India is one of the world’s top 10 energy consumers, and growth is expected around 6% annually over the next few years. However, Indian companies are working to cut energy consumption. The Spectral Services Consultants Corporate Office in Noida, India, achieves over 36% energy savings mainly by providing daylight to occupants throughout the day without gaining heat from the sun.
To accomplish the daylighting strategy, the building faces north-south, the optimal orientation for a building on the Indian subcontinent. Heavy glazing on the north and south façades brings natural light into the space. In addition, recessed windows with fins for shade cut down on direct solar heat gain on the west façade, which receives the most direct sunlight.

The wall to window ratio, optimized at 22.5%, maintains a balance between heat ingress and daylight harnessing. Windows are hermetically sealed low-e double glass with a 0.33 shading coefficient and 60% visible light transmissivity. External walls are made of 8 in. thick autoclaved aerated concrete blocks, backed by 25 mm closed cell rubber insulation. This results in a U-value of 0.077 Btu/

\[ h \cdot \text{ft}^2 \cdot \text{°F}. \]

Roof surfaces are provided with 3 in. thick extruded polystyrene, covered partly with glazed white tiles and high solar reflectance paint (78

**NOIDA, INDIA**

Noida is located towards the north of India and close to Delhi. The climate in the area has an average temperature of 110°F in the summer, 95°F during monsoon season and 40°F in the winter. In a year, 90% of days are bright and sunny.
Hitting Sunlight
Despite the hot and humid climate, the 16,000 ft², five-floor office building provides daylight at a 250–350 lux level throughout the day without gaining heat from the sun. More than 75% of the building’s interior is daylit, and 90% of occupants enjoy outside views. The building site and most parts of northern India receive more than 300 days of bright sunshine annually. On most working days, the sun provides sufficient light so that electric lighting is switched off during operation hours.

A large atrium extends over all floors of the building. A south-inclined (15 degrees to horizontal) skylight encompasses the entire atrium. Because the sun moves southward for the majority of the day, the skylight, also called the light catcher, plays an important role in daylight harnessing. To minimize heat from direct sunlight, the light catcher has permanently inclined louvers of dull aluminum metal. By blocking direct sunlight throughout the day, the louvers reduce air-conditioning loads and glare on workstation computers. The louvers’ angle was computer simulated to study year-round performance.

Night Lighting
In the evening, an advanced lighting management system automati-
Daylight Performance

A south-inclined skylight encompasses the entire atrium and harnesses daylight.

Indoor Air Quality

A high level of indoor air quality is maintained by monitoring indoor CO₂ levels and controlling the fresh air quantity injected into the space by modulating fresh air dampers. The fresh air quantity is 30% higher than recommended by ANSI/ASHRAE Standard 62.1-2004, Ventilation for Acceptable Indoor Air Quality. Recovering energy from the bathroom and atrium exhausts precools the fresh air. Electrostatic precipitators with MERV 13 efficiency combined with prefilter with MERV 6 efficiency on all air-handling units ensure a dust-free indoor environment.

The air-conditioning system, besides providing a dust-free environment to occupants, closely controls indoor temperature and relative humidity levels. Each air-handling unit in the building is provided with an ultrasonic humidifier and electrical heater installed within the supply air duct. The building’s management system runs the entire operation, maintaining indoor temperature and relative humidity between 23°C and 25°C and 40% to 60% respectively. In addition, all air-handling units can execute a complete air-side economizer cycle for free cooling of the indoors during fair weather.

Fire Safety

Even though the constructed area of the building is small, it provides a fire-safe environment to occupants. An intelligent, addressable fire alarm system and water-based fire-fighting system ensure a high level of fire safety, exceeding the norms of India’s national building code.

Reusing Materials

During construction, 96.6% of the building waste was collected and diverted to authorized disposal agencies. To reuse resources, furniture from Spectral’s old offices was remodeled and used in the building. A small amount of Forest Steward Council certified wood was used for the executive floor furniture. Lastly, 2.5% of the building material, like bamboo flooring, is from naturally renewable resources, and 7.7% is reused or salvaged material.

Energy Use

With energy-efficient features, such as north-south building orientation, insulated envelope, low-e double glass and reduced lighting needs, the peak air-conditioning load for the building is 50 tons of refrigeration. This is approximately half the load of a similar office in New Delhi, India. The average year-round load for the Spectral Office hovers around 35–40 tons of refrigeration. The installed air-conditioning plant consists of 72 tons of refrigeration, high COP water-cooled screw chilling machine with twin compressors, variable speed chilled water pumping system, cooling tower with variable frequency drive, air-handling units on all floors coupled to variable frequency drive, and internal air distribution through variable air volume boxes.

The baseline yearly electrical energy demand for the building, per ANSI/ASHRAE/IESNA Standard 90.1-2004, Energy Standard for Buildings Except Low-Rise Residential Buildings, is 394,196 kWh (25 kWh/ft² per year) and the predicted actual annual energy demand for the building is 242,086 kWh (15 kWh/ft² per year). The building achieves 38.6% electrical energy savings over the Standard 90.1 base building. Actual performance is even better, as seen in the energy table. The average monthly energy bill is $2,500. This is less than half of the bill at Spectral’s previous offices, which were well-designed conventional buildings.

### Energy Use

<table>
<thead>
<tr>
<th>Month</th>
<th>Modeled Energy Use</th>
<th>Actual Energy Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>September 2007</td>
<td>22,610</td>
<td>17,492</td>
</tr>
<tr>
<td>October 2007</td>
<td>20,282</td>
<td>14,243</td>
</tr>
<tr>
<td>November 2007</td>
<td>17,460</td>
<td>10,399</td>
</tr>
<tr>
<td>December 2007</td>
<td>17,392</td>
<td>8,386</td>
</tr>
<tr>
<td>January 2008</td>
<td>17,544</td>
<td>4,490</td>
</tr>
<tr>
<td>February 2008</td>
<td>15,345</td>
<td>15,501</td>
</tr>
<tr>
<td>March 2008</td>
<td>18,509</td>
<td>16,724</td>
</tr>
<tr>
<td>April 2008</td>
<td>19,715</td>
<td>21,332</td>
</tr>
<tr>
<td>May 2008</td>
<td>22,751</td>
<td>20,473</td>
</tr>
</tbody>
</table>

Table readings were obtained from the building management system and compiled by an independent thermography commissioning agent.

A model was used to estimate daylight performance. The illumination for the space was calculated using the clear sky conditions at noon on the equinox (March 21).
Building Management System

The services systems operations are coordinated through a Web-based advanced building management system. Only two operation staff members are employed to handle day to day tasks. The operation parameters can be accessed from any of the 150 workstations in the building and provide feedback to occupants. The feedback has been useful in upgrading the HVAC system for winter heating. At ambient temperatures below 24°C (75°F), the building operated in free-cooling mode with a 100% open fresh air and exhaust air damper at all air-handling units. These have been corrected for the winter heating mode operation by energizing the heating coils at ambient temperatures below 20°C.

Payback

Prior to construction of the building, analysis of the total construction cost was carried out to determine the anticipated additional impact due to incorporation of energy-efficient measures such as the high-efficiency chiller, energy conservation strategies for air-handling units, lighting controls, low-e double glass, wall insulation and the sewage treatment plant. The cost of the green building was $1.1 million, approximately 8% above a similar conventional building. The energy simulation predicted a payback period of less than four years. With rising energy costs and anticipated greater energy savings than predicted, the payback period may be reduced to three years.
Although India is one of the world’s top 10 energy consumers, the country is taking measures to increase energy efficiency. According to The Times of India, industry professionals expect the number of green building projects in India to increase from the current 164 to more than 2,000 by 2012. As a role model for future developments, the Spectral Office contributes to this growing sustainable trend.

Overcoming Climate Careful building orientation, optimum window sizing, low-e double glass and envelope insulation demonstrate that, even in the hot and dry climate of northern India, careful design can minimize heat ingress.

Design Discipline It is surprisingly easy to save large amounts of energy and water by imposing discipline on the whole design and build team and by holding regular design coordination meetings with a clear mandate on achieving targets. The design team met regularly to discuss the challenges posed in sustainable construction which spawned new ideas and ensured better coordination of the design elements. For example, ideas for extensive use of waste, such as broken china mosaic tiles on the roof and construction debris as the sub-base for the flooring, originated from these meetings.

Occupant Feedback Employees enjoy the building’s indoor air quality and daylight. Although the building is closely connected to the community with residential and commercial areas near one another, individuals often choose to stay in the building during their lunch break. When compared to previous office situations, employee absenteeism has dropped, and productivity has increased.

Finding Local Sources Obtaining sustainable building materials from local sources was problematic. The building team had to hunt for vendors for bamboo flooring, low Voc paints, low flow fixtures and material made of recycled components.