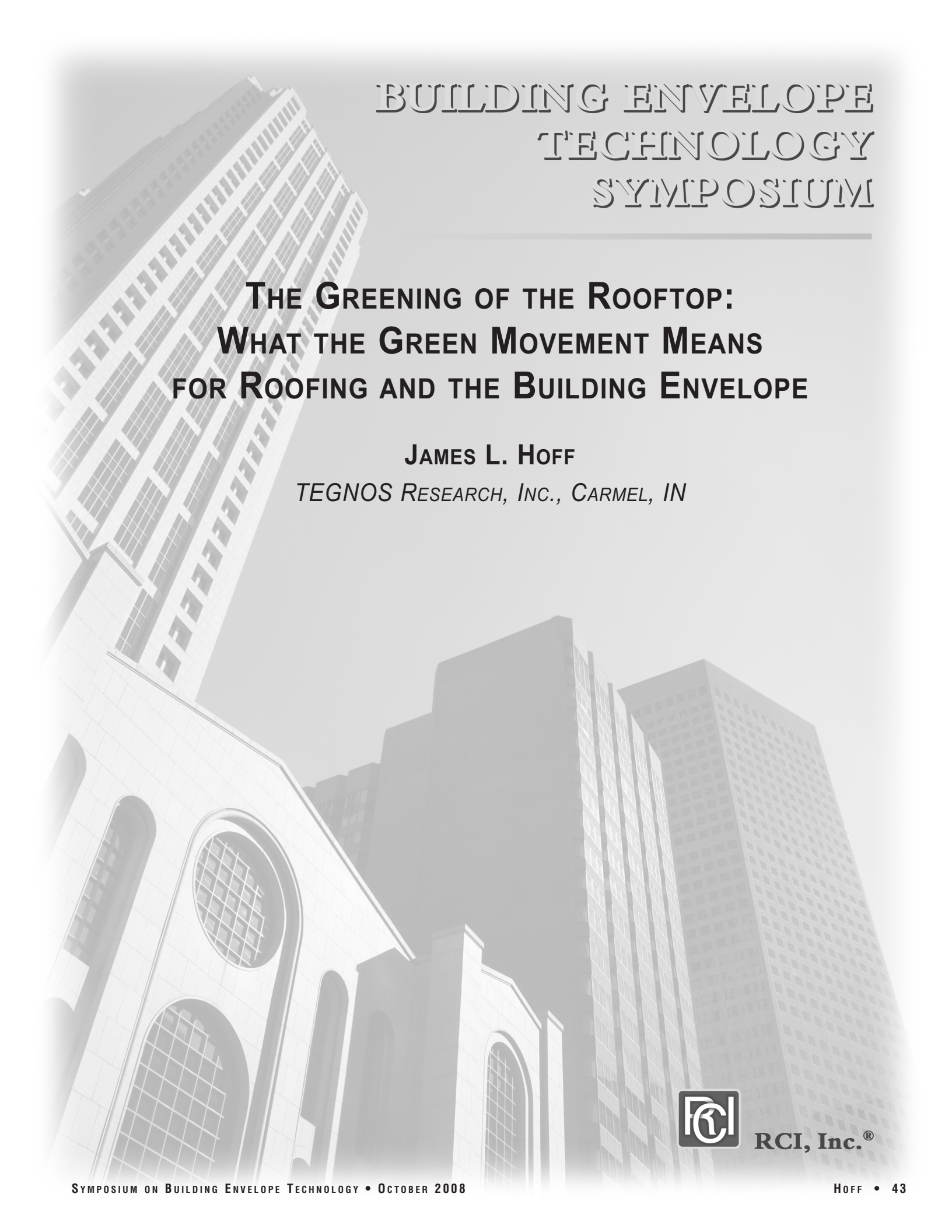

BUILDING ENVELOPE TECHNOLOGY SYMPOSIUM

THE GREENING OF THE ROOFTOP: WHAT THE GREEN MOVEMENT MEANS FOR ROOFING AND THE BUILDING ENVELOPE

JAMES L. HOFF

TEGNOS RESEARCH, INC., CARMEL, IN

RCI, Inc.®

ABSTRACT

Green building assessment tools such as LEED® and Green Globes provide a means of measuring the "greenness" of buildings and key building systems to help building designers make effective decisions regarding the long-term sustainability of a building. However, because these assessment tools typically are employed during the early phases of the building process, they tend to place more emphasis on the initial design of buildings rather than their longer-term operational life. As a result, current rating systems may fail to properly consider durability, life-cycle cost, and potential consequences of premature deterioration on long-term building sustainability.

Starting with a review of current green building rating systems from the perspective of building durability, this paper will discuss the importance of designing for durability and how durability should be defined, measured, and incorporated into the building process. Specifically, the paper will discuss:

1. Defining durability: How should durability be defined for building envelope systems?
2. Measuring durability: What are the key determinants of building envelope durability, and how should they be measured?
3. Planning for durability: What processes should be used to develop a planned approach to building envelope durability?
4. Operating for durability: What processes should be used to assess building envelope durability and take needed countermeasures during the operational life of the building?

The objective of this paper is the development of a practical approach to building envelope durability that can be used by the building envelope practitioner to help designers, owners, and managers achieve truly sustainable building design and operation.

SPEAKER

JAMES L. HOFF — TEGNOS RESEARCH, INC., CARMEL, IN

JAMES L. HOFF is an experienced executive in the building materials industry, recently retired as vice president of technology, quality, and product development for Firestone Building Products after 22 years. Dr. Hoff currently serves as research director for the Center for Environmental Innovation in Roofing, Washington, DC, and as president of TEGNOS Research, Inc., an organization focused on advancing research in the building envelope industry. Dr. Hoff serves as a board member of the Performance Council for Constructed Roofing Systems and the RCI Foundation and is a past chairman of the Polyisocyanurate Insulation Manufacturers Association and the EPDM Roofing Association.

THE GREENING OF THE ROOFTOP: WHAT THE GREEN MOVEMENT MEANS FOR ROOFING AND THE BUILDING ENVELOPE

INTRODUCTION

Beginning with the founding of the U.S. Green Building Council ten years ago, the green building movement has gained significant public recognition. While almost everyone associated with the building envelope industry has become aware of this emerging trend, few industry stakeholders have had the opportunity to learn about the foundations and dynamics of the movement. What does "green" mean? Why is green important? Who is promoting green? Where will the green building movement go in the future? And, most importantly, what does green mean to roofing and building envelope practitioners?

The goal of this paper is to provide a background of the green building movement, with a special focus on the unique social and technological dynamics that are shaping "green thinking" among building professionals. The presentation will also review the basic principles of green or sustainable building design and how these principles are being implemented within the roofing and building envelope industries. Finally, the presentation will discuss how emerging private initiatives and government policies may influence the future of green in the building industry.

Green Links to the Environmental Past

In its broadest usage, "green" may be viewed as the latest manifestation of a growing concern for the environment dating back more than a century. But today's green agenda has moved well beyond past environmental initiatives. From the founding of the Sierra Club in 1892 to the celebration of the first Earth Day in 1970, the primary goal of the environmental movement has been to conserve scarce natural resources and reduce human impact on the environment. In many ways, environmentalism prior to the green movement could be viewed as a zero-sum game in which we could only slow down the inevitable destruction of the earth and its resources. Although the green movement continues to acknowledge that many natural resources are scarce and that environmental impacts are serious, the green mindset has successfully moved beyond a framework of scarcity by adding the assumption that human ingenuity and technological advance offer ways to expand resources well beyond currently perceived limitations.

From Scarcity to Sustainability

By asserting that natural scarcity may be countered by human ingenuity, green has dramatically redefined the historical goal of the environmental movement. Instead of losing a slow and painful battle as limited resources are drained from the earth, society now stands a chance to win – provided that new and innovative resources can be added faster than existing resources are depleted. In other words, with the emergence of the green movement, environmentalism has moved from scarcity to sustainability.

Defining green to be sustainable was first advocated by the Brundtland Commission, chartered by the United Nations in 1987 to address the potentially conflicting goals of environmental protection and economic development. In an effort to move beyond a mindset of scarcity but still recognize the critical importance of environmental stewardship, the commission established sustainability as a new benchmark. And the commission succinctly defined sustainability to be the kind of global development that "meets the needs of the present without compromising the ability of future generations to meet their own needs."[1] With this definition, the goal of sustainability continued to recognize the need to preserve resources, but it also established a criterion by which the merits of development could be measured: Will we preserve and generate sufficient resources for our children and their children to live productive and satisfying lives?

Green = Sustainable

Beginning with the Brundtland report, "green" became synonymous with "sustainable." Using this new definition, the U.S. Green Building Council could well be called the U.S. Sustainable Building Council. This broader usage of green/sustainable may generate some confusion within the building industry because "green" is frequently used to describe the application of vegetation to building components, such as "green roofs" covered with plants. Hopefully, however, the use of "green" as a broader term will prevail, and alternate names for vegetated roofs will be coined. (As a suggestion, "living roofs" may be a good choice, since it is also used to describe wall systems that support vegetation: "living walls.")

In addition to becoming synonymous, "green" and "sustainable" also have become broad, all-encompassing terms for many environmental concepts. Examples of terms used to describe portions of the larger green/sustainable movement include "environmentally responsible," "energy-efficient," "resource-renewable," "recyclable," "carbon-neutral," etc. This expanded concept of sustainability suggests, for example, that an energy-efficient roof is a green roof, just as a recyclable roof is a green roof. But it also implies that a green roof in its fullest sense is an environmentally responsible/energy-efficient/renewable/recyclable/carbon-neutral roof!

Why Is Green Important?

The emergence of "green" as a new development paradigm could not have arrived at a more opportune time, as a confluence of factors has triggered a virtual tsunami of environmental alarms across the globe. And just as the green mindset is broader than previous environmental thinking, the environmental issues we confront today may be larger than any challenge humanity has previously experienced.

Energy Concerns

For those of us who can remember the OPEC oil embargo of 1970, it is easy to identify both similarities and differences in today's predicament of rapidly increasing oil prices. In some ways, the current crisis appears to be milder – after all, there are no

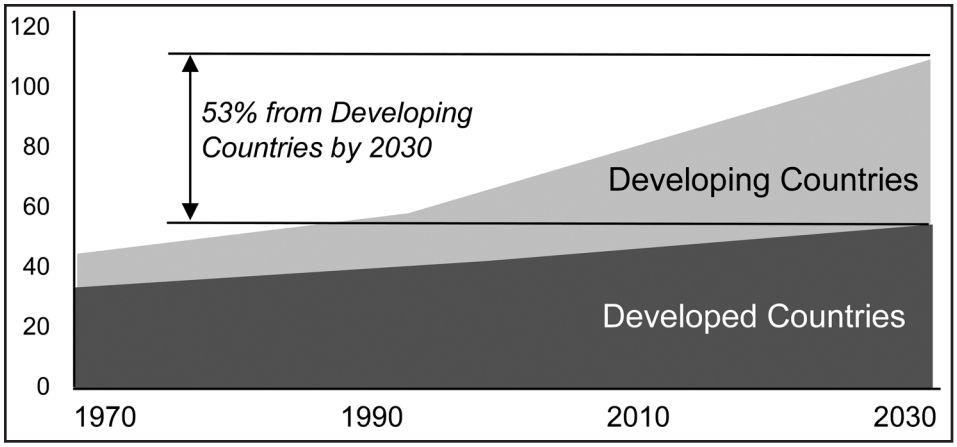

Figure 1: Projected world oil demand: 1970-2030 in millions of barrels per day.
Source: International Energy Agency "World Energy Outlook, 2006" (reference scenario).

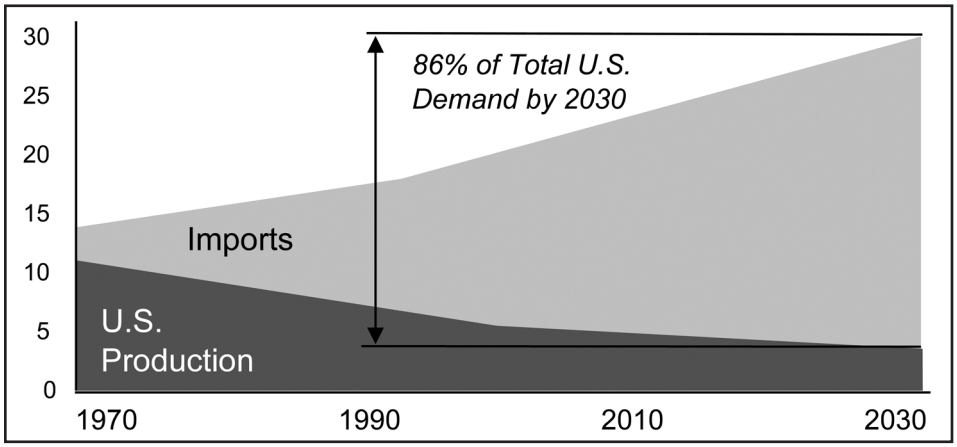

Figure 2: Projected U.S. oil supply: 1970-2030 in millions of barrels per day.
Source: International Energy Agency "World Energy Outlook, 2006" (reference scenario).

lines forming at gas stations, which was a common sight in 1970. At the same time, the current crisis may be viewed as much more severe for several reasons. First, the double-digit runup in oil and gasoline prices hasn't been driven by acute supply constrictions or willful embargos: the world is simply demanding more petroleum-based fuels than are currently available. As illustrated in *Figure 1*, global demand for oil as projected by the International Energy Agency is skyrocketing – and expected to grow even faster as the developing nations seek to join the developed world with modern, consumer-driven economies. In fact, IEA projections suggest that the developing world (which consumed less than 15% of all oil during the 1970 oil crisis) will consume more oil than all the developed nations combined by 2030.

In addition to rapidly growing world demand for oil, U.S. dependence on imported oil is growing at an even faster rate. During the OPEC oil embargo of 1970, the United States was dependent on imports for only 20% of its total oil needs. Today, that percentage is over 50%, and, as illustrated in *Figure 2*, it is projected to grow to 86% by 2030.

Regardless of the cost of oil and regardless of the environmental impacts of continued fossil fuel usage, these two charts clearly indicate the fundamental problem with the current oil-based U.S. economy: it simply isn't sustainable if dependence on imported oil continues to grow as projected.

Environmental Concerns

Increasing energy demands and continued reliance on fossil fuels have heightened concerns about the role of combustion gases in the apparent warming of the earth's temperature. Although a detailed discussion of global warming is well beyond the scope of this brief paper, it is important to note two relatively indisputable facts. First, the planet is warming compared to the recent past. As shown in *Figure 3*, average annual global surface temperatures since 1980 have increased between ½ and 1½° Fahrenheit as compared to the three decades prior to 1980. In addition, the average for the 1950 - 1980 period is ½ to 1° warmer than previous averages since 1880.

Although there may still be reasonable debate regarding global warming and fossil fuel consumption, it is important to recognize that fossil fuel-generated CO^2 will continue to climb at a dramatic rate as the developing world escalates its projected usage of oil, gas, and coal. *Figure 4* illustrates how over 80% of the projected global energy supply will continue to come from fossil fuels by 2030, causing greenhouse gas emissions to rise over 57% during the same period.

Given the sizeable projected increase in greenhouse gas emissions over the next two decades, perhaps the best possible outcome for the planet might come about if the global warming doubters are right. But, if glob-

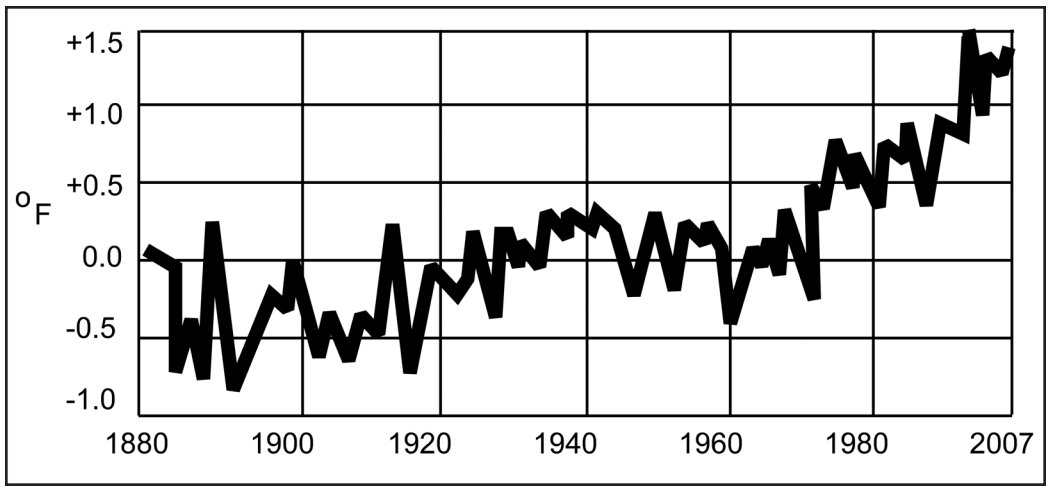

Figure 3: Deviation of global surface air temperature from 1951-1980 average.
Source: NASA Goddard Institute for Space Studies.

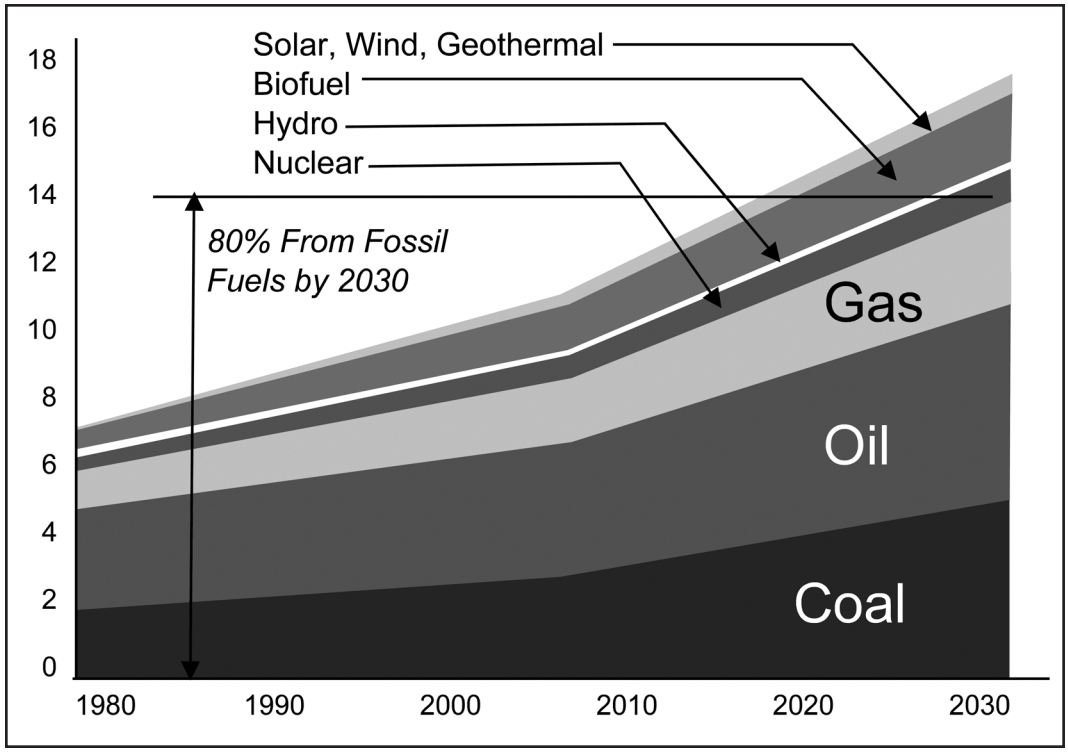

Figure 4: Projected global energy supply: 1980-2030, in billions of tons of oil equivalents.
Source: International Energy Agency "World Energy Outlook, 2006" (reference scenario).

al warming is real and inextricably linked to CO^2 production, then we may be dangerously increasing the risks of irreparable change to the planet's ecosystems.

Other environmental concerns beyond the issue of global warming and CO^2 exist, as well. Many urban areas in the United States, as far north as Chicago, are subjected to increasing summer air temperatures due to the "urban heat island" effect of dark paving and roofs. These same urban areas also tend to suffer from unusually high levels of ozone, produced through the confluence of heat and emissions from vehicles and volatile organic chemicals. Finally, many urban areas of the U.S. continue to endure unacceptably high instances of pollution spills into lakes and streams due to the continued use of combination sewer systems. These environmental problems can be attributed to many different causes, but a sizable portion of their effects can be linked to buildings – the materials used to construct them, the characteristics of their surfaces, and their relationship with the cities in which they are constructed.

Beyond the litany of environmental risks lies one more very important reason why the way we design and construct our buildings is so important. Simply put, we can do so much better. Comparing the experience of California, a state recognized for environmental leadership, with the rest of the United States, the opportunity for improvement becomes painfully obvious. As shown in *Figure 5*, while per capita electrical consumption (used mostly in buildings) has remained relatively constant in California, per capita electrical usage for the entire U.S. has escalated nearly 100%. Clearly, this indicates a significant opportunity for improvement in energy efficiency.

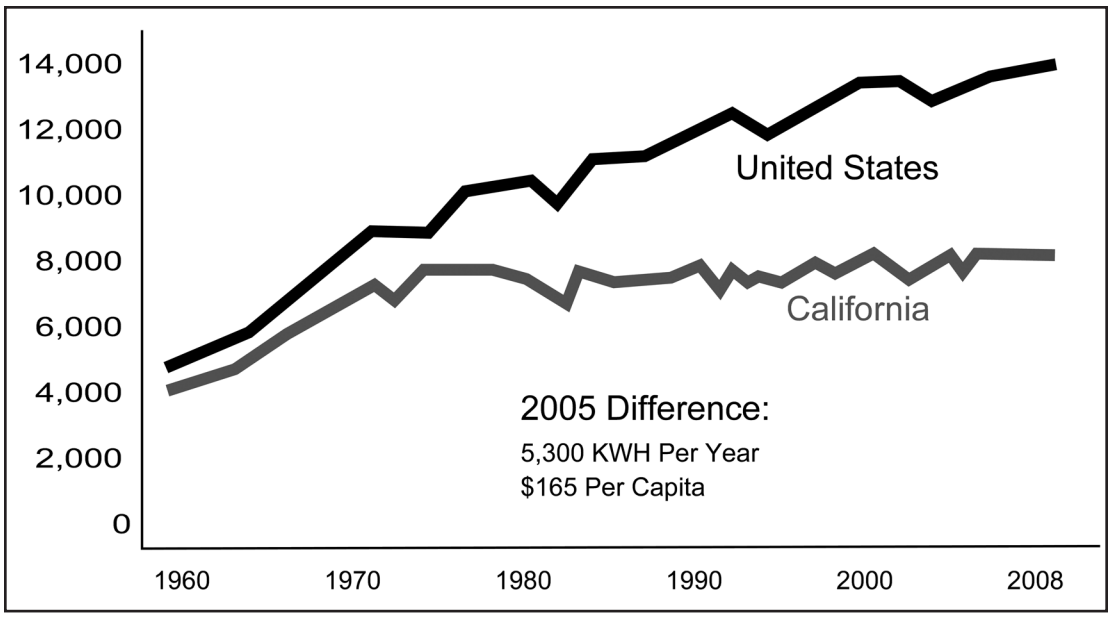

Figure 5: Per capita electricity consumption: United States vs. California — kwh/yr.
Source: California Energy Commission

WHO IS LEADING THE GREEN BUILDING MOVEMENT?

Nongovernmental Organizations

As mentioned previously, the green movement is uniquely different from past environmental initiatives, and this difference is reflected in its leadership. Most important are the many nongovernmental organizations, or NGOs, that have formed under the green banner. A few years ago, the acronym "NGO" was rarely used, but today over one in 15 Americans work directly for NGOs, and their combined annual budgets exceed $500 billion.[2] The following is just a sampling of the many new NGOs involved in the green building movement:

- The U.S. Green Building Council/ LEED
- Global Building Initiative/Green Globes

- Sustainable Buildings Industry Council
- Alliance to Save Energy
- Energy Efficient Building Association
- Green Roofs for Healthy Cities
- Environmental Energy & Study Institute
- Smart Growth Network
- Center for Resourceful Building Technology
- Indoor Air Quality Association
- New Building Institute
- American Council for an Energy-Efficient Economy
- American Solar Energy Society
- The Daylighting Cooperative
- The Center for Environmental Innovation in Roofing

With the exception of several energy-efficiency organizations (whose roots go back to the first U.S. energy crisis of the 1970s), almost all the green organizations on this list have been formed within the past decade.

Global Corporations

In the history of the environmental movement, corporations were frequently cast as antagonists, but in today's green movement, many of the world's largest private corporations are playing leading roles. Obviously, some of the interest of large companies involves a desire to project a positive public image, but corporate involvement in the green movement extends far beyond mere image concerns. Global corporations are also concerned about the prospects for economic growth so vital to their shareholders as well as the need for common standards to conduct business across the world.

Because of this multifaceted interest, global corporations are playing a key role in the funding of green research and the development of sustainable standards. In Europe, the BASF Corporation is a recognized leader in the scientific analysis of environmental impacts through its Eco-Efficiency Analysis program. In the United States, corporate support provided to organizations such as the U.S. Green Building Council by corporations in the building sector has truly been impressive.

State and Local Governments

Finally, governments also are involved; but much of this involvement has emerged at the state and local levels and not from Washington. From the state of California's Title 24 to the city of Chicago's cool roofing standards, green innovation is being spearheaded at local and regional levels of government. As stated in a review of the green movement in a recent edition of *The Economist*:

> The federal government's recalcitrance remains the biggest obstacle to an effective global scheme to tackle the problem. But where in Europe or Asia new ideas often flow from the center to the regions, in America, the states are the incubators of big shifts in policy. *This means that change is coming—fast!* [3]

HOW IS GREEN DIFFERENT?

Process-Based

The focus on sustainability as the watchword of the green building movement has lead to nuanced differences from historical environmentalism that are very important to building industry professionals. First, the "new green" tends to emphasize process over product. While the first response of some in the building industry to the emerging green movement is to quickly specify and use green products, the concept of sustainability extends to ways in which these products are designed, produced, used, maintained, and eventually disposed of. Perhaps the best explanation of this process-based perspective was given by Steve McGuire, environmental market manager for Philips Lighting, at a recent green building conference when he asked rhetorically, "How can a 'green' product be produced in a 'brown' factory? How can a 'green' product be used in a 'brown' facility?" [4]

In many ways, the process-based approach of the green movement is related to a similar process-based perspective that was a hallmark of the quality revolution that started in Japan in the early 1950s and swept across the globe in the 1980s and 1990s. In fact, just as quality management revolves around the well-known ISO 9000 standards, the green movement also involves a similar series of standards: the ISO 14000 series of environmental management standards. And just like the ISO 9000 standards with their emphasis on documentation, accountability, and continuous improvement, the ISO 14000 standards provide a road map to fully integrate our factories, our building sites, and our living environments into a harmonious, sustainable whole.

Science-Based

The green movement's emphasis on process naturally extends to other rational methods, most importantly a science-based approach to resolving problems. At one point in the historical environmental movement, the word "natural" was used widely to promote environmentally preferable products. Today, however, synthetic products may be just as environmentally suitable, providing they are more sustainable than the "natural" alternative. As an example in the building materials industry, studies[5] have demonstrated that some materials made from plastic – most notably plastic foam insulation materials – may be more sustainable and produce lower environmental impact than naturally occurring materials such as cork or mineral fiber. In and of itself, an ounce of raw plastic probably has a greater environmental impact than an ounce of raw cork, but that ounce of plastic may produce a larger quantity of finished product (foam plastic insulation may be significantly lighter than similar cork or mineral wool insulation), and the extraction and processing of the plastic may require less energy than the extraction and production of cork or mineral wool.

It is important, however, to emphasize that these differences between the "new green" and previous environmental initiatives are more subtle than substantive. Certainly, environmentalism has always emphasized process-based and science-based solutions, but the green movement's emphasis on sustainability makes this much more apparent and important.

WHERE IS GREEN BUILDING GOING?

From Life Cycle Cost to Life Cycle Assessment

Life Cycle Assessment (LCA) is a scientific approach for evaluating the environmental impact of a product throughout its life cycle. LCA is frequently referred to as a "cradle-to-grave" approach, although, with the addition of comprehensive recycling programs, it may also be called a "cradle-to-cradle" approach that tracks the impact of a product from the initial extraction raw materials to the final recycling of these materials into new products. Recently, the board of directors of the U.S. Green Building Council voted to incorporate LCA as a key component in its well-known LEED® Green Building Rating System,™ and with this endorsement it is reasonable to assume that the LEED system will be progressively modified to integrate LCA

principles and procedures into the traditional point structure.

Because LCA measures the indirect environmental costs of a product, LCA differs from traditional Life Cycle Cost analysis (LCC), which focuses almost exclusively on direct economic impact. As a consequence, LCC may be more directly related to a product's durability as reflected in its service life. However, if environmental impact is considered a superior measure of economic cost in the long run, then LCA may be viewed as a more accurate form of traditional LCC. And if the long-run environmental impact of a product is indeed the best reflection of its true economic cost, then LCA should be equally as sensitive to the comparative durability of materials as traditional LCC. For example, if an apparently "environmentally friendly" roofing system with a useful service life of under 20 years is compared to a more traditional roofing system with a service life of over 30 years, the total environmental impact of the traditional roof will be lessened due to its superior service life. As a result, the lowered environmental impact of a longer service life may make the traditional roof a superior choice over the supposed environmentally friendly roof.

From Code Compliance to High Performance

While all buildings are (or should be) constructed to mandated minimum codes, the concept of the high-performance building refers to "above the code" buildings with significantly enhanced energy efficiency and longevity. In its High-Performance Buildings Program, the U.S. Department of Energy defines a high-performance building as a building that "delivers energy savings, environmental performance, and economic benefit substantially better than standard practice."[6] High-performance buildings assure a safe environment protected from the elements, reduce energy costs and resource requirements through operating efficiencies, and deliver a lower life cycle cost by extending service life.

This concept of an "above-average" building as opposed to a code-mandated minimum standard is starting to take hold in the marketplace. As a most recent example, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) is preparing a draft of a building energy standard that is not initially designed to be part of standard building codes. ASHRAE 189.P "Standard for High-Performance Green Buildings" is intended to provide a new "above-the-code" level of performance for use by building designers and owners concerned about long-term sustainability. Some of the provisions of this new standard may not be as cost effective as current building code standards, but given the rapid increases in energy costs, they may accurately anticipate where energy design needs to go in order to provide the best economic payoff in the long run.

ROOF-RELATED HEATING AND COOLING COSTS
100,000 SQ FT HEATED AND COOLED WAREHOUSE
CHICAGO, IL

Standard	Roof R-Value	Annual Heating & Cooling Costs	Savings
ASHRAE 90.1-1999	15	$15,295	n/a
ASHRAE 90.1-2007	20	$13,172	$2,123
ASHRAE 189.P	25	$10,855	$4,440

Table 1

Source: NRCA EnergyWise Roof Calculator (roof system only, gas heating/electric cooling).

Table 1 provides an example of the amount of roof-related energy savings possible using the new ASHRAE 189.P standard for a 100,000 sq ft heated and cooled warehouse in Chicago. As compared to the current standard in Chicago (currently based on the 1999 version of ASHRAE 90.1) and even the most recent 2007 version of the ASHRAE minimum standard, the new "Standard for High Performance Green Buildings" may provide a significant annual energy savings, especially if the standard is incorporated either at initial construction or during periodic roof system replacement.

From Energy-Efficient to Carbon-Neutral

Because high-performance measures like the example above may be incorporated with minimal up-front expense and yield sizable cost savings over a building's lifetime, some forward-looking building organizations have established even more ambitious goals to reduce the environmental impacts of energy usage. Most notably, the American Institute of Architects (AIA) has called for a 50 percent reduction by 2010 of fossil fuels used to construct and operate buildings, with additional reductions every five years to achieve "carbon-neutral" buildings by 2030. Moving beyond energy-efficient measures like increased insulation, tomorrow's buildings will actually have to start generating energy in order to achieve zero net carbon emissions. Examples of these "clean" energy sources include photovoltaic, solar, wind, geothermal, and daylighting.

WHAT DOES GREEN MEAN FOR THE BUILDING ENVELOPE PROFESSIONAL?

For the building envelope designer and consultant, the green building movement offers both opportunities and risks. As awareness of the importance of sustainable buildings increases, so, too, will the importance and prestige of informed building professionals who can help building owners chart a green course for their facilities. And because the building envelope will play such a large role in the development of the next generation of green buildings, building envelope designers will have the opportunity to become leaders in the green building movement. But this enlarged role comes with a prerequisite for increased education and professionalism. In the process-based, science-based world of green design, there will be less and less room for building professionals who lack fundamental organizational and technical tools.

For the building envelope designer and consultant seeking ongoing professional development to prepare for a broad and meaningful role in sustainable construction, the following areas of professional development may be very important:

ISO 9000 and 14000

To better understand the process orientation of the green movement, building designers should consider investing time to learn about the ISO family of management standards, both for quality management (ISO 9000) and environmental management (ISO 14000). ISO has become the quality and environmental "language" of major corporations, and building designers would be well served to understand this language. One of the easiest and most economical ways to learn more about ISO is to review the extensive ISO information collected on

Wikipedia for ISO 9000 (www.en.wikipedia.org/wiki/ISO_9000) and ISO 14000 (www.en.wikipedia.org/wiki/ISO_14000).

Sustainable Building Design

An excellent resource for integrating sound management principles into green building design is the *Whole Building Design Guide* (hwww.wbdg.org), published online by the National Institute of Building Sciences. The *WBDG* contains important chapters on key sustainability concepts, including sustainable design principles, building commissioning, and ongoing building systems management.

Life Cycle Assessment

LCA is becoming the primary analytical tool of the green movement, and building professionals need to understand the key principles of LCA in order to make credible design recommendations. Some excellent objective resources for LCA include the U.S. Environmental Protection Agency (www.epa.gov/ORD/NRMRL/lcaccess/) and the Athena Institute (www.athenasmi.ca/about/).

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