corporate citizen, and that it made good business sense." Steven Shultz, former Sustainability and Energy Manager, Pharmacia

Project Description

Building Q is a four-story, 176,000 gross ft^2 (106,900 net ft^2) discovery chemistry laboratory designed and built for Pharmacia Corporation, a global pharmaceutical company. The building was designed specifically for chemistry research. It is also the cornerstone of Pharmacia's redeveloped research campus in Skokie.

The building is a safe, adaptable, and competitive workplace in which to expand Pharmacia's ability to support the development of new products. Scientists focus on research in metabolism, toxicology, medicinal chemistry, and genomics. The company's research is targeted to meeting pharmaceutical and medical needs in the treatment of arthritis and cardiovascular diseases.

The architect was Flad and Associates of Madison, Wisconsin. Affiliated Engineers, Inc., were the mechanical and electrical engineers and lighting designers, and the Weidt Group provided energy and daylighting consulting. Wind tunnel testing was performed by RWDI of Guelph, Ontario, Canada. Turner Construction Company of Chicago was the builder, and the project delivery method was design-bid-build. The construction cost was $58 million ($329/gross ft^2), and the total project cost was $78 million. The building was completed in September 2000; it took 15 months to design and 24 months to build. E Cube, Inc., of Chicago and Boulder, Colorado, was the commissioning agent.

The facility can accommodate 280 research scientists at full capacity. It provides more than 54,000 net ft^2 of laboratory space and includes a nuclear magnetic resonance (NMR) suite. See Table 1 for a breakdown of the space in the building.

Layout and Design

Building Q is a major circulation link for the entire Pharmacia campus in Skokie. It is directly connected to the parking garage and the company's main administration building, so it was very important to integrate the facility efficiently into the site.

The building's four-story caisson/grade beam-steel structure features a skin of architectural precast concrete and glass. Pharmacia values the interaction of the staff, so laboratories are grouped together in "neighborhoods" on each floor, and all staff members are in open-plan workstations. Each laboratory neighborhood has its own color scheme, and each neighborhood uses an adjacent neighborhood's main color as a coordinating color. The goal of the color schemes and the design as a whole is to create interior public spaces that suggest a park or an urban streetscape rather than a laboratory building.

For privacy, designers also included two 10-ft x 12-ft private rooms in each neighborhood. These rooms can

Table 1. Pharmacia Building Q Space Breakdown

(Net ft^2, unless otherwise noted)

Function	Size (net ft^2)	Percentage (1)
Labs (BL-1 and BL-2)	52,110	49%
NMR suite	2,460	2%
Offices	19,510	20%
Conference center (plus conference rooms)	4,075	4%
Breakout space, shipping and receiving, miscellaneous	28,745	18%
Total net ft^2	106,900	100%
Other (2)	70,000	
Total gross ft^2	176,002	

Notes:

1. The percentage is the breakdown of net square feet (net ft^2) only. Net ft^2 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 ratio is 0.607.

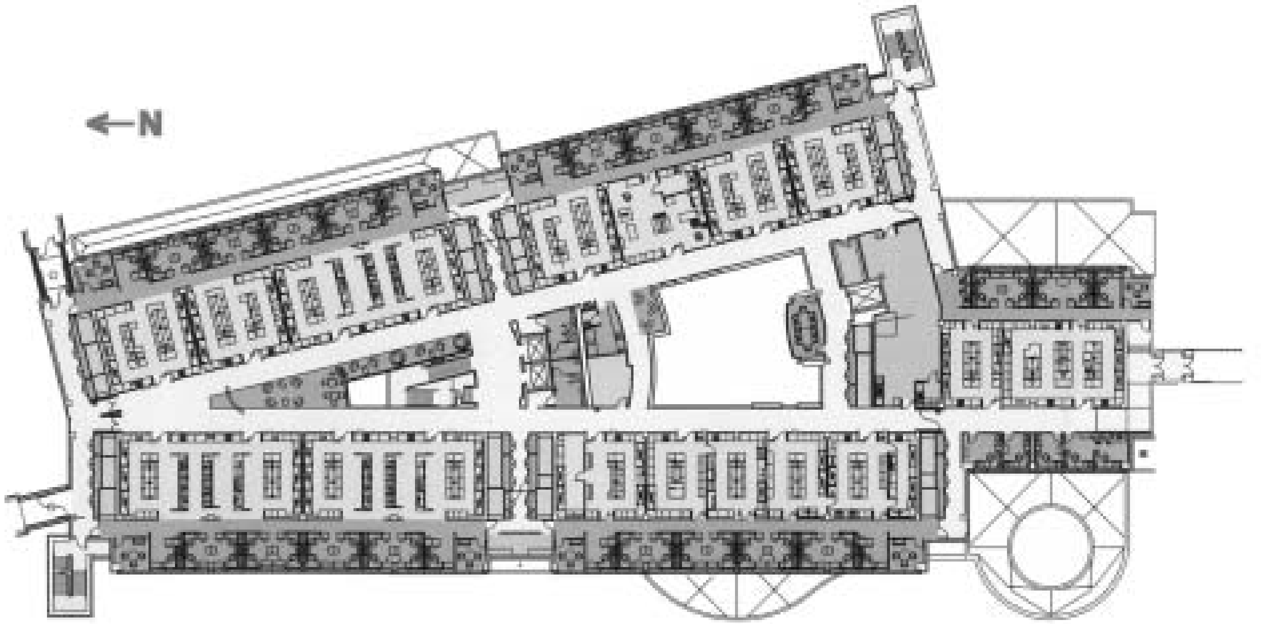

Figure 1. Floor plan of the building (Courtesy of Flad & Associates, Architect).

be used for team meetings, for discussions between supervisors and employees, and by visiting scientists. Glass-lined laboratories are located next to atria to take advantage of the natural light drawn into the interior. Offices are open and adjacent to the less hazardous laboratories in each neighborhood along the building's perimeter, which also allows light to flow in through exterior windows. The floor plan is shown in Figure 1, and the building section is shown in Figure 2.

The first floor is 20 ft in height, floor-to-floor, to accommodate the chemical science/synthesis lab, which contains tall reactors needing high ceilings. The NMR lab, also on the first floor, houses two 750 MHz NMR units; it was designed to accommodate a 900 MHz unit. Smaller shared and open-access NMR units are located on the second and third floors. The second, third, and fourth floors are 16 ft high, floor-to-floor; they house discovery chemistry, chemical science, biology, hydrogenation, genomics, and analytical laboratories.

The as-built facility contains 200 fume hoods and 19 biologic safety cabinets. It was designed to accommodate a maximum of five fume hoods in each lab, or 305 total hoods. The building has both Biosafety Level 1 (BL-1) and BL-2 laboratories. BL-1 labs are appropriate for working with microorganisms that are not known to cause disease in healthy humans. BL-2 labs are suitable for work involving agents of moderate potential hazard to people and the environment.

Utility Servicing

A corridor running perpendicular to the building's long axis serves as the main circulation spine that connects all four lab units in a neighborhood; each neighborhood can accommodate up to 20 people. Each neighborhood is served from two sides by a vertical supply and exhaust system adjacent to the corridors. The supply and exhaust air is then distributed horizontally to the labs. Pipes and

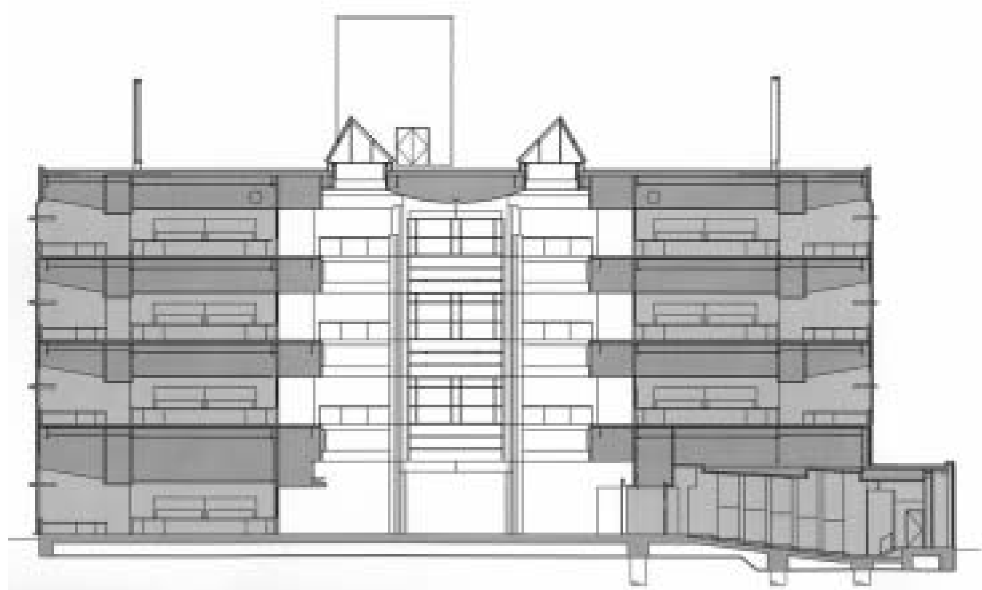

Figure 2. This building section shows the interior perimeter light shelves and the interior atria, which provide daylighting (Courtesy of Flad & Associates, Architect).

valves are accessible from the corridors between the neighborhoods.

The basic lab unit comprises three lab modules, each 28 ft long and 10 ft wide. Hoods are located on the perimeter of labs to minimize air turbulence caused by pedestrian traffic near the hood face. Utilities, power access, and data ports are run vertically to keep countertops clear.

Design Approach

From the outset, Pharmacia planned that Building Q would be a "green building" and would receive the U.S. Green Buildings Council's LEED certification. To accomplish this, the entire design team—including the architect, engineers, construction company, daylighting and energy consultant, and owners—began the project together by meeting to establish sustainable design goals. Pharmacia demonstrated its commitment to meeting these goals by supporting the managers of sustainability and energy and facilities engineering, who led the green lab building design activities.

Early in the design process, Pharmacia held a design charrette. A design charrette is an innovative brainstorming session allowing all the key stakeholders and project members to propose, discuss, and integrate design ideas. Facilitated by the Rocky Mountain Institute of Snowmass, Colorado, the design charrette generated many sustainable design ideas; 80 of the ideas were ultimately used in the project.

During the schematic design, the energy and daylighting consultant developed a simulated computer model, using the DOE-2.1 program, to serve as a reference point, or base case, against which to compare suggested energy efficiency strategies. The base case model was designed to meet the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) standard 90-1-1989, and the 1993 Illumination Engineering Society (IES) lighting standards. The computer modeling was used as a tool to refine the design and help the designers evaluate energy efficiency strategies on a life-cycle cost basis.

Based on the simulation, bundling many energy efficiency measures together into the design reduced energy consumption by an estimated 38% in comparison to a code-compliant reference case. Annual cost savings were originally estimated to be approximately $840,000; an evaluation of actual building operations in 2001 showed that actual electrical energy savings were even greater than predicted.

The Lightscape 3.0 program was used in the daylighting analysis. The program makes use of IES data for luminaires, sky, and sun—along with a rendering methodology called radiosity—to calculate an estimate of the amount of energy being dissipated and absorbed by surfaces in proposed 3-D models of the facility.

The design team made sure that none of the green design strategies would have a negative impact on functions, production, safety, and creativity within the facility. The team achieved all its objectives cost-effectively. Most sustainability measures and strategies that were implemented should pay for themselves in less than three years, except for the heat recovery system, which has a payback of five years.

Technologies Used

The measures chosen for the building include energy-efficient VAV fume hoods combined with a VAV supply and exhaust system, heat recovery, premium-efficiency motors for all mechanical equipment applications, and occupancy sensors for lighting and ventilation. Also chosen was spectrally selective glazing—glass that lets in light but less heat than standard glass—to provide daylighting. The conservation measures extended to water use, as well; designers specified water-saving fixtures that meet or exceed the plumbing fixture requirements of the Energy Policy Act (EPAct) of 1992. In addition, chillers and cooling towers were selected on the basis of lowest life-cycle costs. And all utilities are metered and submetered.

Many of the materials used in constructing Building Q were manufactured or fabricated for final assembly within a 300-mile radius of the campus. This practice reduced fossil fuel emissions into the environment from transporting the materials as well as transportation costs. Local materials were used for site-cast concrete work and accessories, sub-base materials, masonry, landscape stone, building insulation, steel wall panels, wood doors, composite metal panels, fireproofing, gypsum board, ceramic floor tile, some paint products, and metal lockers.

The building's steel frame is made of nearly 100% recycled steel. The wallboard is made from chemical or "synthetic" gypsum, which is a by-product of coal-burning power plants. Synthetic gypsum makes use of sulphur dioxide, a waste product from the exhaust of the power plants. Carpeting and ceiling tiles contain nearly 80% recycled materials. The carpeting supplier also stated it would pick up old carpeting and backing at the end of their useful life and take them back to the plant, where they will be broken down and turned into new carpeting and backing. The wood veneer on interior doors is from certified well-managed forests.

A storage warehouse was deconstructed to make room for Building Q, eliminating the need to break undeveloped ground. The stored equipment included dryers, pumps, drinking fountains, shelving, benches, and miscellaneous electrical and control equipment. In the deconstruction process, 75% of the demolition waste was diverted from landfills. And 75% of the materials stored in the warehouse were relocated for immediate use in Skokie and at other Pharmacia sites; the rest was stored elsewhere.

Heating, Ventilating, and Air Conditioning

Labs typically incorporate either heat recovery or VAV fume hoods as an energy-saving strategy, but they seldom have both in all but the most extreme climates. This is because the reduced amount of conditioned air supplied by the VAV system also reduces the effectiveness of the heat recovery system, and this adversely affects its benefit and payback. However, the building's design team determined early in the design phase that both technologies could be used in an integrated manner in Pharmacia's heating, ventilating, and air-conditioning (HVAC) system.

Heat recovery was economically justified by taking into account the credits from downsizing the heating and cooling systems. These included chillers, boilers, and boiler feed water on a central plan. In sizing the air-handling system, designers assumed that only four of five fume hoods would operate at the same time.

Building Q uses VAV fume hoods to reduce the building's heating and cooling costs by adjusting the amount of air exhausted from the open area of the fume hood sash. This in turn reduces the amount of conditioned air needed. The controls provide operating cost savings and help to maintain the correct pressurization for labs. Sensors monitor the sash position, calculate the open area, and adjust the airflow accordingly. If a sash is fully closed, the fume hood exhausts 340 cubic feet per minute (cfm) rather than 760 cfm. As noted earlier, occupancy sensors are used in ventilation as well as lighting. And chillers and cooling towers were selected because of their low life-cycle costs.

Heat recovery at Pharmacia is accomplished by using a glycol loop. When the outside air temperature is 34° or higher, Pharmacia is able to shut off the preheat coils in the HVAC system because the heat recovery system warms the air to 55°.

Daylighting and Lighting

One important environmental strategy was to bring natural light into the building. Its long axis is oriented north/south, which presents a challenge in terms of the building's ability to control direct-beam radiation. The perimeter windows use spectrally selective low-emissivity (low-E) glass (see Figure 3). Low-E glass allows visible light to permeate the building but filters the infrared rays that generate heat. The visible transmittance of the glazing is 0.55, and the shading coefficient is 0.37. Interior light shelves take light from the perimeter windows adjacent to open offices and bounce it across a transparent or "ghost" corridor to the labs in the building's interior. The walls are 11 ft high at the windows; these walls slope down to a height of 9 ft when they are a distance of 12 ft in from the perimeter windows. This allows more light from the perimeter windows into the building's interior.

The building was designed around two skylit atria (see Figure 4). The skylights in the atria use a passive solar optical system in combination with a refractive 3M Fresnel lens film technology. This technology evens out the light to eliminate hot spots and distribute the illumination downward. The skylights also use spectrally selective low-E glazing with the same properties as the perimeter windows.

The distance from the exterior wall of the building to the atria is 44 ft. Some laboratory areas are not separated from work stations on the perimeter. Where separation is necessary, glazed partitions provide an invisible physical barrier. Inside the building, windows between the labs and the atria allow natural light to penetrate the entire facility. These allow views to the outside from any point in the building. The use of natural light cuts energy

Figure 3. The perimeter windows contain low-E glazing, as do the special skylights.

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Figure 4. Skylit atria bring natural light into the building's four floors.

consumption by reducing the need for supplementary artificial lighting, and sensors shut off the artificial lights when work areas are not in use. The natural lighting also helps to enhance the comfort levels and productivity of employees.

Green Housekeeping

The design team realized that, even giving a great deal of attention to the selection of building materials and construction practices, the potential for poor indoor air quality (IAQ) remained if traditional cleaning chemicals were used in maintenance. Therefore, a cleaning supply company noted for its green line of cleaning products was brought in before the project was even completed. The result was a comprehensive, environmentally friendly cleaning program.

The products and procedures selected had no impact on costs. They involved cleaning agents that are nontoxic, phosphate-free, and biodegradable in approximately five days. They contain no ethers, alkalies, or distillates that are detrimental to IAQ. Although the designers originally intended to use the green product line only in Building Q, Pharmacia decided to implement the program throughout the Skokie campus.

Water Conservation

Using proven water efficiency measures, Pharmacia was able to reduce the facility's water use 52% below the baseline established in EPAct. The water efficiency measures include drift eliminators on the cooling towers, closed-loop process water for lab equipment cooling (rather than once-through tap water), infrared sensors on lavatory sinks, and flow restrictors on all lab and cup sinks in lieu of aspirators.

Commissioning Process

Pharmacia requested that a third-party commissioning agent prepare a full-service commissioning plan, per the General Services Administration's *Model Commissioning Plan & Guide Specifications*. Systems that were commissioned included HVAC, electrical, plumbing, lab piping, fire protection, life safety, and all lab systems. The commissioning plan also included the development of operation and maintenance manuals and training.

Measurement and Evaluation Approach

A measurement and verification (M&V) plan was developed by the commissioning agent in accordance with International Performance Measurement & Verification Protocol (IPMVP) Option A. Broadly, the plan called for establishing a systems performance baseline derived from the DOE-2 simulation model, analyzing the performance of energy conservation measures (ECMs) in comparison to the baseline, and verifying that the installed equipment meets expectations. Periodic measurements are to be made by the building's staff, who have completed the first year of data collection (see Table 2).

Building Metrics

Table 2 shows key design parameters, estimated annual energy use based on the key design parameters and actual energy use based on submetered data. Calculation procedures for the data in column 3, annual energy usage based on design parameters, are described in the footnotes.

Total electrical use in column 3 is higher than actual use because estimates are based on peak sizing. Some assumptions, listed in the footnotes, were made about hours of operation to make these estimates more reasonable. If these assumptions were not made, the estimates in column 3 would be much higher.

Column 4 shows submetered electrical energy data for 2001. Actual annual electrical energy use is 50% lower than estimated use taken from the design parameters.

Summary

Pharmacia Building Q has achieved a Gold LEED rating for its energy-efficient, green design. The building design process began with a design charrette, and a collaborative approach was taken from the very beginning. The building design process addressed many energy-saving measures, including energy-efficient VAV fume hoods, used in combination with a VAV supply and exhaust system; heat recovery; premium-efficiency motors for mechanical equipment applications; and extensive use of daylighting. Many other sustainability features, such as the use of recycled materials and an innovative "green housekeeping" plan, were also used in planning Building Q.

A comparison of actual electrical energy use to estimated energy use showed that the building performs much better than expected.

Acknowledgements

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Table 2. Pharmacia Building Q Metrics

System	Key Design Parameters	Annual Energy Usage (estimated based on design data)	Annual Energy Use (based on utility bills)
Ventilation (Sum of wattage of the supply and exhaust fans)	Supply = 1.08 W/cfm Exhaust = 0.94 W/cfm Total =1.01 W/cfm (1) 3.05 cfm/net ft^2 (6.0 cfm/net ft^2 of labs) (2)	32.7 kWh/gross ft^2 (29.7kWh/net ft^2) (3)	28.5 kWh/gross ft^2 (7)
Cooling plant	2250 tons 0.56 KW/ton	20.68 kWh/gross ft^2 (4)	5.3 kWh/gross ft^2 (7)
Lighting	1.6 W/net ft^2	4.5 kWh/gross ft^2 (5)	3.1 kWh/gross ft^2 (7)
Process/Plug	12 W/net ft^2	30.8 kWh/gross ft^2 (6)	7.0 kWh/gross ft^2 (7)
Heating Plant	27,000 MBH	Not available	Not available
Total		88.68 kWh/gross ft^2/yr (estimated based on design data for electricity only) 302.7 kBtu/gross ft^2/yr for electricity only	43.9 kWh/gross ft^2/yr for electricity only (150 kBtu/gross ft^2/yr for electricity only) $2.94/gross ft^2/yr for electricity only (2001)

Notes:

1. W/cfm for the supply/exhaust air handlers represents the fan brake horsepower (BHP) including belt drive losses (if applicable). W/cfm is 1.08 for supply and 0.94 for exhaust [(1.08 W/cfm + 0.94 W/cfm)/2 = 1.01 W/cfm)].
2. 3.05 cfm/net ft^2 (326,000 total cfm). Total cfm required for all labs = 326,000 cfm/ 54,570net ft^2 of labs and NMR. = 6.0 cfm/ net ft^2 of labs
3. 1.01 W/cfm x 1.85 cfm/gross ft^2 x 8760 hours x2/1000 = 32.7 kWh/gross ft^2 (29.7kWh/net ft^2). Note: this represents operating under peak conditions year round without accounting for savings from the VAV system.
4. 0.56 kW/ton x 2250 tons x 2890 hours/176,000 gross ft^2 = 20.68 kWh/gross ft^2 (assumes cooling runs 33% of the hours in a year, and that 80% of all equipment is operating 60% of the hours in a year).
5. 1.0 W/gross ft^2 x 4534 hours /1000 = kWh/gross ft^2 (1.6 W/net ft^2 x 0.6 = 1.0 W/gross ft^2) (assumes lights are on 87.2 hours\week).
6. 7.32 W/gross ft^2 x 0.80 x 5256 hours/1000 = 30.8 kWh/gross ft^2 (12/net ft^2 x 0.61 = 7.32 W/gross ft^2; assumes that 80% of all equipment is operating 60% of the hours in a year).
7. Based on submetering data provided by Pharmacia. Note that ventilation in column 3 is for fans only; in column 4, it is for fans and pumps.

Note: Estimated data are presented in site Btu (1 kWh = 3412 Btu). To convert to source Btu, multiply site Btu for electricity by 3. Skokie, Illinois (near Chicago), has approx. 6536 heating degree-days and 752 cooling degree-days).

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