On first glance, the building lacks the drama of better-known green buildings, such as the nearby Vanke Headquarters, a much-publicized LEED Platinum building designed by architect Steven Holl. But on closer inspection, it reveals carefully designed features including:

• More than 40 sustainable technologies that were incorporated into a low-cost, low-energy building through the use of integrated design principles;

• Daylighting and natural ventilation, which greatly reduced the energy loads for air conditioning and lighting, typically the highest drivers of energy consumption in an office building;

• Work spaces that are built to emphasize communication and a people-friendly environment, which have resulted in high levels of occupant satisfaction; and

• An integration of nature with the workplace, which provides an environment that is stimulating and restorative. Innovations include landscaped areas, such as the “sky gardens” (see sidebar “Garden in the Sky”) and elevations that are designed to capture the benefits of wind and sun.

Cost and Energy Savings

The construction cost of the building, at $689/m2 ($66/ft²), is lower than the average new commercial structures in Shenzhen. Elements that contributed to construction savings included the integrated design for energy loads for air conditioning and lighting, typically the highest drivers of energy consumption in an office building;

• Work spaces that are built to emphasize communication and a people-friendly environment, which have resulted in high levels of occupant satisfaction; and

• An integration of nature with the workplace, which provides an environment that is stimulating and restorative. Innovations include landscaped areas, such as the “sky gardens” (see sidebar “Garden in the Sky”) and elevations that are designed to capture the benefits of wind and sun.

Cost and Energy Savings

The construction cost of the building, at $689/m2 ($66/ft²), is lower than the average new commercial structures in Shenzhen. Elements that contributed to construction savings included the integrated design for energy loads for air conditioning and lighting, typically the highest drivers of energy consumption in an office building;

• Work spaces that are built to emphasize communication and a people-friendly environment, which have resulted in high levels of occupant satisfaction; and

• An integration of nature with the workplace, which provides an environment that is stimulating and restorative. Innovations include landscaped areas, such as the “sky gardens” (see sidebar “Garden in the Sky”) and elevations that are designed to capture the benefits of wind and sun.
left: Windows are designed for natural ventilation, with horizontally pivoted win-
dows to direct the air flow above the work
surfaces. Unlike in other areas of China, Shenzhen’s coastal location provides rela-
tively good air quality, allowing for natural
ventilation much of the year.
Top left: Overhangs shade the south-facing
glass, and deeper walkways and vegetation
provide shade on the east elevation.
Above: The building elevations are designed
to capture the predominant winds from the
east and be shaded on the west.

**ENERGY AT A GLANCE**

<table>
<thead>
<tr>
<th></th>
<th>Annual Energy Use Intensity (EUI) [Site]</th>
<th>Annual Net Energy Use Intensity 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20.6 kBtu/ft²</td>
<td>2.1 kBtu/ft²</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>2.1 kBtu/ft²</td>
<td>1.2 kBtu/ft²</td>
</tr>
<tr>
<td>Electricity (From Grid)</td>
<td>17.3 kBtu/ft²</td>
<td></td>
</tr>
<tr>
<td>Renewable Energy</td>
<td>1.2 kBtu/ft²</td>
<td></td>
</tr>
<tr>
<td></td>
<td>19.4 kBtu/ft²</td>
<td>3.950</td>
</tr>
</tbody>
</table>

**WATER AT A GLANCE**

|                        | Annual Water Use (GSIS) | 2,978,448 gallons per year | 40% is collected rainwater |

**Land:** A vertical landscape distrib-
uted throughout the building dou-
bles the area available for greener-
y compared to the building’s original
footprint. The roof garden, “sky
garden,” and patio garden all help
restore the ecological balance of the
building site; and

**Water:** A 43% savings in water con-
sumption, compared to that of simili-
larly sized conventional buildings in
Shenzhen, is achieved through use of
storm water collection and reclamed
water.

The building’s structural design
also helped reduce construction
Costs. Most commercial buildings
in Shenzhen use pile foundations, a
Cost associated with conventional
buildings, which rely on AC and elec-
tric lighting throughout. The build-
ing’s resulting annual electricity cost
savings total approximately 700,000
yuan ($105,000) compared to an aver-
age similar building in the region.

**Wind:** Natural ventilation in all the
Office spaces allows for direct con-
tact with nature, and uses 30% less
air conditioning;

**Light:** Daylight for all the office
spaces means no artificial lighting is
needed during the day and provides
views of the surrounding mountains
from all of the workstations;

**KEY SUSTAINABLE FEATURES**

**Water Conservation:** Rainwater collec-
tion, water-saving appliances, recycled
water used for toilet flushing and
dishwashing.

**Materials:** Concrete with high-percent
recycled material, wood products with
10% recycled materials. Construction
materials sorted and collected for recy-
cling. Use of local and native materials.
Low-emission interior finishes.

**Design**

The design team envisioned the proj-
cect as “a green experiment.” As the
architect and the client for the proj-
ect, the team could expand its green
agenda beyond what its counterparts
were doing in China and elsewhere.
The team reviewed over 100 sus-
tainable technologies and strate-
gies, and incorporated more than
40 of them, including daylighting;
Natural ventilation; graywater recy-
cling; solar energy generation; and
efficient HVAC systems. The 12-storey
18,000 m² (193,750 ft²) building was
designed during 2006 and 2007.
Construction was completed in March
2009.
The design team considered sev-
eral other green design features
that did not make it into the final
design because of cost. These
included adjustable exterior shades
of light and increased operational
hours in the building.

The design team also examined the
site and team’s experience working
in other comparable Shenzhen
buildings, which rely on AC and elec-
tric lighting through the whole year.
The building’s resulting annual elec-
tricity cost savings total approx-
imately 700,000 yuan ($105,000)
(compared to an average similar
building in the region).

The sixth floor “Garden in the Sky” is
used frequently for formal and informal
meetings and events.

**GARDEN IN THE SKY**

The “Garden in the Sky,” located on
the sixth floor, is an open green space
with an artificial wetland and lush
vegetation planted throughout the
space, providing a dedicated area for
outdoor meetings. The garden’s
resulting annual electricity cost
savings total approximately 700,000
yuan ($105,000) compared to an aver-
age building in the region.

In addition, the building is
designed to take advantage of
natural ventilation and daylighting,
which are not commonly found in
other comparable Shenzhen
buildings.

The building is the result of the
design team’s belief that coexis-
ting with nature is one of the impor-
tant features of green buildings.

**Sustainable Strategies**

The design team started with
the natural ventilation and daylit-
ing strategies, which were
the team’s key priorities.

The team reviewed over 100 sus-

tainable technologies and strate-
gies, and incorporated more than
40 of them, including daylighting;
Natural ventilation; graywater recy-
cling; solar energy generation; and
efficient HVAC systems. The 12-
story 18,000 m² (193,750 ft²) building was
designed during 2006 and 2007.
Construction was completed in March
2009.
The design team considered sev-
eral other green design features
that did not make it into the final
design because of cost. These
included adjustable exterior shades

of light and increased operational
hours in the building.

The design team also examined the
site and team’s experience working
in other comparable Shenzhen
buildings, which rely on AC and elec-
tric lighting through the whole year.
The building’s resulting annual elec-
tricity cost savings total approx-
imately 700,000 yuan ($105,000)
(compared to an average similar
building in the region).

The sixth floor “Garden in the Sky” is
used frequently for formal and informal
meetings and events.

**GARDEN IN THE SKY**

The “Garden in the Sky,” located on
the sixth floor, is an open green space
with an artificial wetland and lush
vegetation planted throughout the
space, providing a dedicated area for
outdoor meetings. The garden’s
resulting annual electricity cost
savings total approximately 700,000
yuan ($105,000) compared to an aver-
age building in the region.

In addition, the building is
designed to take advantage of
natural ventilation and daylighting,
which are not commonly found in
other comparable Shenzhen
buildings.

**Sustainable Strategies**

The design team started with
the natural ventilation and daylit-
ing strategies, which were
the team’s key priorities.

The team reviewed over 100 sus-

tainable technologies and strate-
gies, and incorporated more than
40 of them, including daylighting;
Natural ventilation; graywater recy-
cling; solar energy generation; and
efficient HVAC systems. The 12-
story 18,000 m² (193,750 ft²) building was
designed during 2006 and 2007.
Construction was completed in March
2009.
The design team considered sev-
eral other green design features
that did not make it into the final
design because of cost. These
included adjustable exterior shades

of light and increased operational
hours in the building.

The design team also examined the
site and team’s experience working
in other comparable Shenzhen
buildings, which rely on AC and elec-
tric lighting through the whole year.
The building’s resulting annual elec-
tricity cost savings total approx-
imately 700,000 yuan ($105,000)
(compared to an average similar
building in the region).

The sixth floor “Garden in the Sky” is
used frequently for formal and informal
meetings and events.
windows to ensure optimal natural ventilation that directs airflow above the work surfaces. Unlike in other areas of China, Shenzhen’s coastal location provides relatively good air quality, allowing for natural ventilation much of the year. Offices with operable windows are located on the upper floors above street-level air and noise pollution.

COMFORT CONDITIONS AND OCCUPANT SATISFACTION

Maintaining comfort conditions is an important consideration for any work environment. This building is unusual in that it allows for natural ventilation for much of the year. Workers also augment the natural ventilation with desk fans and floor fans located near the perimeter window wall.

Unlike in other areas of China, Shenzhen’s coastal location provides relatively good air quality, allowing for natural ventilation much of the year. Offices with operable windows are located on the upper floors above street-level air and noise pollution.

To further analyze thermal comfort, especially focusing on natural ventilation performance, data from the tenth floor’s indoor temperature was compared with the outdoor air temperature. During 2011, the building’s indoor thermal conditions met ASHRAE Standard 55-2010 comfort conditions. The majority of conditions are within 90% acceptability range, and only a few conditions lie between 80% and 90% acceptability limits.

Like most open-plan office buildings, the highest dissatisfaction is with the acoustic environment. While two-thirds (67%) of the staff are satisfied with the noise level in their work space, 15% find it too noisy, and a surprising 18% find it too quiet. The lighting environment has high acceptability (79%), with 15% of the staff finding it too dark, and 6% finding it too bright. The staff survey responses are not connected to the staff members’ location in the building, so it is not possible to correlate their perceptions and their location relative to the window wall.

The indoor air quality and indoor humidity were also viewed as acceptable. Only 4% perceived the indoor air quality as “polluted,” which presumably had a detectable odor. Most of the occupants (75%) found the indoor humidity to be comfortable, with 10% finding it too humid and 15% finding it too dry. These findings supported the earlier surveys that reported similar levels of satisfaction, both overall and for these specific areas.

On a daily basis, approximately 400 people work in the building. The average age of the staff is 32 years old.

The building has several dedicated monitoring stations for local weather data. The IBR Headquarters Building collects energy data for several office buildings in downtow Shenzhen.
The Institute of Building Research Vision

The Shenzhen Institute of Building Research was founded in 1982 as a comprehensive science and technology research institute focused on the built environment. IBR today provides services for the whole life cycle of buildings and low carbon urban development. Its responsibilities include research and consultation; urban and rural planning; design; project quality inspection; materials and indoor environment testing; project management; and the dissemination of information about building research.

THE INSTITUTE OF BUILDING RESEARCH VISION

By organizing portions of the building (such as lab areas and office areas) into various blocks and stacking them, the architects were able to create a 12-story outdoor atrium on the east side that captures southeasterly breezes and brings daylight deep inside. Photovoltaic panels covering the atrium provide clean energy — part of China’s first state-level renewable energy demonstration project.

The first floor is the open lobby. The second and third floors are green technology exhibition halls. The fourth floor has testing labs for green materials. The fifth floor is the conference center, and the sixth floor is an open green floor — the “sky garden.”

Floors seven through 10 are office space. Floor 11 has rooms for visiting guests. Floor 12 is dining space and floor 13 is the roof garden.

Orientation, Massing, and Organization

The building is roughly on a north-south axis to take advantage of the prevailing winds from the east for natural ventilation. PV film and vegetation to provide shade are located on the west elevation.

These technologies throughout multiple systems, using building information modeling (BIM). The result is a building layout based on systems analyses of structural design and functional zoning.

Envelope

The thermal envelope is differentiated on each elevation. The building envelope has low-e double-paned windows and frames made from an aluminum alloy, providing good daylight, thermal and acoustic performance.

and aluminum exterior finishing on cast concrete, which makes the building envelope easy to clean and maintains good thermal integrity.

The west side of the building facade is integrated with thin film PV panels. This PV-integrated facade has a visible transmittance of 0.2, which maintains acceptable visibility while harvesting renewable energy for building operations. Renewable Energy The building includes a variety of PV systems, small wind turbines and a solar thermal system. Various technologies were chosen to demonstrate different applications of building-integrated solar.

The photovoltaic system consists of rooftop PV panels, PV modules on overhangs and the thin film PV system on the building’s west facade.

Most of the PV arrays are composed of monocrystalline silicon PV modules, while translucent amorphous modules are used on the building facade to allow daylighting as well as shading. The building also has a standard solar hot water array.

These PV systems generate roughly 70,000 kWh of electricity per year. A solar thermal system collects and stores heat for all of the hot water used for the building’s kitchen and guest hotel rooms.

Heating and Cooling Systems

The IBR Headquarters Building uses a high-efficiency HVAC system. Because the building is located in a hot and humid subtropical area,
moisture control is important for indoor thermal comfort. The building uses a temperature- and humidity-independent control system to treat outdoor air.

A dedicated outdoor air system is used to dehumidify outdoor air. This system also allows the terminal equipment to just provide the sensible cooling load of the building.

Different HVAC systems accommodate different cooling needs. For example, the basement and first floor use a water source heat pump (WSHP). The heat pump is located near the landscaped water pool, so the closed-loop condenser water exchanges heat directly with the landscaped water pool, which further reduces condenser water temperature while increasing WSHP system efficiency.

The designers included an experimental radiant cooling system for one section of the building, but disconnected it after they had trouble controlling condensation.

Examination Building Performance

Whole Building Energy Consumption. The building’s highest energy consumption is during summer, due to the air conditioning, and the base load consumption is also high, due to the larger servers that store energy data for commercial buildings in Shenzhen. The total energy use for the building in 2011 was 1,151,033 kWh, 84% of which came from the city grid. Roughly
LESSONS LEARNED

Green Design Does Not Mean More Expensive. The building was built with more than 40 new sustainable technologies, and still kept costs well within the range of new commercial office construction in Shenzhen.

A Model for What’s Possible. Perhaps the most important lesson learned is that this innovative building demonstrates that a very low energy building is not only economically possible, but that it can provide a comfortable and inspiring place for people to work. If others can learn how this process was applied in this building, it will make possible many more sustainable design projects in China and elsewhere.

REFERENCE WORKERS can be fined a small amount if they leave lights and equipment on in their area, but this is rarely done, as routine habits ensure that they are turned off. Reducing Electric Lighting. Daylighting for all office workstations means that little energy is used for electric lighting. Also, occupants and building operators routinely shut off lights and plug loads at the end of the day.

End Use Breakdown. The distribution of energy use on an annual basis is shown in Figure 2. The largest end use (36%) is the electricity to run the servers and other IT equipment. Like other parts of China, Shenzhen, due to its coastal location, has relatively good outdoor air quality, allowing for natural ventilation to be an acceptable strategy for much of the year.

Air-Conditioning Use. The building was predicted to use 33 kWh/m² (10 kBtu/ft²) for air conditioning, but the actual AC energy use in 2011 was 14 kWh/m² (4 kBtu/ft²), less than half the predicted use. The likely reason for this difference is that the predicted AC energy is calculated based on the Chinese-commercial design standard that assumes a fully air-conditioned building and does not account for the building’s natural ventilation system.

Plug Loads and Lighting. The IBR Headquarters Building is designed to maximize use of daylighting, which includes the use of daylighting tubes in the basement. Occupants and staff turn off lights and plug loads on weekends and during periods of low occupancy. The submetered data show that lights and plug loads are well controlled, with very low energy consumption on nights and weekends.

A Model for What’s Possible. Perhaps the most important lesson learned is that this innovative building demonstrates that a very low energy building is not only economically possible, but that it can provide a comfortable and inspiring place for people to work. If others can learn how this process was applied in this building, it will make possible many more sustainable design projects in China and elsewhere.

References

ABOUT THE AUTHOR
Rick Diamond, Ph.D., is a staff scientist at Lawrence Berkeley National Laboratory, in Berkeley, Calif., where he studies the energy performance of buildings.
Wei Feng, Ph.D., Member ASHRAE, is a senior scientific engineering associate at Lawrence Berkeley National Laboratory in Berkeley, Calif., where he studies the energy performance of buildings.
Ye Qing is director of the Shenzhen Institute of Building Research, Shenzhen, China. She is an architect and planner working on low carbon buildings and cities in China.

10% of the energy used in the building was supplied by city gas mains, and 6% from the building’s PV array.

Cooling Benefit Over Much of the Year. Unlike other parts of China, Shenzhen, due to its coastal location, has relatively good outdoor air quality, allowing for natural ventilation to be an acceptable strategy for much of the year.

Natural Ventilation Can Provide Significant Cooling Benefit Over Much of the Year. Even in China’s hot-humid southern region, a carefully designed system of properly sized windows, carefully located to capture southeastern breezes, allowed for significantly reduced need for air conditioning. Unlike other parts of China, Shenzhen, due to its coastal location, has relatively good outdoor air quality, allowing for natural ventilation to be an acceptable strategy for much of the year.

End Use Breakdown. The distribution of energy use on an annual basis is shown in Figure 2. The largest end use (36%) is the electricity to run the servers and other IT equipment. Like other parts of China, Shenzhen, due to its coastal location, has relatively good outdoor air quality, allowing for natural ventilation to be an acceptable strategy for much of the year.

Plug Loads and Lighting. The IBR Headquarters Building is designed to maximize use of daylighting, which includes the use of daylighting tubes in the basement. Occupants and staff turn off lights and plug loads on weekends and during periods of low occupancy. The submetered data show that lights and plug loads are well controlled, with very low energy consumption on nights and weekends.

REFERENCES

ABOUT THE AUTHOR
Rick Diamond, Ph.D., is a staff scientist at Lawrence Berkeley National Laboratory, in Berkeley, Calif., where he studies the energy performance of buildings.
Wei Feng, Ph.D., Member ASHRAE, is a senior scientific engineering associate at Lawrence Berkeley National Laboratory in Berkeley, Calif., where he studies the energy performance of buildings.
Ye Qing is director of the Shenzhen Institute of Building Research, Shenzhen, China. She is an architect and planner working on low carbon buildings and cities in China.

They rely on constant checking of equipment and systems, and are looking forward to the installation of a building management system, which will give them detailed information on systems performance.

They acknowledged that there is not a lot of familiarity with the heat pump systems and other innovative systems like the radiant cooling, and that they have had to “learn by doing.”

Conclusion
In many ways, the Shenzhen IBR Headquarters Building is a model green building. It is designed to operate in harmony with nature, resulting in lower energy use, lower costs and high occupant satisfaction. The idea is not that a single building can be replicated, but that the process and spirit that guided the design, construction, and operation of one successful building can be studied, absorbed, and spread throughout the global architectural community.

REFERENCES

ABOUT THE AUTHOR
Rick Diamond, Ph.D., is a staff scientist at Lawrence Berkeley National Laboratory, in Berkeley, Calif., where he studies the energy performance of buildings.
Wei Feng, Ph.D., Member ASHRAE, is a senior scientific engineering associate at Lawrence Berkeley National Laboratory in Berkeley, Calif., where he studies the energy performance of buildings.
Ye Qing is director of the Shenzhen Institute of Building Research, Shenzhen, China. She is an architect and planner working on low carbon buildings and cities in China.

They rely on constant checking of equipment and systems, and are looking forward to the installation of a building management system, which will give them detailed information on systems performance.

They acknowledged that there is not a lot of familiarity with the heat pump systems and other innovative systems like the radiant cooling, and that they have had to “learn by doing.”

Conclusion
In many ways, the Shenzhen IBR Headquarters Building is a model green building. It is designed to operate in harmony with nature, resulting in lower energy use, lower costs and high occupant satisfaction. The idea is not that a single building can be replicated, but that the process and spirit that guided the design, construction, and operation of one successful building can be studied, absorbed, and spread throughout the global architectural community.

REFERENCES

ABOUT THE AUTHOR
Rick Diamond, Ph.D., is a staff scientist at Lawrence Berkeley National Laboratory, in Berkeley, Calif., where he studies the energy performance of buildings.
Wei Feng, Ph.D., Member ASHRAE, is a senior scientific engineering associate at Lawrence Berkeley National Laboratory in Berkeley, Calif., where he studies the energy performance of buildings.
Ye Qing is director of the Shenzhen Institute of Building Research, Shenzhen, China. She is an architect and planner working on low carbon buildings and cities in China.