TOWARDS ZERO ENERGY ARCHITECTURE

NEW SOLAR DESIGN

Mary Guzowski

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Laurence King Publishing

With love and appreciation to
John and James Lindbeck
and the next generation of ecological designers.

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361–373 City Road
London EC1V 1LR
United Kingdom
Tel: + 44 20 7841 6900
Fax: + 44 20 7841 6910
e-mail: enquiries@laurenceking.com
www.laurenceking.com

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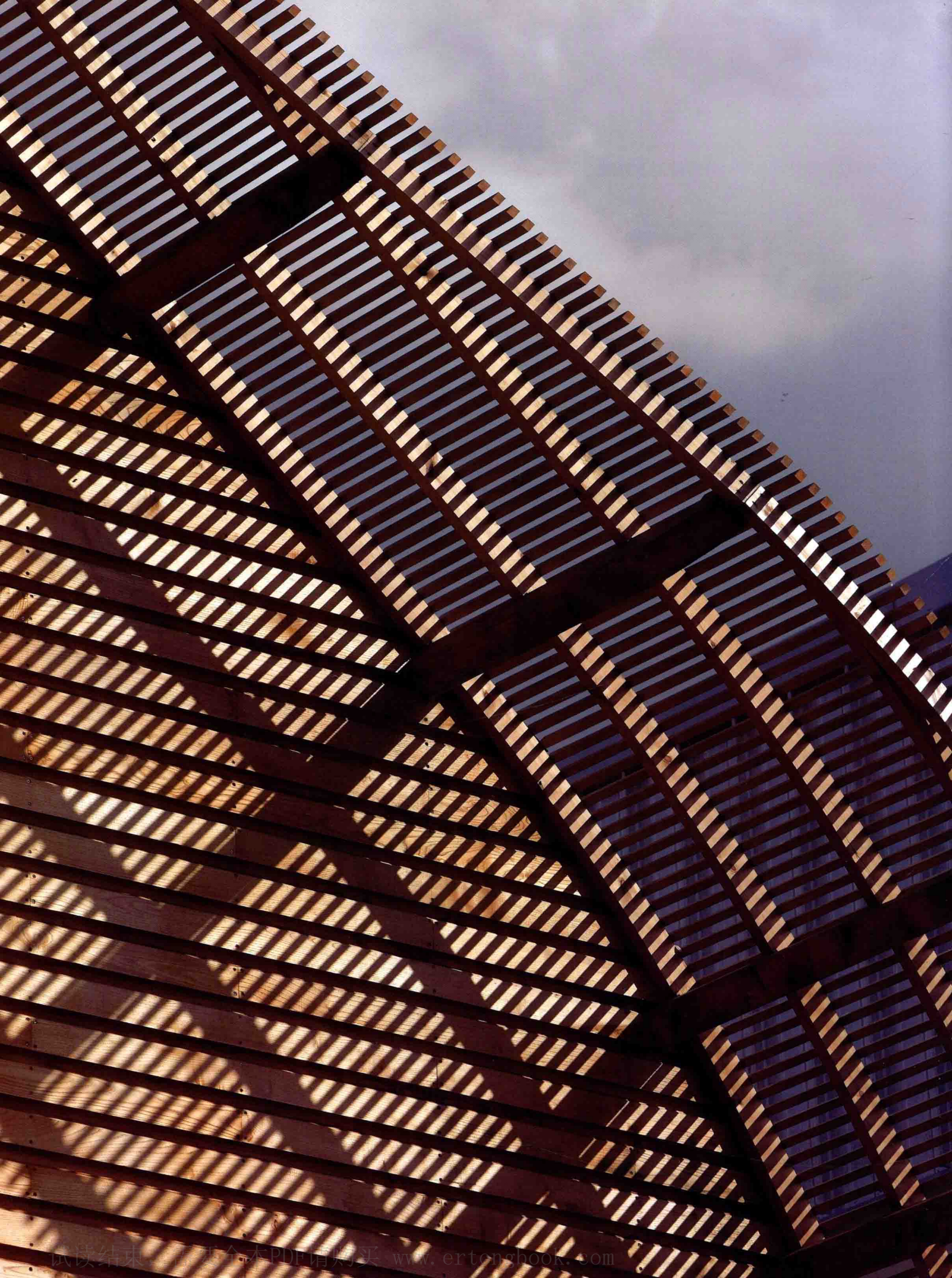


Introduction

"Solar radiation is the primary source of renewable energy. Besides offering a direct source of energy, it drives the Earth's climate creating opportunities to draw energy from wind, waves, tidal (together with the moon) and a host of biological sources... Since the sun drives every aspect of the climate it is logical to describe the techniques adopted in buildings to take advantage of this fact as 'solar design'." [1]
Peter F. Smith, *Architecture in a Climate of Change*

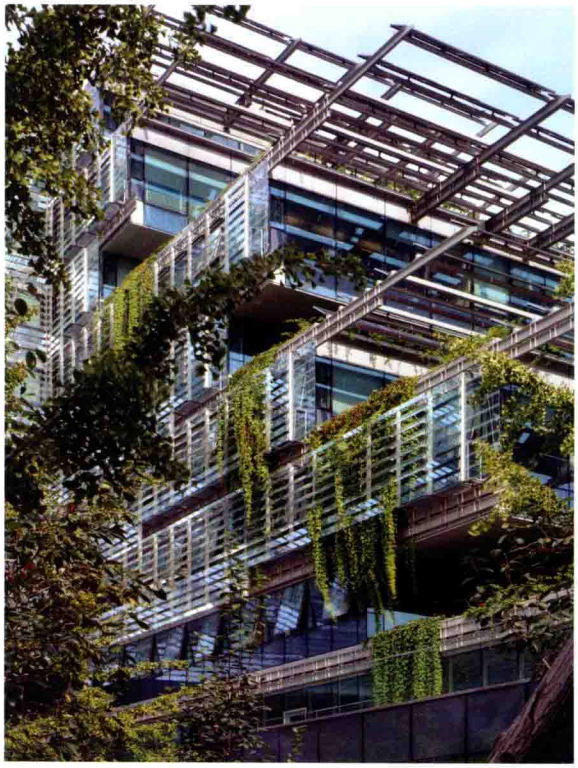
Opposite
Detail of the slatted roof eave on the Kingspan Lighthouse in Watford, UK. As the first net zero-carbon house in the United Kingdom, this prototype is designed to respond to the impacts of climate change. Poetic and pragmatic design considerations are integrated in ways that embody both a new solar aesthetic and a new level of solar performance.

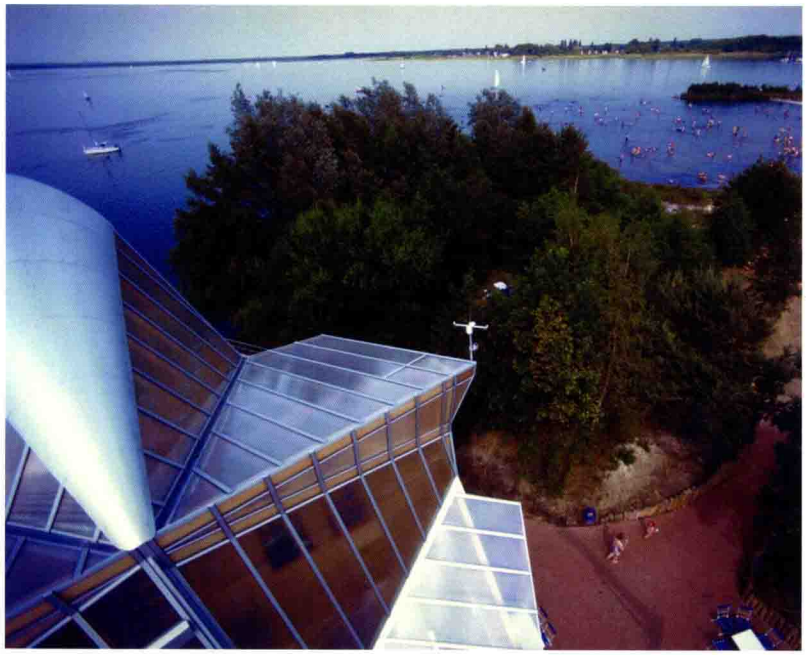
Humans continue to adapt to the rhythms of light and darkness in the eternal cycle of night and day as the sun rises and sets, season after season, millennium upon millennium. We find ways to harness the forces of the sun and wind to sustain our lives, and these forces have shaped the built environment. Our ancestors used simple and ingenious strategies to create dwellings, neighborhoods, public spaces, villages, and even sophisticated solar cities. The forces of the sun and wind have inspired architectural design at all scales, from building form to plan, section, materials, and detailing. We have always relied on the sun and wind to meet seasonal needs for lighting, heating, and cooling; always celebrating our relationships with the varied places and climates of the world.

Not until the mid-twentieth century, with the widespread construction of roads, distribution of fossil fuels, and manufacture of mechanical systems were we able to turn our backs on the sun and wind as providers of light, heat, and air. As a consequence, in just a few decades we have witnessed an exponential growth in the consumption of resources, production of pollution and waste, and alienation from the natural world. Fortunately, in response to this grim trajectory, architects and designers from around the world are joining a movement to create buildings that mitigate global warming and climate change. Zero-energy and carbon-neutral architecture has emerged as a top priority, although low-energy and low-carbon design is often more readily achieved.

A true architecture of the sun and wind is more than the sum of passive strategies, technological systems, and ecological engineering. Buildings that are shaped by the sun and wind promote social and ecological values by revealing how our lives can be powered by renewable resources; and just as importantly, they also promote aesthetic values by creating relationships with place and site that are based on the form-giving and poetic attributes of these forces. The new solar architecture has a thin profile that optimizes light and air; it employs an ecological envelope that is responsive to the site and environmental forces; it reduces or eliminates dependence on fossil fuels, is renewable, and strives for little or no carbon-based energy consumption.

Above all, a true architecture of the sun and wind is beautiful and fosters health, well-being, and a connection to the local site and ecosystems. As architect Sim Van der Ryn explains in *Design for Life*: "Architecture is 're-membering'—putting back together our collective dreams... The building should tell a story about place and people and be a pathway to understanding ourselves within nature."[2] This new generation of architecture uses the sun and wind not only to address energy and resource consumption but





also to awaken, or "re-member," our ecological relationship to the world and to express an ecological aesthetic.

The growing interest in zero-energy and carbon-neutral architecture is generating an evolution in design processes, strategies, and protocols. Evidence of this transition is found in recent legislation, revisions to green standards and guidelines, new evaluative tools, and in design firms that are striving to learn more about the issues. It is a hopeful sign that a great number of projects are in the development stage. In the next few years there will be many more precedents to help designers understand the architectural opportunities and challenges of reducing or eliminating fossil fuel consumption and greenhouse gas emissions.

The firms that have designed the ten architectural projects featured in this book are leading the way into a new and more sustainable future. Differing in size, location, and scope, these projects can be viewed as pilot studies, in some cases even experimental endeavors, that explore and expand the role of the sun and wind in reducing or eliminating our dependence on fossil fuels. The ten case studies reveal that there is no single strategic approach to low- and zero-energy architecture. Formal, aesthetic, and expressive responses are as varied as are the individual architects and design firms. Yet, a common thread in all of the projects is a deep commitment by the design teams to harvest the sun, wind, and other sources of on-site renewable energy to heat, light, and cool the buildings. Spanning the range of these architectural expressions we also find approaches to solar design that integrate ancient lessons of passive and climate-responsive design with state-of-the art technologies and new, innovative approaches to high-performance and responsive building envelopes. Working within essential solar and climate-responsive parameters, we find seemingly unlimited formal, stylistic, and expressive design opportunities.

Five broad themes emerged from the study of these pioneering works. First, the projects inspire change. They strive to go beyond incremental improvements to energy codes and instead respond to the design problems with deeper ecological solutions. Second, the projects respond to place. The works are clearly informed by the environmental forces of their immediate site in addition to the surrounding landscapes. Passive strategies that are essential in reducing energy consumption are coupled with renewable-energy technologies to take advantage of the particular diurnal and seasonal attributes of sun and wind in each location. Third, the projects tend to be modest in size and scope. The architects eliminate excess and seek multiple pathways toward efficiency and ecological effectiveness. The projects find ways to do more with less without compromising design integrity.

Above left
Detail of the terraces and hanging gardens at the Sino-Italian Ecological and Energy Efficient Building (SIEEB) at Tsinghua University, Beijing, China. Photovoltaic shading devices provide thermal and luminous control while generating electricity. A terraced building form was selected to block northern winter winds and admit winter sun, while providing solar control and shading to the south during summer months.

Above right
Aerial view of the observation tower and landscape at the Steinhude Sea Recreational Facility, Germany. The building is sited to minimize ecological impacts and to protect a neighboring bird sanctuary as well as to take advantage of northern views over the Steinhude Meer while harvesting on-site solar energy.

North facade of the west bedroom pavilion at the Rozak House on Lake Bennett in Australia's Northern Territory. The building envelope creates a minimal boundary and plays a critical role in achieving zero-energy and low-carbon emission goals. Porches, screened walls and floors, jalousie windows, and solar louvers enclose spaces while creating dynamic and adjustable connections.

Fourth, the projects focus on design of the envelope as a means to create a responsive skin that enhances building performance, ecological response, and connections to the site. And last but not least, the projects are beautiful. They demonstrate that design excellence is as important as is ecological performance. These five themes guide us through the thoughtful and elegant ways in which the architects have approached the new solar architecture to achieve ecological effectiveness within aesthetically beautiful designs.

Each case study includes an overview of the design intentions, climate and site responses, daylighting and thermal strategies, energy systems, lessons for the next generation of sustainable design thinking and practice, and a profile summarizing design strategies. Basic solar analyses are provided for each case study using the Ecotect Solar Tool to illustrate the varied diurnal and seasonal conditions for solar access at the site scale. The solar studies are illustrated for the solstices and equinoxes (December 21, March/September 21, and June 21) at 9:00 a.m., noon, and 3:00 p.m. In addition, each case study includes a summary of climate data which was developed with the Ecotect Weather Tool (using the Energy-Plus weather data from the US Department of Energy) to provide a general introduction to the seasonal averages in temperature, relative humidity, solar radiation, wind speed, and prevailing wind direction. The solar studies and climate data are intended to provide the reader with a general overview of the context and prevailing bioclimatic conditions that informed the architectural design and are not intended for design or engineering purposes.

The following case studies may be useful in inspiring a broader understanding of the potential of the sun and wind to shape the next generation of sustainable architecture. The pioneering architects and projects featured in the case studies reveal the promise of a new solar architecture that responds deeply to the ecological challenges of our day, while recognizing that when our buildings delight our senses, architecture can help inspire us to dwell more lightly on our beautiful Earth.

Endnotes:

1 Peter F. Smith, *Architecture in a Climate of Change* (Oxford: Architectural Press, 2001), 33, 45.
2 Sim Van der Ryn, *Design for Life* (Layton, Utah: Gibbs Smith, Publisher, 2005).

Chapter 1

Fostering an ecological vision

"We are now experiencing a moment of significance far beyond what any of us can imagine. What can be said is that the foundations of a new historical period, the Ecozoic Era, have been established in every realm of human affairs. The mythic vision has been set into place. The distorted dream of an industrial technological paradise is being replaced by the more viable dream of a mutually enhancing human presence within an ever-renewing organic-based Earth community... In the larger cultural context the dream becomes the myth that both guides and drives the action."[1]
THOMAS BERRY, theologian and historian,
The Great Work: Our Way into the Future

"Solar power: All energy is solar energy, stored in different forms. Every two minutes the sun gives the earth more energy than is used annually world-wide. It is the only renewable resource with the capacity to provide all the energy we need on a global level."[2]
BRUCE MAU, *Massive Change*

To reach the next level of sustainable design we will need more than just the best ecological design strategies, principles, and performance indicators; we will also need a new vision to inspire our imaginations. As Thomas Berry explains in *The Great Work*, the challenge of our day is to envision a new ecological era: "History is governed by those overarching movements that give shape and meaning to life by relating the human venture to the larger destinies of the universe. Creating such a movement might be called the Great Work of a people... The Great Work now, as we move into a new millennium, is to carry out the transition from a period of human devastation of the Earth to a period when humans would be present to the planet in a mutually beneficial manner... This is our Great Work and the work of our children..."[3] This vision will come into being when we design not only to make a profound ecological difference, but also to guide new ways of living on Earth. David Orr, Professor of Environmental Studies at Oberlin College in the USA, argues that we—*homo sapiens sapiens*—are the design challenge: "The greatest impediment to an ecological design revolution is not, however, technological or scientific, but rather human... A real design revolution will have to transform human intentions and the larger political, economic, and institutional structure that permitted ecological degradation in the first place..."[4]

During the past decade there has been significant progress in mainstreaming ecological principles into architectural practice. A variety of voluntary sustainable design guidelines and standards such as the US Green Building Council's Leadership in Environmental Design, the UK's Code for Sustainable Homes, and the International Organization for Standards (ISO 21930:2007) have been established around the world. Although we have seen expectations for ecological performance raised through such regulatory codes and building standards, the scope and breadth of the current ecological challenges require an even greater level of leadership from the design communities. We need innovative designers to imagine ever-deeper ecological visions of the future. This will require more than the incremental, yet slow, changes we have seen over the past several decades.

In considering the panoply of emerging trends and responses to the design challenges occurring throughout the world, Bruce Mau from the Institute Without Boundaries, cites the wisdom of former US president John F. Kennedy, whose words are as relevant today as they were four decades ago: "The problems of the world cannot possibly be solved by skeptics or cynics whose horizons are limited by the obvious realities. We need people who can dream of things that never were."[5] Over the past several years, we have seen new visions and depths of innovation emerging as designers reconsider the interrelated design consequences of fossil fuel consumption and greenhouse gas emissions. This has led to a growing focus on zero-energy, zero-emission, and carbon-neutral design; as well as explorations into plus-energy and carbon-sequestering approaches that promote the healing principles of regenerative and restorative design. To reach zero and go beyond, designers

View of the kitchen, dining area, and outdoor garden spaces in the First LivingHome in Santa Monica, California, USA. Large floor-to-ceiling sliding doors enable the inhabitants to extend the house into the gardens as the seasons change.

are looking with renewed interest and commitment to the abundant and renewable resources of sun and wind. Nearly 30 years ago, legendary innovator and visionary R. Buckminster Fuller encouraged designers to look to nature, and specifically the sun, for answers to our ecological design challenges: "Nature as the omni-informed and omni-concerned, omni-considerate cosmic designer discovered and heeded the fact that human organisms and their absolutely essential ecological support complex could not operate safely at a distance of less than ninety-two million miles away from the nearest atomic-energy plant—the sun—and all the latter's lethal radiation involvements. The would-be exploiters of atomic energy on board our plante Earth will in due course discover there is no way for them to solve atomic-energy-radiation waste-disposal problems save by rocketing it all back into the sun, where it belongs. Humans will then have to learn how to keep all humans and their ecological support system operating successfully on our vastly adequate daily income of solar atomic energy."[6] As authors Sophia and Stefan Behling explain in *Solar Power*, the sun is the giver of all life and all energy on Earth: "The sun is the Earth's only energy source... Solar energy is far more than just radiation... Solar energy reaches the atmosphere in various forms. The sun is a non-polluting source of renewable energy and is essential in the formation of wind, clouds, thunderstorms, rain, and other weather conditions, some of which can be converted into usable energy."[7]

The new ecological designers have developed fresh and effective ways to integrate both passive design and active systems into projects that combine the lessons of ancient climatic-design traditions with the most brilliant state-of-the-art technologies. In responding to the forces of the sun (and the related dynamics of the wind, climate, place, and the seasonal cycles and the rhythms of day and night) these projects address our ecological concerns while also speaking to our deepest design and aesthetic aspirations. While the ecological challenges of our day may not be completely new, we are certainly facing an unprecedented scale of concern and rate of change. The elevated sense of urgency has given rise to a new spirit of design innovation and exploration, and a commitment to redouble efforts for deeper ecological response. Today, perhaps more than ever, we need to return to our essential source of life—the sun—to design our way into a more sustainable future.

Can architecture address serious ecological concerns and also people that we can live comfortably and elegantly at a new level of sustainability? To go beyond the current limits of "best practice," the profession must reframe the fundamental questions that inform design thinking. Designers need to push beyond current design thinking to take architectural design—and the people who inhabit buildings—to the next generation of sustainability. Inspiration and vision are needed to move design beyond mandates and regulations. David Orr reminds us that we need to find ways to elicit new human behaviors and values. Orr suggests that ecological design is a vehicle for profound and transformative ecological education: "The ultimate object of