

## Green and Healthy Buildings for the Healthcare Industry

Author: Gail Vittori  
Center for Maximum Potential Building Systems, Austin, Texas

### Introduction

Just as health care professionals diagnose a patient's illness and prescribe appropriate treatment, so too are a growing number of building professionals diagnosing how buildings affect human health and the environment and prescribing strategies to minimize these impacts. This is in response to mounting evidence that buildings through their life cycle are significant causes of human illness and environmental degradation. According to the U.S. Environmental Protection Agency (EPA) and its Science Advisory Board (SAB), indoor air pollution is one of the top five environmental risks to public health.<sup>i</sup> On average, people in the US spend 90% of their time indoors.<sup>ii</sup>

Many common construction materials can emit dangerous compounds and harbor infectious molds, fungi and bacteria. Specific materials such as adhesives, carpeting, upholstery, and manufactured wood products emit volatile organic compounds (VOCs), including formaldehyde, a probable human carcinogen. PVC (Polyvinyl chloride or vinyl) products such as in flooring, carpet and wall covering can release a variety of hazardous additives, including endocrine disrupting phthalate plasticizers and heavy metal stabilizers.

For people confined indoors due to illness and particularly for those with depressed immune systems, both prominent populations in healthcare facilities, the consequences of any of these impacts can be significant. As well, facility staff and visitors are susceptible to the range of potential health effects of poor indoor air quality, including asthma and other respiratory health problems, cancer, and reproductive and developmental impairment.

How buildings are designed, and the materials and methods used to construct and operate them, have significant consequences to the natural environment and health outcomes of people outside of the building envelope as well. Building-related activities are responsible for 35% to 45% of CO<sub>2</sub> releases into the atmosphere,<sup>iii</sup> a precursor to global warming, and deplete the stratospheric ozone layer by using refrigerants and products, including some insulation materials, manufactured with ozone depleting compounds. Buildings use over 75% of the polyvinyl chloride (PVC or vinyl) produced.<sup>iv</sup> Manufacture and disposal of PVC, as well as its combustion in accidental fires, is linked to emissions of a wide range of persistent bioaccumulative toxins. Indeed, PVC is likely the leading material contributor to the environmental release of dioxin, the most potent synthetic carcinogen ever measured. Construction also accounts for about 40% of raw stone, gravel, sand, and steel consumption, and 25% of virgin wood. Buildings use about 40% of energy resources and 16% of water, while building construction and demolition generates about 25% of municipal solid wastes.<sup>v</sup> Each of these impacts has direct or indirect consequences on human health, the extent of which is becoming better understood as the interconnections between buildings, human health and environmental quality are subjected to more rigorous analyses.

Recognizing these issues, professional associations such as the American Institute of Architects (AIA) and the UIA/AIA World Congress of Architects have issued clear directives to incorporate sustainable design and green building strategies as basic and fundamental to standard practice.<sup>vi</sup> The American Society of Healthcare Engineering (ASHE) has developed a guidance document specifically to encourage the incorporation of sustainable design elements in healthcare facilities<sup>vii</sup>. In addition, local, state and federal public policymakers are adopting green building guidelines, and corporations are establishing

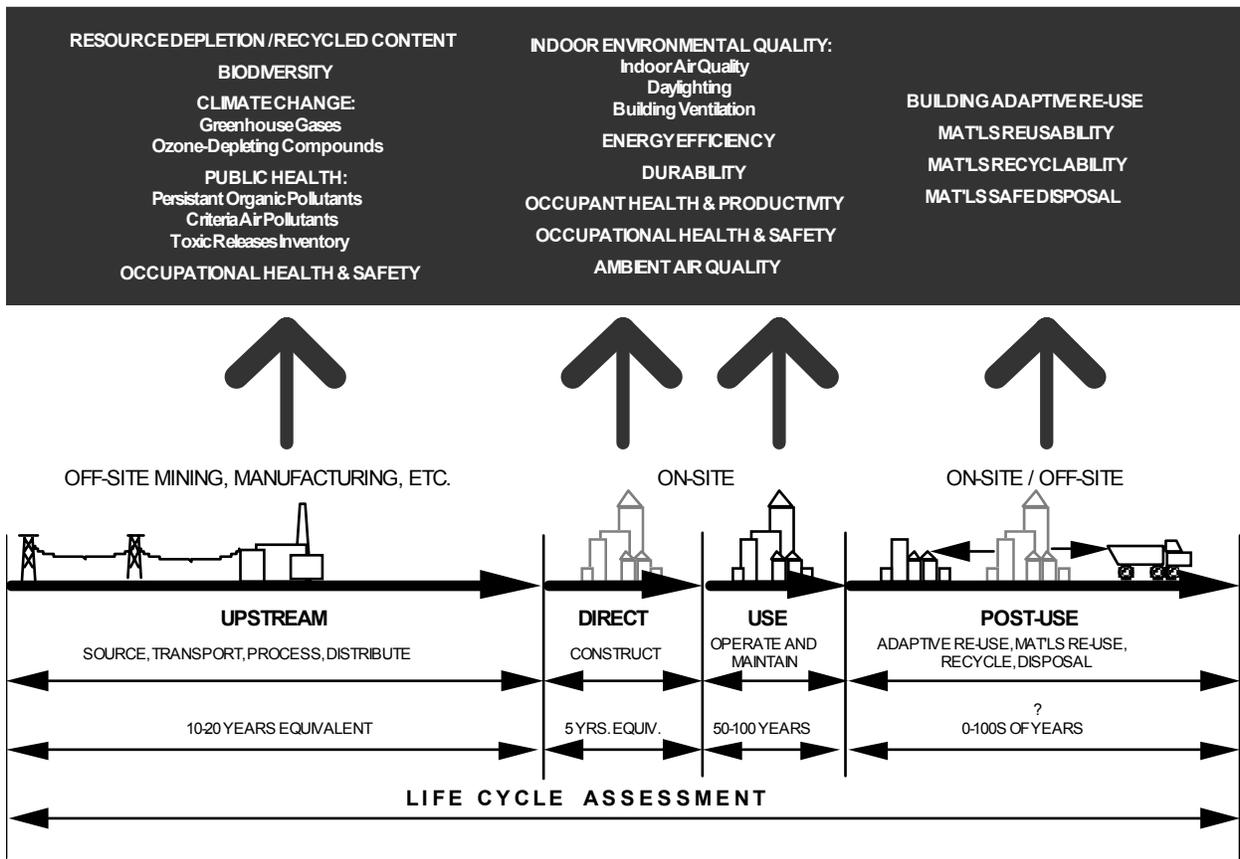
environmental building standards. These emerging strategies redefine the way buildings are designed, built, and operated, and extend the conventional notion of building performance to include human health and environmental quality as essential cornerstones of quality and value.

This shift in practice towards green and healthy buildings is fundamentally consistent with the core value of health care professionals – first, do no harm. To this end, healthcare practitioners should assume a public health oriented position relative to the facilities in which they operate, and ensure that these buildings do not degrade the health of individuals or of the general public by implementing sustainable design, operation, and maintenance practices.

The process of creating and maintaining dynamic healthcare settings is just beginning to be understood by owners and providers. They must learn that budgeting needs to change from first-cost to full cost accounting that, for example, extends a conventional balance sheet to include a value for health impacts and the environment. They must grasp the concept of preventive maintenance and integrated, anticipatory design. Finally, they must embrace the concept of partnering with their suppliers and design professionals to continue to explore the linkages between the nature of the physical environment and the impact the environment--including the built environment--has on medical outcomes, user satisfaction and productivity.<sup>viii</sup>

### **Guiding Principles**

More than an optimization of any single component, sustainable design and construction represents the integration of materials and methods that, together, create the physical manifestation of a building. The entire life cycle of building materials and products, as well as the building as a whole relative to its physical, environmental and human contexts on the local, regional and global scales, must be evaluated for environmental and health considerations (see Figure 1 below). We are informed by the U.S. EPA's findings that indoor air pollution is one of the top five environmental risks to public health, and by the U.S. Science Advisory Board's assessment of highest global environmental priorities: global climate change, loss of biodiversity, habitat destruction, and stratospheric ozone depletion. While not as obvious as to their affect on human health as indoor air quality, these indicators of environmental health at risk--rising global temperatures, increased exposure to ultraviolet radiation, and diminished supplies of natural resources--signal trouble for the human species. Establishing life cycle health and environmental considerations as evaluative criteria for design decisions and material and product specifications yield measurable benefits in enhanced patient outcomes, improved worker productivity, and reduced operations and maintenance costs, to name a few. This recognition should trigger immediate review and modification of existing A/E Guidelines, standard procurement policies and specifications.



**FIGURE 1: LIFE CYCLE ASSESSMENT OF BUILDING MATERIALS AND PRODUCTS**  
(Figure by CENTER FOR MAXIMUM POTENTIAL BUILDING SYSTEMS)

**Upstream** environmental and health impacts occur during the materials acquisition (source), transport, manufacture, and distribution life cycle stages of materials and products. These impacts can be equivalent to 10-20 years of a building’s operation. In conventional economics, these impacts are called “externalities.”

Construction of the building is the **Direct** life cycle stage. Its impacts are equivalent to about five years of building operation. The **Use** stage includes the operation and maintenance of the building and is typically assumed to be 50 years or more in Life Cycle Costing estimates. Owners are interested in payback periods during the expected life of the building, i.e., in how many years will savings in operational costs become equal to or greater than an initial investment in a particular improvement. Beyond a cost justification, investment in healthy building practices yields measurable results in medical outcomes for patients.

After the building’s useful life, the building can be modified for “adaptive re-use” or the building’s materials and products can be reused, recycled, or disposed. This is the **Post-Use** stage of materials and products. Reusing or recycling materials reduces burdens on landfills, conserves resources, and saves the contractor or owner the costs of landfill disposal. This is one example of “cost avoidance”.

Case studies confirm that facilities can be greened with nominal, if any, additional costs. Design decisions and material choices that may represent higher first costs are recouped through savings in operations, maintenance and enhanced worker performance over the life of the building. Indeed, recent studies at major commercial/manufacturing facilities, such as Herman Miller’s SQA Factory in Zeeland,

Michigan and at government facilities such as the U.S. EPA's Research Facility in Research Triangle Park, North Carolina correlate superior indoor environmental quality (IEQ) with enhanced worker productivity.<sup>ix</sup> Because worker salaries represent the highest portion of a building's operational costs, a 1% improvement in productivity far outweighs any additional costs associated with green design features or healthy materials and products.<sup>x</sup> Consistent with these findings and more germane to healthcare professionals, other research shows that improving the quality of hospital spaces can lead to decreased length of stays for patients.<sup>xi</sup> Clearly, establishing the highest achievable standards for indoor environmental quality (IEQ) is an important guiding principle for all healthcare facilities.

## **Problem Statement**

### ***Unique Characteristics of Healthcare Facilities***

Healthcare facilities, averaging between 70 and 75 million square feet of construction per year,<sup>xii</sup> have unique programming criteria that guide design decisions and material, product and equipment specifications. Understanding the complex of human health implications of these decisions is critical. For example, the Academy of Architecture and Health cites research indicating that natural lighting, indoor landscaping, rooftop gardens, solariums, and small atria have a health impact on hospital staff and can improve the feeling of well being and medical outcomes in patients. They recommend maximizing views of nature and landscaping from all patient environments, and increasing the use of skylights, interior transom windows, and natural light.<sup>xiii</sup>

In addition, these buildings undergo a high rate of change, as interior spaces are reconfigured, remodeled and outfitted with new furnishings and equipment reflecting changes in management and delivery systems.<sup>xiv</sup> The result is an enormous amount of waste. Recognizing this trend, the International Facility Management Association (IFMA) Healthcare Council has tracked the development of flexible healthcare interiors based on building shell construction with universal distribution networks designed to minimize waste and accelerate schedules. According to an article in IFMA's *Facility Management Journal*, "The advantages of this approach are rapid project completion, clean and quiet installation, great flexibility and costs similar to those of conventional construction, but with significant lifecycle cost and operational savings".<sup>xv</sup>

Representing a substantial share of annual design and construction activities in the U.S., the healthcare sector is well-positioned to highlight the potential that buildings have to reverse environmental decline and to create environments for people that enhance health, patient outcomes, and workplace performance. The purchasing power represented by the healthcare industry can lead to industry partnerships to improve the health and environmental profiles of buildings throughout their life cycle. Recognizing this shared responsibility among designers, manufacturers, building owners, facility managers and public policymakers sets an agenda that will yield important outcomes. As the allied building professionals are directed to implement green and healthy buildings, manufacturers will be increasingly encouraged to shift their practices in response to a growing demand for sustainable products and practices.

Similarly, it is appropriate and timely to establish partnerships between the regulating and the regulated communities. Guidelines and regulations overseeing hospital design and construction should be evaluated based on their impacts on environmental quality and human health and revised so that they reflect these as priority considerations.

### ***Indoor Environmental Quality***

While poor air quality is commonly associated with outdoor air, air inside buildings is often worse. As buildings were constructed to tighter energy efficiency standards in the 1970's, the materials and compounds used to manufacture common building materials were found to have harmful emissions, with

direct affects on people's health. In response, improved ventilation standards were established; however, numerous common building materials and products--standard specifications for commercial and institutional buildings--continue to be sources of indoor air pollution. Both improved ventilation rates and source elimination are necessary to achieve and maintain good indoor air quality.

According to the U.S. EPA, most sources of indoor air pollution come from materials and products used in the building such as adhesives, carpeting, upholstery, and manufactured wood products that emit volatile organic compounds (VOCs), including formaldehyde, a probable human carcinogen.<sup>xvi</sup> Indeed, the construction industry is the primary end-user of formaldehyde-based products, representing 70% of its use.<sup>xvii</sup> Health affects from VOCs and other contributors to poor indoor air quality include asthma, cancer, and reproductive and development effects, and are manifested in thousands of cancer deaths and hundreds of thousands of respiratory health problems.<sup>xviii</sup> Specifications that require use of materials with low or no VOCs and no added formaldehyde certified by strong emissions testing protocols can greatly improve indoor air quality.

PVC (polyvinyl chloride) building products raise serious indoor health concerns along with the life cycle environmental concerns mentioned above. The release of highly toxic hydrogen chloride gas fumes and dioxins and furans resulting from accidental or intentional combustion of PVC has prompted a range of domestic and international firefighter organizations to advocate the use of PVC alternative products. In addition, exposure to PVC can lead to exposure to the host of hazardous compounds used as additives in PVC products. Particularly notable are the offgassing of endocrine disrupting phthalate plasticizers used in many flexible PVC products, and the release of toxic heavy metals stabilizers such as lead, cadmium and organotins used in rigid PVC products. PVC has also been found to encourage toxic mold growth as moisture is trapped behind PVC wall coverings.<sup>xix</sup>

One of the plasticizer additives used in flexible PVC products, DEHP (di-ethylhexyl phthalate), was evaluated by the federal Center for the Evaluation of Risks to Human Reproduction (CERHR) of the National Toxicology Program. In their report, the CERHR expressed concern that exposure of pregnant women to current estimated adult exposure levels of DEHP might adversely affect the development of their offspring. They also raised serious concern about the possibility of adverse effects on the developing reproductive tract of male infants exposed to very high levels of DEHP from medical devices.<sup>xx</sup> As a result, the U.S. Food and Drug Administration recently urged healthcare providers to consider alternatives to PVC medical products that leach DEHP.<sup>xxi</sup> and Health Care Without Harm has recommended that hospitals specify building products made without PVC.<sup>xxii</sup>

Acknowledging these concerns, some major hospital systems are seeking to eliminate PVC from both medical devices and building products. PVC free products, in both traditional and new material formulations, are available for the entire range of building applications from carpet and flooring products to wall coverings, roof membranes, furniture and pipes.<sup>xxiii</sup>

### ***Obstacles to Green Building***

Despite a growing recognition of the benefits of green building, many factors contribute to only a modest transformation of design and building practices to date. These include:

- *Resistance to change:* Innovation in the building industry lags behind virtually every other economic sector, with a few notable exceptions. The consolidation of ownership of natural resources and manufacturing infrastructure retards the competitive vibrancy that has become a distinguishing characteristic of other sectors such as telecommunications. In addition, professional academic training for architects and engineers has been slow to incorporate environmental and human health considerations into the core curriculum, so practitioners leave school without the benefit of this training.

*Recommendation:* Require the same level of innovation in your buildings as in your healthcare delivery systems; contract with design professionals with established credentials in green and healthy buildings; provide appropriate training to building-related professionals to implement the changed practice.

- *Fear of liability:* Introducing unfamiliar methods and materials raises liability concerns, especially when professional architects and engineers are required to stamp drawings.

*Recommendation:* Establish strategic academic and industry partnerships, invest in research, development and demonstration projects, and monitor outcomes to reduce the liability risks. Compare the benefits of enhancing the environmental and health performance of buildings with the present liability of buildings that compromise environmental quality and human health. Consider that these present liabilities could be substantially expanded and increased as a more robust economic valuation of environmental quality and human health is codified and enforced.

- *Perception of higher costs:* Healthcare facilities typically operate for 30, 50, 100 years or more. An accounting system that artificially distinguishes the capital (first cost) budget from the operations and maintenance (O&M) budget hampers the ability to make decisions based on life cycle cost analysis.

*Recommendation:* Front-loading the design process and material and product specifications to create a green and healthy building and optimize cost performance over the life of the building is a sound investment. A study by the National Bureau of Standards concludes that in a typical office the labor cost of employees is 13 times the cost of the facility itself over its life cycle, including construction, furnishings, maintenance, and interest, while the cost of design is only about 1/50<sup>th</sup> the labor cost of people.<sup>xxiv</sup> Investing in design, materials and products that enhance productivity and improve health-related outcomes are quickly recouped and improve the bottom-line over time.

### **Solution**

Redefining buildings through their life cycle as integral parts of a healthy regional ecosystem, and as environments that directly impact human health, are basic principles of green building. Minimizing wastes, pollution, and toxics associated with the construction and operation of buildings and pursuing every opportunity to optimize indoor environmental quality are measurable performance goals. This agenda is consistent with the fundamental mission of healthcare professionals and should be reflected in their building portfolios.

The healthcare industry is appropriately positioned to invest in research and demonstration projects to evaluate, make recommendations and implement policies and procedures to enhance the therapeutic qualities of healthcare facilities, and minimize material- and labor-intensive remodeling and renovation practices. Moreover, investments should extend to enhance the environmental performance of their buildings by adopting and implementing green building guidelines and establishing health and environmental performance parameters for all planning, design, specification, operations, maintenance, and post-use decisions.

## **Implementation**

### ***Short-Term Actions (Year 1)***

1. Incorporate green and healthy buildings into the strategic plan and establish an in-house “green team” to implement corporate commitment with mandate to:
  - review existing building-related policies and procedures, augmented by consultants as appropriate;
  - develop green specifications;
  - develop green housekeeping guidelines for building superintendent and custodial staff; engage in legislative advocacy; and
  - establish accountability protocols
2. Require architects, engineers and contractors to specify commercially available, cost competitive materials and products as substitutes for products that compromise environmental quality and human health. Example substitutes are:
  - PVC-free products, e.g., flooring, wall covering, carpet backing, ceiling tile, plumbing pipe, roof membrane
  - formaldehyde-free engineered wood products, e.g., oriented strand board, medium density fiberboard, plywood, furnishings
  - no/low VOC products, e.g., paints, adhesives, stains, finishes, floor coverings
  - acoustical ceiling tiles that do not support growth of fungi and bacteria
  - materials and products manufactured without ozone depleting compounds (CFCs, HCFCs and halon), e.g., insulation, refrigerants, fire suppressants
  - treated wood manufactured without chromium or arsenic
  - certified sustainably harvested wood products (as per Forest Stewardship Council)
  - highest available recycled content steel and concrete to fulfill performance requirements
3. Provide and/or require attendance at green and healthy building training seminars for all building related staff and upper management
4. Expand responsibilities of Environment, Health & Safety Department to include monitoring indoor air quality and ongoing commissioning of major operational systems
5. Measure energy and water consumption , greenhouse gas emissions, and waste generation and establish efficiency goals based on baseline
6. Adopt the American Society of Healthcare Engineering (ASHE) Green Healthcare Construction Guidance Statement as a goal for facility project design and use to create a road map of strategies to incorporate in designs.
7. Review and modify, as appropriate, U.S. Green Building Council's LEED rating as a preliminary green building evaluative tool
8. Establish reuse and recycling as prioritized tiers of the facilities' waste management practices

### ***Mid- to Long-Range Actions (Years 3-5)***

1. Establish life cycle metrics for environmental, human health and natural resource performance to guide design decisions, material and product specifications and construction and operational protocols
2. Design for the long-term (50-year+ building life expectancy)
3. Merge capital & O&M budgets to optimize life cycle costing
4. Establish procurement policies and building material and product specifications consistent with the green and healthy metrics; provide for annual review/revision
5. Establish partnership with regulators to review/revise regulations to reflect impacts on human health and environmental quality

6. Establish an internal green and healthy building rating system, and/or adopt the U.S. Green Building Council's LEED with amendments to reflect particular priorities of healthcare facilities with focus on environmental health criteria and environmental exposures
7. Establish permanent position to oversee compliance with green and healthy building standards and create a template for green building design, construction, operation and maintenance
8. Provide ongoing green building training opportunities (on-site/off-site) for all building related staff and upper level management
9. Integrate/balance resource flows (energy, water, materials) to enhance life-cycle efficiency
10. Design for flexibility to facilitate operational changes, respond to changing user needs and minimize waste generation and labor requirements

### **Key Online Resources**

Healthy Building Network • [www.healthybuilding.net](http://www.healthybuilding.net)

Hospitals for a Healthy Environment • [www.h2e-online.org/](http://www.h2e-online.org/)

Environmental Building News • [www.buildinggreen.com](http://www.buildinggreen.com)

National Institute of Building Sciences (NIBS) Whole Building Design Guide • [www.wbdg.org/index.asp](http://www.wbdg.org/index.asp)

### **Organizations**

American Society for Healthcare Engineering (ASHE)  
One North Franklin, 27th Floor • Chicago, IL 60606  
(312) 422-3800 • [www.ashe.org](http://www.ashe.org)

The Center for Health Design  
3470 Mt. Diablo Blvd. • Lafayette, CA 94549  
925/299-3631 • [www.healthdesign.org](http://www.healthdesign.org)

Center for Maximum Potential Building Systems  
8604 F.M. 969 • Austin, TX 78724  
512/928-4786 • [www.cmpbs.org](http://www.cmpbs.org)

Committee on the Environment  
American Institute of Architects  
1735 New York Avenue, NW • Washington, DC 20006  
202/626-7300 • [www.e-architect.com/pia/cote](http://www.e-architect.com/pia/cote)

Environmental Building News  
122 Birge Street, Suite 30 • Brattleboro, VT 05301  
800/861-0954 • [www.buildinggreen.com](http://www.buildinggreen.com)

Green Roundtable  
Brookline, MA  
617/374-3740 • [www.greenroundtable.org](http://www.greenroundtable.org)

HDR Inc.  
8404 Indian Hills Drive • Omaha, NE 68114-4049  
402/399-1000 • [www.hdrinc.com](http://www.hdrinc.com)

Health Care Facility Research Consortium  
International Facility Management Association Healthcare Council  
P.O. Box 151 • Barrington, RI 02806  
401/245-6212 • yarmeco@aol.com

Health Care Without Harm  
1755 "S" Street NW, Unit 6B • Washington DC 20009  
(202) 234-0091 • www.noharm.org

Healthy Building Network  
C/o Institute for Local Self Reliance  
2425 18<sup>th</sup> Street, NW • Washington, DC  
202-232-4108 • www.healthybuilding.net

Hospitals for a Healthy Environment (H2E)  
1755 S Street NW, Suite 6B • Washington DC 20009  
800-727-4179 • [www.h2e-online.org/](http://www.h2e-online.org/)

The Natural Step  
Thoreau Center for Sustainability • P.O. Box 29372 • San Francisco, CA 94129  
415/561-3344 • www.naturalstep.org

Rocky Mountain Institute  
1739 Snowmass Creek Road • Snowmass, CO 81654-9199  
970/927-3851 • www.rmi.org

U.S. Green Building Council  
1825 I Street, NW • Washington, DC 20006  
202/429-2081 • www.usgbc.org

### **Case Studies**

See [www.healthybuilding.net/healthcare/hindex.html](http://www.healthybuilding.net/healthcare/hindex.html) for case study listings



The author wishes to acknowledge and thank the following people who contributed valuable comments and content to this paper: Carol Antle, Davis Baltz, Gary Cohen, Rich MacMath, Jan Stensland Patton, Kevin Powell, Scott Pyrsi MD, Mark Rossi, Tom Lent, Bill Walsh.

## Endnotes

---

- <sup>i</sup> U.S. Environmental Protection Agency, Indoor Air Quality Home Page, [www.epa.gov/iaq/](http://www.epa.gov/iaq/), 23 August 2000.
- <sup>ii</sup> U.S. Environmental Protection Agency, "Healthy Buildings, Healthy People: A Vision for the 21<sup>st</sup> Century" (Draft Report), Office of Air and Radiation, March 2000.
- <sup>iii</sup> Roodman Malin, David & Nicholas Lenssen, "A Building Revolution: How Ecology and Health Concerns are Transforming Construction". Worldwatch Institute, Washington, DC, March 1995.
- <sup>iv</sup> Geiser, Kenneth, Ph.D., presentation materials, June 2000.
- <sup>v</sup> Roodman Malin, David & Nicholas Lenssen, "A Building Revolution: How Ecology and Health Concerns are Transforming Construction". Worldwatch Institute, Washington, DC, March 1995.
- <sup>vi</sup> American Institute of Architects, Sustainable Design Resolution 00-3, passed unanimously by convention delegates, May 6, 2000, and UIA/AIA World Congress of Architects, "Declaration of Interdependence for a Sustainable Future". Chicago, Illinois, 18-21 June 1993.
- <sup>vii</sup> American Society of Healthcare Engineering, "Green Healthcare Construction Guidance Statement" Chicago., IL, January, 2002 See also ASHE's Sustainable Design Awards Program.
- <sup>viii</sup> Yarme, Howard and Judith Yarme, "We Have Heard of Sick Buildings, But Can Buildings Also Be Therapeutic?", Health Care Facility Research Consortium, Barrington, RI, 2000.
- <sup>ix</sup> U.S. Green Building Council, LEED™ Reference Guide, Pilot Version 1.0, April 1999.
- <sup>x</sup> American Institute of Architects Committee on the Environment, "Healthy, Productive Buildings: A Guide to Environmentally Sustainable Architecture". [www.e-architect.com/pia/cote/hlth\\_bld.asp](http://www.e-architect.com/pia/cote/hlth_bld.asp).
- <sup>xi</sup> Parimucha, Joseph P. AIA, James Lussier, Barbara J. Huelat, "Health-Facility Planning, Design, and Construction: It Costs How Much? Bottom Line Reality". Conference Report, Academy of Architecture for Health.
- <sup>xii</sup> McKahan, Donald, AIA, "Healthcare Facilities: Current Trends and Future Forecasts". Planning Design and Construction of Healthcare Environments, Joint Commission on Accreditation of Healthcare Organizations, Oakbrook Terrace, IL 1997.
- <sup>xiii</sup> Ibid.
- <sup>xiv</sup> Baskerville & Son, "Healthcare Design Newsletter", 2000, 804/343-1010.
- <sup>xv</sup> Yarme, Howard and Judith Yarme, "Assuring Speech Privacy in Flexible Healthcare Settings". Facility Management Journal, International Facility Management Association
- <sup>xvi</sup> U.S. Environmental Protection Agency, "Indoor Air Facts No. 4 (revised): Sick Building Syndrome". Office of Air & Radiation, Office of Research and Development, Office of Radiation and Indoor Air, April 1991.
- <sup>xvii</sup> Massachusetts Toxics Use Reduction Institute, 2000 Formaldehyde Chemical Fact Sheet, [www.turi.org](http://www.turi.org).
- <sup>xviii</sup> U.S. Environmental Protection Agency, "Healthy Buildings, Healthy People: A Vision for the 21<sup>st</sup> Century" (Draft Report), Office of Air and Radiation, March 2000.
- <sup>xix</sup> Thorton, Joe, Ph.D., "Environmental Impacts of Polyvinyl Chloride Building Materials," Healthy Building Network, Washington, D.C., October 2002.
- <sup>xx</sup> National Toxicology Program, Center For The Evaluation Of Risks To Human Reproduction, Expert Panel Review Of Phthalates, July 14, 2000.
- <sup>xxi</sup> U.S. Food and Drug Administration July 15, 2002 [www.fda.gov/cdrh/safety.html](http://www.fda.gov/cdrh/safety.html)
- <sup>xxii</sup> Health Care Without Harm, Press Release: "Government Panel Expresses "Serious Concern" that Toxic chemical in Vinyl Medical Products May Harm Sick Infants". 13 July 2000.
- <sup>xxiii</sup> "PVC Free Alternatives Materials" [www.healthybuilding.net/hindex.html](http://www.healthybuilding.net/hindex.html), Healthy Building Network, 2002,
- <sup>xxiv</sup> American Institute of Architects Committee on the Environment, "Healthy, Productive Buildings: A Guide to Environmentally Sustainable Architecture". [www.e-architect.com/pia/cote/hlth\\_bld.asp](http://www.e-architect.com/pia/cote/hlth_bld.asp).