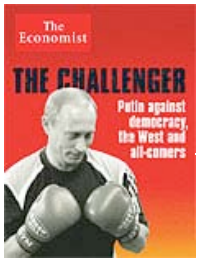

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The rise of the green building

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Architecture: New buildings use design and technology to reduce environmental impact, cut costs and provide better places to work

IT IS officially known as the Swiss Re Tower, or 30 St Mary Axe. But Londoners universally refer to the newest addition to their skyline as "the Gherkin", thanks to the 41-storey building's distinctive, curved profile, which actually looks more like a pine cone (see right). What is most remarkable about the building is not its name or its shape, however, but its energy-efficiency. Thanks to its artful design and some fancy technology, it is expected to consume up to 50% less energy than a comparable conventional office building.

Most people are not used to thinking of large buildings as vast, energy-guzzling machines. But that is what they are. In America, buildings account for 65% of electricity consumption, 36% of total energy use and 30% of greenhouse-gas emissions. So making buildings more energy-efficient could have a significant impact on energy policy, notes Rebecca Flora of the Green Building Alliance, a group that promotes sustainable architecture. That is a key goal of the "green architecture" movement, which is changing the way buildings are designed, built and run.

Proponents of green architecture argue that the approach has many benefits. In the case of a large office, for example, the combination of green design techniques and clever technology can not only reduce energy consumption and environmental impact, but also reduce running costs, create a more pleasant working environment, improve employees' health and productivity, reduce legal liability, and boost property values and rental returns.

The term "green architecture" only came into use in the 1990s, but the movement's roots can be traced back a long way. Crystal Palace in London and Milan's Galleria Vittorio Emanuele II, for example, built in 1851 and 1877 respectively, used roof ventilators and underground air-cooling chambers to regulate the indoor temperature. Today's enthusiasm for green architecture has its origins in the energy crisis of the 1970s, when architects began to question the wisdom of building enclosed glass-and-steel boxes that required massive heating and cooling systems. Early proponents of more energy-efficient architecture included William McDonough, Bruce Fowle and Robert Fox in America, Thomas Herzog in Germany, and Norman Foster and Richard Rogers in Britain.

These forward-thinking architects began to explore designs that focused on the long-term environmental impact of maintaining and operating a building, looking beyond the so-called "first costs" of getting it built in the first place. This approach has since been formalised in a number of assessment and rating systems, such as the BREEAM standard introduced in Britain in 1990, and the LEED (Leadership in

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Energy and Environmental Design) standards developed by the United States Green Building Council (USGBC) starting in 2000.

The LEED standards are intended to produce "the world's greenest and best buildings" by giving developers a straightforward checklist of criteria by which the greenness of a building can be judged. Points are awarded in various categories, from energy use (up to 17 points) to water-efficiency (up to five points) to indoor environment quality (up to 15 points); the total then determines the building's LEED rating. Extra points can be earned by installing particular features, such as renewable-energy generators or carbon-dioxide monitoring systems. A building that achieves a score of 39 points earns a "gold" rating; 52 points earns a "platinum" rating. A gold-rated building is estimated to have reduced its environmental impact by 50% compared with an equivalent conventional building, and a platinum-rated building by over 70%.

Rating buildings in this way reveals how inefficient traditional buildings and building processes are. "We can sometimes waste up to 30 cents on the dollar," says Phillip Bernstein, an architect and professor at Yale University. "It's not just the consumption of energy, it's the use of materials, the waste of water, the incredibly inefficient strategies we use for choosing the subsystems of our buildings. It's a scary thing." In part, he says, this is because the construction industry is so fragmented. Designers, architects, engineers, developers and builders each make decisions that serve their own interests, but create huge inefficiencies overall.

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Green is good

But things are now changing, as green architecture moves into the mainstream. In the spring of 2003, Toyota completed a 624,000-square-foot office complex in Torrance, California, that received a LEED gold rating, thanks to the inclusion of features such as solar cells to provide up to 20% of the building's energy needs. Also last year, Pittsburgh opened the doors on its 1.5m-square-foot convention centre, the largest building to be awarded a gold LEED rating so far. The USGBC says nearly 1,700 buildings in 50 states are now seeking LEED certification and 137 have been constructed and certified so far. And America's General Services Administration, which oversees all non-military government construction, recently decreed that all new projects and renovations must meet the minimum LEED standards.

In Britain, meanwhile, 70 office buildings constructed during 2003, representing 25% of the total by floor area, met the BREEAM standard. Similar standards have been adopted in New Zealand, Australia and Canada. In China, the Beijing Organising Committee of the Olympic Games aims to host the first zero-net-emissions games, which will include constructing all buildings and sports venues using green-architecture principles.

There are many ways to reduce a building's environmental impact. Consider the 48-storey Condé Nast Building at 4 Times Square in New York, for example, which was designed by Fox & Fowle Architects. It was one of the first examples in which green-architecture principles were applied to a large urban office building, and informed the drawing up of the LEED points system, since it uses almost every energy-saving technique imaginable.

"Going green saves money by reducing energy and maintenance costs, and may boost productivity."

Special glass allows daylight in to reduce the need for interior lighting, keeps heat and ultraviolet rays out, and minimises heat loss in winter. Two natural-gas-powered fuel cells provide 400 kilowatts of power, enough to provide all the electricity needed at night, and 5% of the building's needs during the day. The hot-water exhaust produced by the fuel cells is used to help heat the building and provide hot water. The heating and cooling systems, located on the roof, are gas-powered

rather than electric, which reduces energy losses associated with electrical power transmission. Photovoltaic panels on the building's exterior provide up to an additional 15 kilowatts of power. Inside the building, motion sensors control fans and switch off lights in seldom-occupied areas such as stairwells. Exit signs are illuminated by low-power light-emitting diodes. The result is that the building's energy consumption is 35-40% lower than that of a comparable conventional building.

30 St Mary Axe, designed by Foster and Partners, is also packed with energy-saving features. In particular, it uses natural lighting and ventilation wherever possible. The façade consists of two layers of glass (the outer one double-glazed) enclosing a ventilated cavity with computer-controlled blinds. A system of weather sensors on the outside of the building monitors the temperature, wind speed and level of sunlight, closing blinds and opening window panels as necessary. The building's shape maximises the use of natural daylight, reducing the need for artificial lighting and providing impressive long-distance views even from deep inside the building.

The highest-profile green building currently on the drawing board is the Freedom Tower, which will be built on the site of the World Trade Centre in New York. The architects, Skidmore, Owings & Merrill and Studio Daniel Libeskind, have incorporated environmental design features throughout the huge complex. The main tower, which will rise 1,776 feet, will include solar panels and a wind farm, the turbines of which are expected to deliver around one megawatt of power, enough to provide up to 20% of the building's expected demand. Like other green buildings, it will rely on natural light and ventilation, and energy-efficient lighting.

Clockwise from bottom left: Pittsburgh's convention centre, Toyota's building at Torrance, and New York's future Freedom Tower

High energy costs, environmental concerns and anxiety about the “sick building syndrome” associated with the sealed-box structures of the 1970s all helped to jump-start the green-architecture movement. But now economics is driving the shift towards greener design, as new materials and techniques fall in price, argues Michael Crosbie, an architect at Steven Winter Associates, a consultancy based in Norwalk, Connecticut. He says his clients “are much more demanding because they see the incredible amount of money it takes to get something constructed, and they want a return on that investment.”

Why it pays to be green

Going green saves money by reducing long-term energy costs: a survey of 99 green buildings in America found that on average, they use 30% less energy than comparable conventional buildings. So any additional building costs can be recovered quickly: according to the USGBC, the 2% increase in construction costs required to achieve a LEED gold rating typically pays for itself in lower running costs within two years. The traditional approach of trying to minimise construction costs, by contrast, can lead to higher energy bills and wasted materials.

Energy-saving techniques need not all be as exotic as installing coated glass, computer-controlled blinds or photovoltaic cells. Mr Crosbie says builders are now insulating buildings more effectively, in some cases using materials such as recycled paper and fabrics, including old, shredded jeans. It is more effective than traditional insulation, he says, saves money and is easier on the environment.

Green buildings can also have less obvious economic benefits. The use of natural daylight in office buildings, for example, as well as reducing energy costs, also seems to make workers more productive. Studies conducted by Rachel and Stephen Kaplan, environmental psychologists at the University of Michigan, found that employees with views of a natural landscape report greater job satisfaction, less stress and fewer illnesses. Lockheed Martin, an aerospace firm, found that absenteeism fell by 15% after it moved 2,500 employees into a new green building in Sunnyvale, California. The increase in productivity paid for the building's higher construction costs within a year.

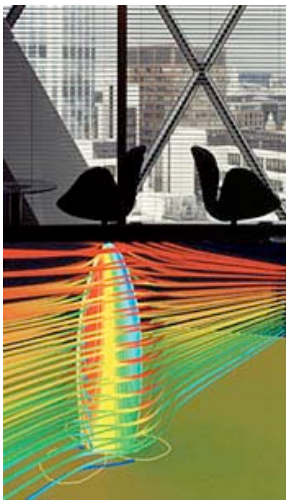
Similarly, the use of daylight in shopping complexes appears to increase sales. The Heschong Mahone Group, a California-based consultancy that specialises in energy-

efficient building technologies, found that sales were as much as 40% higher in stores lit with skylights. It also found that students in naturally lit classrooms performed up to 20% better. Green buildings can also reduce legal liabilities for their owners, since they are less likely to give rise to “sick building” lawsuits. But more studies are needed, says Caren Glotfelty, director of the environmental programme at the Heinz Endowments, a non-profit foundation run by Teresa Heinz Kerry that funds sustainable initiatives.

Despite its benefits and its growing popularity, green architecture is still the exception, not the rule, however. The main problem is co-ordination, says Mr Bernstein, who is also vice-president of the building solutions division at Autodesk, a software company. Green buildings require much more planning by architects, engineers, builders and developers than traditional buildings. “The building industry is very disaggregated,” he says, “so adoption patterns are really, really slow.” But new software is now improving planning by simulating how a building will perform before it is built.

Autodesk's software can create a three-dimensional model of a building and then work out how much energy it will use, taking into account its shape, heating and cooling systems, orientation to the sun and geographic location. Other such tools abound: the designers of 4 Times Square calculated its energy consumption using a free package called DOE-2, developed by James J. Hirsch & Associates together with the Lawrence Berkeley National Laboratory, with funding from America's Department of Energy.

Greener by design



In the old days, says Mr Bernstein, assessing a building's environmental impact had to be done with spreadsheets, calculators and informed guessing, and three-dimensional modelling was primarily used to prepare presentations. But now the three-dimensional computer models are being used with sophisticated analytical tools. “We are getting to the next phase where you can analyse rather than simply represent,” he says. It is then possible to predict how much energy and water a building will consume, how much material will be needed, and other parameters that determine its LEED certification. All of this is old hat for the airline and automobile industries, where computer models have long been used to trim costs and streamline design before construction begins. Now the same technology is being applied by architects.

Computers also make possible entirely new designs. 30 St Mary Axe, for example, could not have been built without a computer model to specify the exact shape of every one of its 5,500 glass panels, or to model the airflow in and around it. Similarly, computer modelling made possible the Avax office building completed in Athens, Greece, in 1998. It has sheaves of glass which open and close automatically, depending on the intensity and angle of the sun, to provide sunlight while preventing the building from overheating. The ventilation system in Pittsburgh's convention centre uses the natural “chimney effect” created by its sweeping roof to draw air through vents by the river below, cooling the building without using a single fan.

This is more than a mere fad, or the use of technology for the sake of it, says Mr Bernstein. Green architecture will, he suggests, help to reshape the construction industry over the next five years, with ever more innovative, energy-efficient and environmentally friendly buildings. “No one is doing this for fun,” he says. “There's too much at stake.”