The EcoCommercial Building is part of the Bayer Climate Program, which seeks to reduce the company’s greenhouse gas emissions, and improve energy and resource efficiency. Part of this effort involves designing and constructing net zero energy buildings around the world. So, the building, which became India’s first net zero energy building, was conceived by Bayer as a prototype with plans to build several such buildings to establish new benchmarks for future sustainable developments.

Project teams discussed and brainstormed ideas from conception as part of an integrated project delivery approach. Some of the project’s highlights include:

• A 40% reduction in energy use (compared with the ASHRAE/IESNA Standard 90.1-2004 baseline) through high performance envelope insulation, improved protection against sunlight via high performance double glazed windows with integrated motorized blinds, and the use of energy-saving technologies associated with the electrical power supply system/building management system;

• Emission-free, on-site energy generation through the use of a 57 kW photovoltaic system;

• Chilled beams for radiant cooling that eliminate fan energy; and

• A zero water discharge system that recycles and treats all sewage that is generated on site. The sewage treatment plant is compact, odor-free and uses a sequential batch reactor system to provide high efficiency aerobic treatment. The treated effluent is used for makeup in cooling towers and flushing.

Environmental Footprint:
The EcoCommercial Building achieved its net zero energy objective by targeting the following parameters that optimize its air-conditioning load and environmental footprint:

• Efficient building envelope design;

• Climatically responsive façade concepts, including a roof that extends beyond all four sides of the building, protecting it from direct sun and reducing heat gain;

• Efficient glazing balancing low thermal conductivity and shading coefficient;

• Thermal mass and insulation materials;

• Lighting and daylighting controls;

• Energy recovery opportunities;

• HVAC system equipment selection at highest full-load and part-load efficiency points; and

• Commissioning.

Table 1 depicts the 2011 actual annual energy consumption and amount of carbon emitted. When compared to the Standard 90.1-2004’s calibrated baseline, this translates into CO₂ emission reduction of approximately 40 tons. The building’s actual on-site electricity generation for 2011 was 72,023 kWh, which is 8,113 kWh over the 63,910 kWh consumed that year, resulting in net zero energy status.

Design Condition Analysis:
A year-round air-conditioning load profile was created using ASHRAE data file-Weather Data and Design Conditions (W eDCo) to size equipment. A conventional building may be designed for peak ambient conditions, but in this project’s system design, annual building
The envelope design minimizes the energy demand and operating power. It also reduced the size and cost of the HVAC system needed to maintain adequate building pressurization, good indoor air quality and a comfortable thermal environment for building occupants.

**Lighting**

Since the EcoCommercial Building is a day-use building, daylighting is maximized in all occupied spaces. Simulation software was used to evaluate the impact of various shading devices to minimize glare indoors. The main objective of simulation was to ensure that the use of blinds/curtains on windows not compromise occupants’ visual comfort. Integrated motorized blinds are achieving these goals, and no problems have been reported regarding their operation. An energy-efficient lighting system with daylighting controls provides additional light when daylighting is not sufficient.
**Defining Daylight Factor**

Daylight Factor (DF) is a ratio of internal light level to ambient light level and is defined as \(DF = \frac{E_i}{E_o} \times 100\), where \(E_i\) is illumination due to daylight at a point on the indoor working plane and \(E_o\) is simultaneous outdoor illumination on the horizontal plane from an unobstructed hemisphere of overcast sky.

**Energy-Efficient Lighting Fixtures**

Energy-efficient lighting fixtures with daylight controls contribute to the building’s low energy use. Window integrated motorized blinds minimize glare while maximizing daylighting.

Energy-efficient fixtures and ballasts contribute to a 37% reduction in lighting energy compared to Standard 90.1-2004. Other benefits include enhanced lighting quality and productive work environment. Lighting equipment selection sought to balance the design requirements and limit the number of fixture types and lamp selection in order to have reasonable inventories.

The building uses a combination of energy-efficient T5 linear fluorescent and compact fluorescent lamps, which have good color rendering properties and long life and are readily available, easily controllable and affordable. Excessive and fatigue due to excessive lighting levels are reduced by high frequency electronic ballasts linked to daylight sensors.

Occupancy sensors in normally unoccupied areas like storage areas, toilets and mechanical rooms minimize lighting use. Lighting controls ensure minimum internal heat gain and reduced air-conditioning load in those spaces.

Approximately 87% of total regularly occupied spaces in the building have a minimum daylight factor of 2%. A lighting power density (LPD) of 7.2 W/m² (0.67 W/ft²) in all occupied spaces is significantly lower than the Standard 90.1-2004 baseline of 11.8 W/m² (1.1 W/ft²).

**Energy Modeling**

It is a conventional practice to compute air-conditioning loads using peak ambient conditions that occur 0.4% or 1% of the year. This leads to oversized equipment selection, which introduces inefficiency in the system due to part-load operation most of the year. For the EcoCommercial Building, computer simulation tools were used to create a year-round AC load profile that helped improve understanding of operating conditions.

Building thermal performance calculations were made for two primary reasons: to size and select mechanical equipment and to predict the performance of each component that contributes to heat gain in the space. After several iterations, the calculations resulted in a final breakdown of space sensible and latent loads.

The careful planning of passive and active design features resulted in a total diversified AC load of 84 kW for 891 m² (24 tons for 9,600 ft²). The project achieved 37.5 kW²/m² (1,401 btu/ft²) for the overall built-up area and 20 m²/kW (1060 btu/h/ft²) for the conditioned spaces. Further comparison is made with Standard 90.1-2004 (for calibrated baseline case) to study the benefit of each strategy (2011 Actual Energy Use vs. Calibrated Baseline).

**DOAS and DCV**

DOAS is a design strategy, the room sensible and latent heat gains were computed separately. A dedicated outdoor air system (DOAS) was selected for the project that accommodated the building’s entire latent loads.

Dry outdoor ventilation air is supplied through an externally mounted unit that dehumidifies the air before it is supplied to occupied space. This dry outdoor air acts as primary air to the chilled beams.

A design ventilation rate of 30% additional outdoor air over ASHRAE Standard 62.1-2004 enhances the indoor air quality within the building and provides occupant comfort. The air quality is monitored inside the entire building with help of CO₂ sensors located 1.5 m (6 ft) above the floor level in various spaces. These sensors provide an audible alarm to the operator when the difference between outdoor and indoor CO₂ levels exceeds 530 ppm. The DOAS system starts at 7 a.m. to remove moisture that builds up during unoccupied hours and brings down the temperature to desired level before office start-up.

The DOAS provides heat recovery from the building’s exhaust. Dehumidified cold exhaust air from the bathrooms and office space is collected in each service core. This air enters one side of the rotating heat wheel, chilling the wheel and drying the desiccant coating.

This cool and dry part of the wheel then rotates into the outdoor airstream where it absorbs heat and gains humidity from the incoming ventilation air before it is cooled to room temperature in the air-handling unit (AHU) room. The energy recovery wheel reduces the ventilation AC load by 80%, minimizing operating energy and the size of air-conditioning equipment. Dedicated floor-mounted AHUs are located on the ground floor and the first floor.

**Chilled Beams**

Chilled beams provide cooling and offer several advantages, including reduced operation costs due to savings in AHU fan energy and simultaneous reduction in chiller energy. The beams receive incoming chilled water at 15°C (59°F) rather than at the conventional 7°C (45°F).

Based on indoor design conditions of 24°C (75°F) and 55% relative humidity, the room dew-point temperature is 14°C (57°F) and chilled water is supplied at a temperature 1°C (0.6°F) higher (at 15°C [59°F]) to avoid any condensation on

**Water at a Glance**

Annual Water Use: 96,240 gallons

**Energy at a Glance**

Annual Energy Use Intensity (EUI) (Site): 22.73 kBtu/ft²

Electricity (From Grid): 2.15 kBtu/ft²

Renewable Energy: 20.57 kBtu/ft²

Annual Source Energy: 63 kBtu/ft²

Annual Energy Cost Index (ECI): $0.059/ft²

Annual On-Site Renewable Energy Exported: 5.02 kBtu/ft²

Annual Net Energy Use Intensity: –2.86 kBtu/ft²

Savings vs. Standard 90.1-2004: Design Building: 40%

Heating Degree Days (base 65°F): 848

Cooling Degree Days (base 65°F): 5,091

Average Operating Hours per Week: 40
surfaces. In addition, dry fresh air is injected into chilled beams (after passing through the DOAS), enhancing the sensible load handling capability and minimizing the number of beams inside.

Double entry doors with an air lock help prevent hot humid outdoor air from entering the building. Additionally, a drip tray is provided for beams in the reception area to minimize the possibility of condensation.

Construction phase commissioning to ensure the proper implementation of mechanical and electrical systems.

Acceptance phase commissioning, which required contractors to demonstrate the operation of the equipment as per design intent.

Occupancy phase commissioning, which focused on proper operation of the systems by the operation and maintenance (O&M) staff.

Ongoing commissioning, which will be done at a later stage to periodically verify operational methods and equipment performance.

Energy meters monitor equipment performance and continuously log data. This data is compared with the baseline data to determine the savings.

The monthly consumption of the whole building and the individual

<table>
<thead>
<tr>
<th>TABLE 3 2011 ENERGY PRODUCTION, USE (KWH)</th>
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<td>Jan</td>
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<tr>
<td>PV Production</td>
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<td>Building Consumption</td>
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<td>Equipment</td>
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<td>Monthly Net Energy Production/Use</td>
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Note: Equipment includes laptops, printers, copiers, coffee maker, refrigerator, etc.
NZEBS AND INDIA’S FUTURE BUILDING GROWTH

Buildings account for 33% of the total electricity consumption in India. An estimated 70% of the building stock required for 2030 has not yet been built. This formidable growth in the construction industry and the resulting energy demand is predicted to increase dependence on imported fuel, contribute to higher greenhouse gas emissions, and strain the country’s fossil fuel-dependent infrastructure. While implementing minimum energy performance standards for buildings will contribute toward checking the increasing energy demand, net zero energy goals are needed for energy security. The U.S. Agency for International Development (USAID) launched a five-year program in July 2012 in partnership with India’s Ministry of Power and the Ministry of New and Renewable Energy that aims to accelerate India’s transition to a high performing, low emissions and energy secure economy.

In the building sector, the program involves promoting energy efficiency and net zero energy goals. Activities include technical resource development, capacity building, demonstration projects, Energy Conservation Building Code (ECBC) implementation support and updating the ECBC 2007 with provision for NZEB components.

The EcoCommercial Building is one of only a few net zero energy buildings in India. While initial project costs were significantly higher than typical commercial construction costs, the investment is providing reduced operating expenses for the long term.

The commissioning team did not identify any aspects of the project that needed improvement. This project’s innovative design and its high performance that meets design goals demonstrate the effectiveness of integrated project delivery.

Solar PV

The project’s 57 kW crystalline silicon grid-connected solar system is expected to generate 38.9 MWh/year. It produced 72 MWh during 2011 due to mutual shading of the panels in a few locations, but still exceeded the building’s consumption. The excess energy is fed into the existing adjacent building within the campus.

Other Sustainable Features

Site Selection. The EcoCommercial Building is a part of Bayer’s factory campus located in an industrial park. The site is supported by well-connected public transportation. Bayer also provides buses to transport employees to various parts of Delhi and its satellite cities.

Water. Rainwater harvesting pits 3 m (10 ft) in diameter and 5 m (16 ft) deep are located in all four corners of the ECB site and have a total volume of 141 321 L (37,333 gallons). The rainwater is primarily used to recharge the underground aquifer. Storm water pipes empty into 500 mm × 450 mm (20 in. × 18 in.) water retention tanks/catch basins, and overflow passes through oil and silt traps before reaching the rainwater harvesting pits. The additional overflow water from the harvesting pits is discharged in the municipal drain. In addition to the on-site sewage treatment system, which recycles the building’s wastewater, low-flow plumbing fixtures help reduce water use.

Landscaping. Native and indigenous species were selected for landscaping, eliminating the need for regular irrigation. To help establish the new landscaping, plants were watered twice a day for the first two years.

Material Selection. The building team placed a priority on regional building materials with recycled content. The team also selected low-VOC paints, sealants, coatings and adhesives whenever possible.

Conclusion

The EcoCommercial Building exceeds the existing standards for high performance buildings and ensures that a building can deliver back to the climate rather than exploiting resources. It illustrates the potential energy savings that can be achieved via early collaboration to design an efficient building envelope and building systems.

ABOUT THE AUTHOR
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