Design for Health

Summit for Massachusetts Health Care Decision Makers

For further information, see www.noharm.org/designforhealth or contact Alexis Karolides, alexis@rmi.org or Bill Ravanesi, ravanesi@comcast.net.

Working closely with our strategic partners (most notably, Gail Vittori of the Center for Maximum Potential Building Systems, Robin Guenther of Guenther 5 Architects, and Barbra Batshalom of the Green Roundtable), Rocky Mountain Institute and Health Care Without Harm organized and facilitated *Design for Health: Summit for Massachusetts Healthcare Decision Makers*, which took place at Massachusetts Medical Society, Waltham Woods Conference Center, 860 Winter Street, Waltham, MA on 28–29 September 2004. This report documents the recommendations of the Summit.

Rocky Mountain Institute (RMI) is a market-oriented resource policy center. Its mission is to foster the efficient and restorative development of natural, human, and other capital to make the world secure, just, prosperous, and life sustaining. Founded in 1982 by resource analysts Hunter and Amory Lovins, RMI was noted initially for its pathfinding work on energy efficiency and its relationship to environment, development, and security. RMI's energy research rapidly expanded into related efforts to adapt its information and implementation techniques to wider social needs.

Today, RMI's roughly 50-person staff is engaged in projects that use market implementation to solve environmental and community problems. Program areas include: climate protection, community services, energy, greening of commercial and institutional buildings and developments, commercial industrial services, and water efficiency.

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Health Care Without Harm (HCWH) is an international coalition of hospitals and health care systems, medical professionals, community groups, health-affected constituencies, labor unions, environmental and environmental health organizations and religious groups. Its mission is to transform the health care industry worldwide, without compromising patient safety or care, so that it is ecologically sustainable and no longer a source of harm to public health and the environment.

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RMI's super efficient headquarters building located in Snowmass, Colorado.

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Acknowledgements

Rocky Mountain Institute and Health Care Without Harm are deeply grateful for the generous support of our donors and collaborators, without whom this Summit would not have been possible.

We would especially like to thank the following financial contributors:

Merck Family Fund,
An anonymous foundation,
Massachusetts Health & Educational Facilities Authority,
Julia Reid Summers,
Massachusetts Technology Collaborative,
Mineral Acquisition Partners,
Ferdinand “Moose” Colloredo-Mansfeld,
Dr. Bradford Cannon,
Henry F. Dup Harrison,
Sarah and Cornelia “Lia” Cannon Holden, and
Stephen E. Binder and Kris R. Estes
Margaret Hubbard
Polly B. Drinkwater
Susan and William A. Bartovics
Susan Morser Klem
Anna Ruthe Tyson
Doris and M.W. Bouwensch
Dr. and Mrs. Robert H. Potts, Jr.
Mary Crowe
Asa de Roode
Charles and Hannah Keevil
Peter J. and Fannie C. Watkinson
Emily and Thomas Haslett

We are indebted to the following individuals and organizations for their significant help planning, preparing, and facilitating the Summit and for their contributions to this report:

Robin Guenther, Guenther 5 Architects,
Gail Vittori, the Center for Maximum Potential Building Systems,
Barbra Batshalom, the Green Roundtable, Massachusetts Hospital Association, and
Alex Chase.

Finally, we extend a sincere thank you to all of our Summit presenters, facilitators, experts and scribes for dedicating their time and expertise to this effort and to the Summit participants, who came both to learn and to contribute, and made the Summit a tremendous success.

Executive Summary

The primary goal of Design for Health: Summit for Massachusetts Healthcare Decision Makers was to bring together leading healthcare facility decision makers, discuss the arguments for and evidence supporting "healthy design," and brainstorm initiatives and implementation strategies to achieve healthier hospitals—healthier for patients, healthier for staff, healthier for the environment and community, and healthier for hospital financial security.

Featured Summit speakers presented multiple arguments in favor of greening hospitals. These included *environmental stewardship* to avoid harming public health while healing individuals, *higher performance* to enhance patient outcomes and staff performance, and *better business practices* to provide long-term resource/operational savings, better capital infusion, and better systems reliability and quality.

Summit participants collaboratively came up with recommended hospital initiatives that fell into four categories: Collaborative Boston Community/Regional Initiatives, Individual Hospital Policy Initiatives, Architecture/Design Initiatives and Engineered Systems Initiatives. Highlights of these initiatives included:

Collective next steps

- Establish a Massachusetts "Green Hospital Champions Council" to facilitate collaboration and information exchange.
- Work with local/state government, utilities, Massachusetts Technology Collaborative or others to promote tax, rate, and other incentives (and to remove barriers) for green building and, in particular, for combined cooling heat and power (CCHP) initiatives.
- Work with standard setting organizations to improve state regulations and remove roadblocks to implementation of sustainable building strategies.
- Purchase collaboratively to leverage market transformation toward more sustainable building materials, products, and medical equipment.
- Endorse the *Green Guide for Health Care* (GGHC).
- Hold an integrated design workshop bringing "green" engineering and design professionals together with healthcare engineers to develop optimal mechanical systems for healthcare settings. Focus particularly on ventilation strategies and their relationship to infection control.
- Provide or support public education on environmental health factors and healthy building design.
- Establish an information exchange forum and case-studies database:
  - Further the business case for green hospital design by collecting usable cost/benefit data.
  - Support evidence-based studies comparing outcomes associated with high-performance vs. standard design.
  - Continually record, collect, and circulate green hospital case studies.

Individual hospital next steps

- Engaging top hospital decision-makers, adopt an operational policy framework that addresses the relationship between human and environmental health, and embraces environmental stewardship, the "precautionary principle," and the maxim "first do no harm."
- Provide education for hospital staff and for the public regarding healthy building operations and lifestyle practices.
- Assess your facility for resource usage and environmental impacts; then implement a program to save water, energy, and other resources, reduce construction and operational waste, and reduce the hospital's environmental footprint. For specific recommendations about strategies to save energy and other resources, see the following report sections:

Individual Hospital Policy Initiatives, Architecture/Design Initiatives and Engineered Systems Initiatives.

- Establish purchasing policies that promote environmental and human health.
- Incorporate life-cycle costing in construction policies.
- Commit to integrated holistic green design for new capital projects, including a broader range of stakeholders and experts in upfront planning: adopt the *Green Guide for Health Care* (GGHC) and register a pilot project.
- In cooperation with the distribution utility, develop a combined cooling, heating, and power (CCHP) system to provide efficient energy supply and premium reliability.
- Establish building design practices that incorporate healthy indoor environmental quality (including optimal lighting/daylighting, acoustics, ventilation, exposure to nature, healthy building materials, etc.), effective and sufficient maintenance, continuous commissioning of mechanical systems, and effective and flexible design (see Architecture/Design and Engineered Systems sections for specific recommendations for patient rooms, nursing stations, operating rooms, etc.).
- Engineer ventilation strategies (particularly in labs and other critical areas) to improve indoor air quality and reduce hazards while maximizing energy efficiency; evaluate and consider using displacement ventilation (see Engineered Systems section for specific recommendations).
- Generate and circulate case study information: inventory the status quo, implement green programs and construction practices, monitor and evaluate results of sustainability improvements.
- Join Hospitals for a Healthy Environment (H2E).
- Assign dedicated staff members to these efforts and green the design team: create an internal “green” team with cross-departmental representation and assure that outside contractors are experienced with and motivated to follow green design practices.

Summit Background and Description

Design for Health: Summit for Massachusetts Healthcare Decision Makers

Health Care Without Harm and Rocky Mountain Institute joined forces to lead the two-day Design for Health Summit (also noted in this report as "the Summit") to address the opportunities and challenges in implementing sustainable design principles in the Massachusetts healthcare construction marketplace. The Summit was held at the Massachusetts Medical Society's Waltham Woods Conference Center during September 28–29, 2004.

We sought participants who are either actively engaged in the early development of a "green" capital project, or are considering such a project in the near future. To maximize participation, we limited Summit attendance to 115 people, 85 of whom were key decision makers from healthcare institutions across the Commonwealth, including CEOs, CFOs, directors of capital planning and facilities, vice presidents of support services, operations, and real estate, and directors of energy, engineering, and facilities. Additionally, the Summit registered a dozen leading healthcare architecture and engineering firms that are actively engaged with the represented facilities.

The primary goal of the Summit was to bring together this community of leading healthcare facility decision-makers, discuss the arguments and evidence supporting "healthy design" and brainstorm initiatives and implementation strategies to achieve healthier hospitals—healthier for patients, for staff, for the environment and community and for hospital financial security.

Projected favorable outcomes from "green" design included:

* Reduced operating costs,
* Better clinical outcomes for patients,
* Reduced risk and potential liability,
* Meeting potential future regulatory requirements,
* Improved market performance in key health areas,
* Enhanced staff satisfaction, recruiting, and retention,
* Enhanced community relationship,
* Demonstration of corporate responsibility and environmental leadership, and
* Healthier environmental impact.

Summit participants pursued candid and constructive dialogue on the critical issues surrounding green design for the healthcare sector: determining the market and business case for it, the obstacles against it, and the policies and strategies that would implement it.

The Summit offered 15 breakout sessions facilitated by professionals with expertise in healthcare design, high-performance green design, and environmental health. These roundtable working sessions focused on specific topics relevant to hospital design and operations, including environmental health, indoor air quality, energy, water, business case, community, products and waste streams, and healing environments. Each breakout group produced performance and policy recommendations associated with the topic area. The Design for Health Summit also included a green building healthcare poster session that highlighted a dozen high performance healthcare capital projects from North America.

In addition to the breakout sessions the Summit's featured speakers included:

- Dr. Samuel Wilson, Deputy Director, National Institute of Environmental Health Sciences. Dr Wilson's opening remarks addressed "Environmental Health: A Response Based on Partnership, Planning, and Environmental Stewardship."
- Amory Lovins, CEO, Rocky Mountain Institute. His presentation addressed, "The Triple Bottom Line for Hospitals: Healthy People, Healthier Environments, Healthier Financials." This

presentation focused on how energy-efficient, high-performance buildings with clean, reliable power can meet all three goals.

- Dr. Sandra Steingraber, biologist and author of *Living Downstream: An Ecologist Looks at Cancer and the Environment*. Dr. Steingraber addressed the life cycle toxicity of Polyvinyl Chloride (PVC) as a discredited building material.
- Charlotte Brody, RN, co-executive director of Health Care Without Harm, whose role it was to “connect the dots” from the preceding day’s activities.
- Douglas Foy, Secretary of Commonwealth Development, Office of Community Development, Commonwealth of Massachusetts. He spoke about what Massachusetts is doing on sustainability/energy performance and how his office is knitting together a number of state agencies (housing, transportation, energy, etc.) so they can be more strategic about development.
- Boston Mayor Thomas Menino. He presented the City of Boston’s “Green Building Policy Perspective,” focusing on the importance of the healthcare sector adopting high performance “green” building standards.

The Summit staff made a concerted effort to record the proceedings and capture the essence of the two-day gathering. The summit proceedings, including breakout sessions outcomes, recommendations matrix, power point presentations, agenda, list of participants, etc. can be accessed at: http://www.noharm.org/designforhealth.

Introduction: Toward Healthier Hospitals

In many ways, hospitals are particularly well suited to be green, high-performance buildings.[1] Hospital operators typically own their buildings and thus bear the life cycle implications of their construction choices. Normal hospital operation consumes large amounts of resources and energy, and thus presents a great opportunity for savings from efficiency measures. Finally, the very mission of healthcare institutions implies that they should be leaders in healthy construction and operational transformations, from the elimination of mercury to adherence to Infection Control Risk Assessment (ICRA) protocols to rigorous, sustainable construction practices that could inform the wider construction industry.

Hospitals are also particularly complex and provide unique building challenges.[2] Critical around-the-clock building operation and the need for heat and power makes hospitals ideal candidates for clean, reliable on-site combined heat and power generation. Healthcare facilities are most often multiple-building campuses of varying ages, conditions, and systems, and construction frequently occurs adjacent to occupied buildings. The design and operation of healthcare buildings is highly regulated with intense economic and life-safety oversight.

Described as "the most vibrant and powerful force(s) to impact the building design and construction field in more than a decade" by *Building Design & Construction* magazine, the otherwise successful green building movement has been relatively slow to infiltrate the hospital market. With over $16 billion spent on the healthcare construction sector annually (expected to increase to $20 billion per year by 2010)[3] considerable opportunity exists to design the next generation of healthcare facilities. In a report released by Robert Wood Johnson's Designing for the 21st Century Hospital Project, Sara Marberry offers evidence to show that many of the best design practices for offices, factories, and schools are often applicable to the hospital industry.[4] Adapting green building design to the healthcare facilities market will help ensure that future healthcare buildings are healthier, more effective, cost less to operate, and are more enjoyable places in which to work and heal.

Nationwide Progress Toward Healthier Hospitals

- As depicted in the three charts below, the built environment is, in general, both consumptive and polluting[5] and hospitals are one of the most energy- and resource-intensive building types. Undoubtedly, there is room for improvement.

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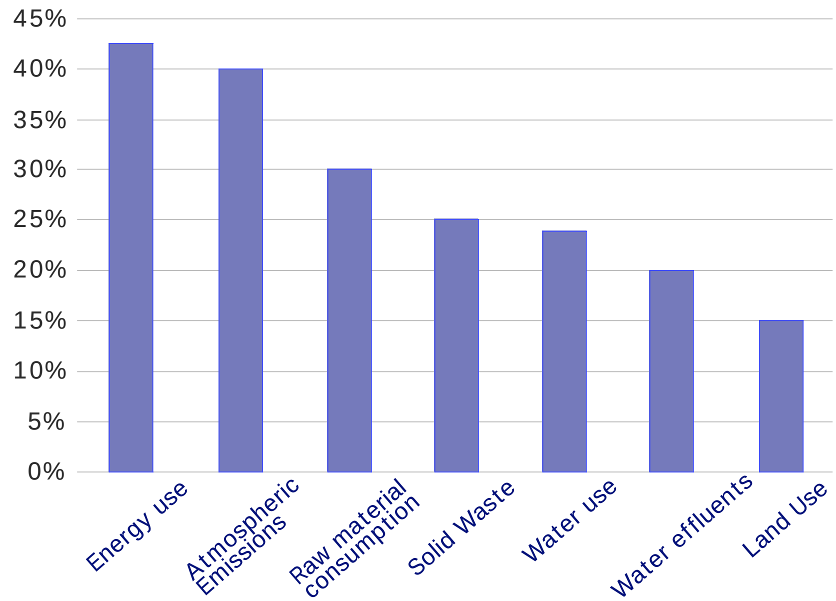
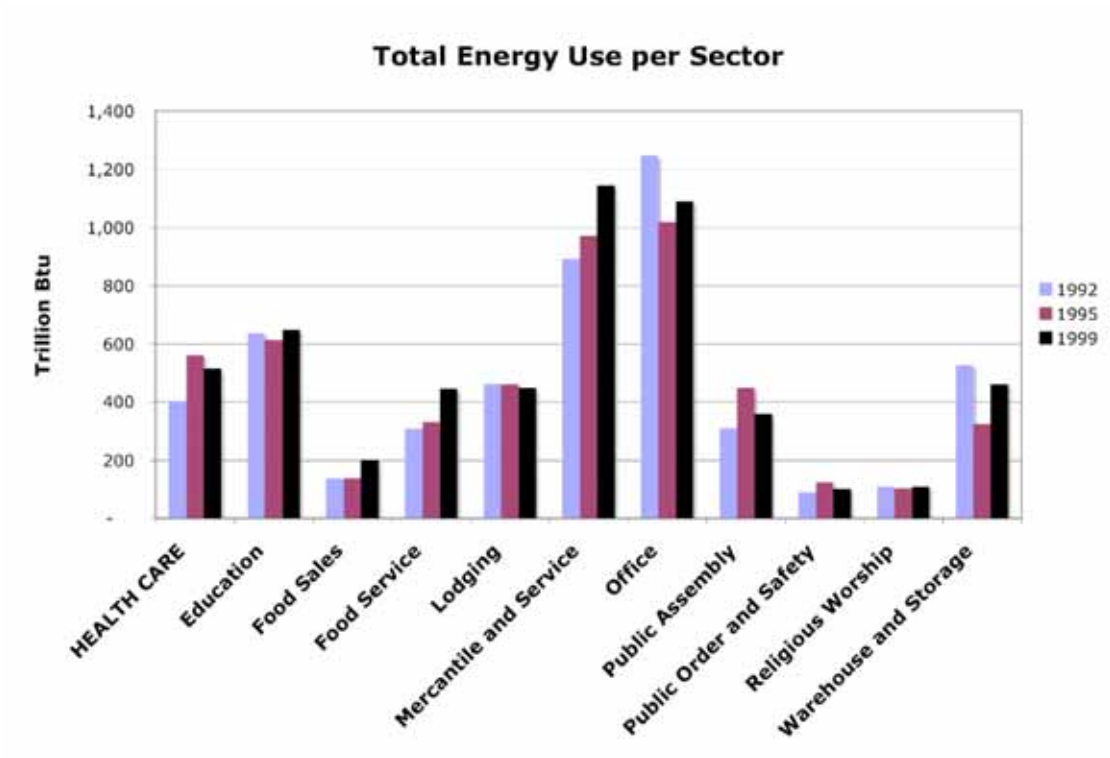
[1] Guenther, Robin and Gail Vittori, presentation, *Design for Health: Summit for Massachusetts Health Care Decision Makers*, 28 September 2004.
[2] Ibid.
[3] Ulrich, Roger et al, "The Role of the Physical Environment in the Hospital of the 21st Century: A Once-in-a-Lifetime Opportunity," 2004.
[4] Marberry, Sara, "Designing Better Buildings: What can be learned from offices, factories, and schools," 2004.
[5] Guenther, Robin and Gail Vittori, presentation, *Design for Health: Summit for Massachusetts Health Care Decision Makers*, 28 September 2004.

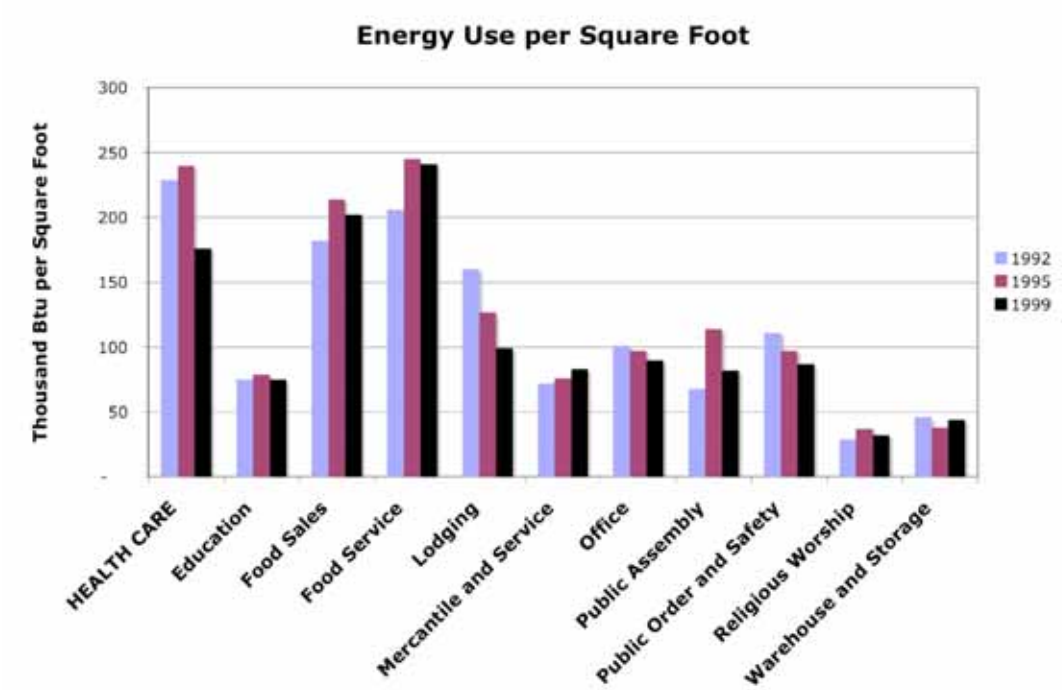


Building Construction, Operation, and Demolition as a Percentage of Overall Environmental Impact[6]



Source: U.S. Department of Energy.[7]

[6] Guenther, Robin and Gail Vittori, presentation, *Design for Health: Summit for Massachusetts Health Care Decision Makers*, 28 September 2004.
[7] http://www.eia.doe.gov/emeu/efficiency/cbecstrends/cbecs_tables_list.htm#Commercial%20Buildings%20Primary%20Energy



Source: U.S. Department of Energy[8]

- In 1996 the U.S. Environmental Protection Agency (EPA) identified dioxin as the most potent human carcinogen ever measured and named medical waste incineration as a major contributor to worldwide airborne dioxin levels. In 1996 there were 5,600 medical waste incinerators in operation in North America; today only 111 remain.[9]
- In 1998 the American Hospital Association signed a voluntary memorandum of understanding with the EPA pledging reductions in solid waste and virtual elimination of mercury by 2005.
- An international health advocacy group with more than 20,000 members, Physicians for Social Responsibility (PSR) has brought a powerful and scientifically respected message to policy makers and the public. The group targets toxics and health, children's environmental health, air pollution and health, climate change, energy and health, chronic disease and the environment, safe drinking water, land use and public health, and vulnerable populations.
- In 2001, the American Society for Healthcare Engineering (ASHE), a division of the American Hospital Association (AHA), issued a construction guidance statement that called for:
  - Protecting the immediate health of building occupants,
  - Protecting the health of the surrounding community, and
  - Protecting the health of the global community and natural resources.
- In its first decade (1995-2005), the U.S. Green Building Council (USGBC) has grown exponentially to 5,500 members, and its Leadership in Energy and Environmental Design (LEED) building rating system (a voluntary consensus-based national standard for developing high-performance sustainable buildings) has grown exponentially as well. According to the USGBC's website, since the first-version release of LEED in 1999, 1771 projects have been registered.
- In the opinion of Summit presenters Gail Vittori and Robin Guenther, as green building is linked with high performance, human health, safety and security, regulation and policy will support continued development of the industry; conversely, buildings perceived as weak, unsafe, or contaminated will fall under eventual public scrutiny and potentially incur future financial liabilities.

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[8] Ibid.
[9] Guenther, Robin and Gail Vittori, presentation, *Design for Health: Summit for Massachusetts Health Care Decision Makers*, 28 September 2004.

A Key Step toward Healthier Hospitals: The Green Guide for Health Care (GGHC).

The GGHC was launched in 2003 with the goal of transforming the healthcare sector's building portfolio into healthy, high performance healing environments. Recognizing and reinforcing organizations that strive to engage in environmental stewardship, the GGHC addresses construction, usage and regulatory challenges, emphasizes environmental health, and considers operations and maintenance along with building design.

The GGHC was convened by the Center for Maximum Potential Building Systems and is sponsored by the Merck Family Fund, New York State Energy, Research and Development Authority (NYSERDA), and Hospitals for a Healthy Environment (H2E), a partnership of the American Hospital Association, the U.S. EPA, the American Nurses Association, and Health Care Without Harm. The Green Guide's ongoing development process relies on the work of its 18-member Steering Committee, a professionally and geographically diverse group of experts representing a broad spectrum of technical, operational, business and policy perspectives. This range of expertise assures consideration of the diverse issues relevant to the GGHC.

Based on a framework structured with permission after the U.S. Green Building Council's LEED®, the Green Guide for Health Care is a self-certifying metric tool, currently available in its 2.0 Pilot version. To fully embrace the broad view of healthcare facilities' planning, design, construction, and operations and to facilitate ease of use, the GGHC 2.0 pilot is divided into two sections, *Construction* and *Operations,* and emphasizes adoption of integrated processes and principles as imperative to achieving desired outcomes. The *Construction* section addresses integrated design, sustainable sites, water efficiency, energy & atmosphere, materials & resources, and innovation; the *Operations* section addresses integrated operations, energy conservation, water conservation, chemical management, waste management, environmental services, and environmental purchasing.

Underpinning each GGHC credit is a fundamental recognition of and links to an environmental health perspective—that is, the recognition that building-related decisions have profound impacts on human health and environmental quality through the life cycle. Moreover, the Green Guide is based on the values of prevention and precaution, as these values are intrinsic to healthcare itself. This explicit recognition of the direct and indirect human health consequences associated with the built environment distinguishes the Green Guide from other green-building rating tools, and presents an opportunity for the Green Guide to serve as a point of reference for other green-building rating tools as they evolve. Indeed, this expanded view of "health" within the context of the built environment holds resonance for every building sector seeking to enhance its performance.

Since its initial release for public comment in December 2003, the GGHC has commanded national and international attention, with over 5000 website registrants and 35 pilot projects in the United States, Canada, Europe and Asia, representing about 7,300,000 square feet. These engaged architects, engineers, healthcare providers, facility managers, medical professionals and policymakers in the public, private, and non-profit sectors represent the broad stakeholder interest that has voiced support for and interest in adopting the best practice strategies put forward in the Green Guide.

Massachusetts' Sustainability Efforts[10]

Sustainable design is spreading rapidly throughout the Commonwealth of Massachusetts. Both the public sector and private sector are seeing a flourishing of green building that is motivated both by policy and market trends. There is a growing list of over 80 individual projects of varying shades of green in the greater Boston area, in both new construction and renovation, spanning the institutional, educational, commercial, and residential categories. The majority is market rate construction with notable exceptions that were intentionally aggressive either with aesthetics, alternative technologies or "statement buildings." The following list gives more detail of ongoing activities within the different sectors.

Commonwealth of Massachusetts: Governor Romney restructured state departments to create the Office for Commonwealth Development (OCD), which combined the previously separate departments of transportation, environment, energy, and housing. He appointed Doug Foy to head OCD, the former executive director of Conservation Law Foundation, a nonprofit advocating for sustainable development. OCD focuses on sustainable development on a statewide scale and advocates for smart growth. In 2003, OCD outlined its agenda in a set of ten sustainable development principles.

The State Sustainability Initiative (SSI) is a program run by the Executive Office of Environmental Affairs, in collaboration with other state departments, under Executive Order 438. The SSI has a Roundtable made up of more than 50 stakeholders from public and private sectors who are in the midst of a one-year process to formulate recommendations and strategies that will make all state–funded construction projects green.

The Division of Capital Asset Management (DCAM) is the entity responsible for all public construction. DCAM has been internalizing green building standards, processes and practices for more than three years. It has written green design requirements into its request for proposals and rewritten standard specifications and other guidelines that inform projects. DCAM has already built projects and has many more underway.

For years, the Department of Education has been running a green schools program in collaboration with the Massachusetts Technology Collaborative/Renewable Energy Trust (MTC/RET), which uses the Massachusetts Collaborative for High Performance Schools (CHPS) as the green standard for compliance. MTC has been providing competitive grants for the green schools program that have been an effective catalyst to engage private sector design teams as well as communities to pursue green design.

MTC has been a catalyst for market transformation outside of the public schools realm as well. MTC's competitive grants have been obtained for 70 projects across the Commonwealth including universities, corporations, residential projects, biotech companies, and others. MTC is in the process of launching an in-depth case study compendium showcasing in detail each of these projects, their strategies, and various aspects of cost and performance data.

The Massachusetts Department of Environmental Protection organized and facilitated a public/private sector effort to create and implement a solid waste master plan to grow capacity and market for recycling construction and demolition waste. This multi-year effort has resulted in reduced costs for diverting material from landfills and an accelerated trend in the private sector to comply with new waste bans.

The Massachusetts Port Authority (Massport) has completed its first LEED registered terminal for Delta Airlines, which is its flagship green building. Massport's significant sustainable development efforts are even more deeply rooted in the south and east Boston neighborhoods that it has authority over, and it has been requiring green building in the development of the residential and mixed-use parcels surrounding the airport.

[10] Batshalom, Barbra, presentation and follow-up information, *Design for Health: Summit for Massachusetts Health Care Decision Makers*, 28 September 2004.

Local Government Initiatives: Cities and municipalities across the Commonwealth have been instituting various types of green building initiatives. Cambridge, Somerville, Brookline, Arlington, Belmont, Watertown, and Boston are all examples of local governments that have addressed green building from zoning, planning, and individual project angles. Boston's Mayor Menino launched the most comprehensive initiative to date with the completion of the Mayor's Green Building Task Force. The Task Force released recommendations to make Boston a leader in green building that are now being implemented. This comprehensive initiative requires and incentivizes green building in both the public and private sectors, and involves every city department in its implementation. More than 50 percent of Boston's land is owned or held by nonprofits, such as academic and religious institutions, which are emerging as leaders in green building developments.

***Institutional Initiatives*:** Colleges and universities such as Harvard, MIT, and Smith were early adopters of green building policies. All have completed projects and have incorporated sustainable development into their long term planning initiatives. Harvard has developed a revolving internal loan fund to incentivize projects and encourage aggressive green strategies, which has proven to be a financial success. There are more than four different healthcare institutions that have already incorporated green design strategies into current projects and have been using the Green Guide for Healthcare. The three major Boston museums—the Boston Children's Museum, The Museum of Science, and the Institute for Contemporary Art—all have significant green projects underway. More than five different private schools also have green building projects in the works process.

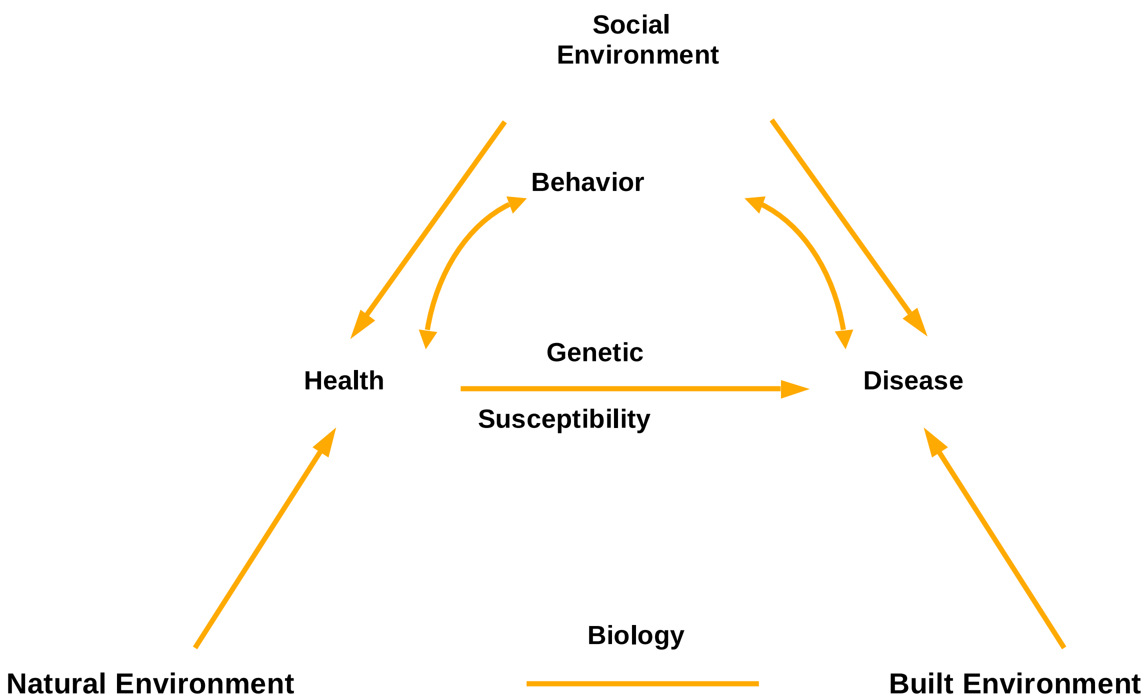
Statewide Green Building Programs: There are three green building programs underway that are being run by nonprofit organizations. The Green Community Development Corporation (CDC) Initiative is working with CDCs across the state to green their projects. The Massachusetts Municipal Outreach Program works with cities and municipalities across the State to incorporate green building initiatives into their policies and projects and the residential green building program, Green Homes Northeast (GHNE), which is a new program focused on market transformation in the residential sector.

Private Sector Transformations: The transformations in the private sector design professions and trade associations are accelerating on a daily basis. The number of LEED Accredited Professionals continues to grow exponentially and all LEED trainings in Massachusetts are filled to capacity. Development associations such as National Association of Industrial and Office Properties (NAIOP), Urban Land Institute (ULI), and Building Owners and Managers Association (BOMA) have ongoing green building programs for their constituents; contractors and unions have also begun to run training and education programs internally to build capacity in their trades. Financial institutions have launched a small number of green products for the residential market. Most requests for proposals (RFPs) that are issued in the private sector have some requirement for green design, which has triggered the most vigorous response in the design professions, and the trend continues to grow.

The Case for "Designing for Health"

The Case for Environmental Stewardship

There is no question that "environment" affects human health and well-being. The environment, however, is not simply limited to the natural realm; it is also comprised of social factors and human-built structures. As illustrated below, the natural, social, and built environments, and their complex interrelationships, impact human health and together comprise what we term "environmental health."[11]



> *"In its broadest sense, environmental health is the study of the direct pathological effects on health of chemical, physical and biological agents…and of the effects of the broad physical and social environment on human health.*"
>
> –World Health Organization, 1997

[11] Wilson, Samuel, presentation, *Design for Health: Summit for Massachusetts Health Care Decision Makers*, 28 September 2004.

When Rachel Carson wrote *Silent Spring*, Americans were awakened to the potential health impacts of human activity's toxic byproducts, alarmingly persistent in our environment. At the Design for Health Summit, Charlotte Brody soberly noted that dozens of bio-accumulative toxins are commonly found in mother's milk, and Sandra Steingraber described the potentially hazardous effects of common building materials. "Sick Building Syndrome," referring to the negative health effects of poor indoor air quality, has become a familiar term in the United States. The number of worker respiratory claims in healthcare environments more than doubled between 1985 and 1990, and it has continued at the same rate since measurements were taken.[12]

In addition, two health epidemics have been at least partially attributed to the design of the modern built environment:

> Obesity has become increasing rapid since the 70s and is now implicated in more than 300,000 premature deaths per year, second only to tobacco-related deaths. It is attributed to inactivity and poor eating habits, which may be partly caused by environmental factors—automobile dependence of sprawl-based community development, community design that discourages walking and biking, and workplace design and location that contributes to a sedentary lifestyle.
> The asthma epidemic (prevalence of asthma has increased 22 percent in males and 97 percent in females during 1982–1996) may be partly caused by environmental factors—increased exposure to indoor allergens and poor indoor air quality combined with more time spent indoors (90 percent on average), and decreased physical activity.[13]

These linkages between environment and health highlight the importance of environmental stewardship as part of the core mission of a healthcare institution. If, as stated by Dr. David Lawrence, Chairman & CEO of Kaiser Foundation Health Plan & Hospitals, healthcare is about "improving the health of the communities we serve,"[14] then healthcare institutions must commit to safeguard the environment, and to improve its design as relevant to health. The fact that hospitals (while adhering to status-quo, code-approved building practices) could negatively impact public health in the process of healing the sick is disturbingly ironic.

> *"There is a direct link between healing the individual and healing this planet. We will not have healthy individuals, healthy families, and healthy communities if we do not have clean air, clean water and healthy soil."*
>
> "*It is our core business to minimally impact the environment and to provide an optimum health[y] and safe environment for our workers and our patients."*
>
> –Lloyd Dean, President and CEO of Catholic Healthcare West[1]

How can health centers enhance environmental health? The challenge is to develop a holistic approach to environmental stewardship, to partner and collaborate with academic centers, government research labs, and private and public leaders, and to address the impacts of healthcare's own buildings by adopting environmentally conscious design and planning. Kaiser Permanente, for instance, has committed to limiting the adverse environmental impacts of its building siting, design, construction and operation. It is also pursuing two bold initiatives: its chemical policy will avoid the use of carcinogens,

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[12] Guenther, Robin and Gail Vittori, presentation, *Design for Health: Summit for Massachusetts Health Care Decision Makers*, 28 September 2004.
[13] Wilson, Samuel, presentation, *Design for Health: Summit for Massachusetts Health Care Decision Makers*, 28 September 2004.
[14] Excerpted from the proceedings of *Setting Healthcare's Environmental Agenda*, 16 Oct 2000.

mutagens, reproductive toxins, and persistent bioaccumulative toxins. Its food policy will support ecologically sound, economically viable, and socially responsible food practices, including issues of ecosystem health, antibiotic use, pesticide use, and food security as well as nutrition and reduction of obesity.[15]

Other executives in health care administration have expressed similar support for a multidisciplinary and integrated approach to changing the industry and creating better healing environments, as the following comments indicate:

"Just as we have responsibility for providing quality patient care, just as we have responsibility for keeping our facilities and technology up to date, we have a responsibility for providing leadership in the area of the environment. The stakes are extraordinarily high. We have to keep folding these questions and these considerations back into our leadership. We have to incorporate them into our incentives, into what it is we're held accountable to do, how we measure our impact. We all know the old saw "no margin, no mission." But as a colleague said, without the mission, I don't want to get up in the morning. Competing effectively is a need that we all have, but it isn't what healthcare is about. It's about improving the health of the communities we serve."—David Lawrence, MD, Chairman & CEO of Kaiser Foundation Health Plan & Hospitals. Excerpted from the proceedings of *Setting Healthcare's Environmental Agenda,* 16 Oct 2000

"The question is whether healthcare professionals can begin to recognize the environmental consequences of our operations and set our own house in order. This is no trivial question."—Michael Lerner, PhD, founder of the Health and Environmental Research Institute, Excerpted from the proceedings of *Setting Healthcare's Environmental Agenda,* 16 Oct 2000.

"The built environment has a profound impact on health, productivity and our natural environment. Healthcare facilities shall be designed within a framework that recognizes the primary mission of healthcare (including "first do no harm") and considers the larger context of enhanced patient environment, employee effectiveness, and resource stewardship—proposed draft text, AIA *Guidelines for Construction of Hospitals and Health Care Facilities*, 2006 edition, Chapter 2 Environment of Care.

The Case for Higher Performance Hospitals

The United States is currently spending more than $16 billion per year building hospitals, a number that is expected to increase to over $20 billion per year by 2010.[16] These buildings will remain in service for decades. If poorly designed, they will deplete natural resources, consuming more water and energy and producing more waste than necessary. If well designed, they will minimize resource depletion and waste production while improving the "indoor" environment for human health.[17] Improving the indoor environment has profound implications—it can affect staff performance, satisfaction and retention, as well as patient outcomes.

Commission for Architecture and the Built Environment (CABE) study on nurses' working environment:[18] The CABE evidence-based study on nurses and their working environment

[15] Kaiser Permanente, 2002-2004.
[16] Ulrich, Roger et al, "The Role of the Physical Environment in the Hospital of the 21st Century: A Once-in-a-Lifetime Opportunity," 2004. Full report: http://www.healthdesign.org/research/reports/physical_environ.php
[17] Wilson, Samuel, *Design for Health: Summit for Massachusetts Health Care Decision Makers*, 28 September 2004.
[18] PricewaterhouseCoopers LLP, et al, "The role of hospital design in the recruitment, retention and performance of NHS nurses in England," commissioned by the Commission for Architecture and the Built Environment (CABE), July 2004. Full report: http://www.healthyhospitals.org.uk/diagnosis/HH_Full_report_Appendices.pdf

concluded that a healthcare facility's exterior appearance and integration into the community (including transportation issues) impacts nurse recruitment, while its interior environment and functionality strongly affects nurse performance. This is especially critical, as hospital-based nurses are becoming scarcer and as their population ages. Registered nurses have an average turnover of 20 percent per year; they currently average 43 years old, and will likely average 50 by 2010. According to Joint Commission on Accreditation of Health Care Organizations data, low nursing-staff levels contributed to 24 percent of 1,609 patient deaths and injuries studied as of March 2002.[19]

Fable Study on high performance hospital design:[20] The Center for Health Design's "Fable Hospital" study combined the following hospital design changes:

- Additional family/social spaces on each patient floor,
- Health information resources center for patients and visitors meditation rooms on each floor,
- Staff gym,
- More art for public spaces and patient rooms,
- Interior and exterior healing gardens,
- Larger private patient rooms,
- Acuity-adaptable rooms,
- Larger windows,
- Larger patient bathrooms with double-door access,
- Hand-hygiene facilities, and
- Decentralized nursing substations.

Results included:

- Reduced patient falls (reduced by 80 percent),
- Reduced patient transfers,
- Reduced nosocomial infections,
- Reduced medication costs,
- Reduced nursing turnover,
- Increased hospital market share, and
- Increased philanthropic giving.

The total payback period was estimated to be just over a year.

High performance hospitals—impacts on infection control: Perhaps most dramatic is the opportunity for better hospital design to improve infection control**:**

- The Institute of Medicine (2000, 2001) found that medical errors and hospital-acquired infections are among the leading causes of death in the United States, each killing more Americans than AIDS, breast cancer, or automobile accidents.
- Three-fourths of Toronto SARS cases were hospital-acquired.
- Current societal risks of pandemics and bioterrorism make it ever more vital to design hospitals for enhanced containment, negative pressure options, etc.[21]
- Hospital air is often less clean than is normal in industrial cleanrooms, suggesting the need for better technology transfer.[22]
- Hospital-acquired infections decrease with single rooms and very high air quality: design affects both airborne and contact transmission routes.[23]

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[19] Joint Commission on Accreditation of Healthcare Organizations, *Health Care at the Crossroads: Strategies for Addressing the Evolving Nursing Crisis*, www.jcaho.org.
[20] Berry, Leonard, et al, "The Business Case for Better Buildings," *Frontiers of Health Services Management*, 21(1) pp 4-24. Full report: http://www.healthdesign.org/aboutus/press/releases/frontiers_0904.pdf.
[21] Lovins, Amory, presentation, *Design for Health: Summit for Massachusetts Health Care Decision Makers*, 28 September 2004.
[22] Ibid.

- Immunocompromised patients have fewer infections when staying in HEPA-filtered isolation rooms (for example, bone-marrow-transplant patients have ten times fewer *Aspergillus* infections).[24]

High performance hospitals--other clinical outcomes: In an important 2004 compendium, "The Role of the Physical Environment in the Hospital of the 21st Century: A Once-in-a-Lifetime Opportunity," by primary researchers Roger Ulrich and Craig Zimring, Texas A&M University and Georgia Tech research teams reviewed thousands of scientific articles and identified over 600 studies, mainly in top peer-reviewed journals, that establish how hospital design can impact clinical outcomes. Two key examples from this compendium are the impacts of acoustics and lighting on patients and staff:

Hospital acoustics
- Most hospitals are excessively noisy due to hard surfaces and gratuitous noise sources (paging systems, alarms, bedrail raise/lower, phones, staff voices, ice machines, trolleys, roommates, etc.).
- Noise stresses both neonates and adults—higher blood pressure and heart rate, lower neonatal oxygen saturation levels—and, critically, spoils sleep, causing effects such as more re-hospitalization in cardiac patients.
- Single rooms increase patients' acoustic satisfaction by 11 percent (2.1 million patients in 1,462 facilities during 2003).
- Environmental changes—such as reducing noise sources (e.g., using noiseless pagers) and providing better sound absorption (e.g., using high-performance acoustic ceiling tile)—prove effective at quieting the hospital environment, and are more successful than behavioral changes.
- Over months, the same group of coronary care nurses, when given quieter surroundings, experienced lower perceived work demands, increased workplace social support, improved quality of patient care, and better speech intelligibility.

Hospital daylighting
- Sunlight influences mood, sleep-wake patterns, and length of hospital stay. For example, bipolar patients randomly assigned to eastern rooms with bright morning light had a mean 3.67-days shorter stay than those in west-facing rooms.
- Morning light is twice as effective as evening light in reducing Seasonal Affective Disorder (photobiologically linked winter depression) and can reduce agitation from senile dementia.
- Elective spinal surgical patients exposed to stronger sunlight experienced less perceived stress and pain, took 22 percent less opioid analgesia per hour, and had 20 percent lower analgesic costs.
- There is evidence that brighter light can reduce medication errors.

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[23] Ulrich, Roger et al, "The Role of the Physical Environment in the Hospital of the 21st Century: A Once-in-a-Lifetime Opportunity," 2004. Refer to appendix E for full report.
[24] Ibid.

Healing Environments

[1] As suggested by Robin Guenther at the Boston Design for Health Summit, a better building is one that facilitates physical, mental, and social well-being, and productive behavior in its occupants. Three goals of "healing environments" are:

- Reduce stress of building occupants (provide connection to nature, individual choice and control, social support, positive distractions, elimination of environmental stressors),
- Improve safety (provide better air quality, lighting quality, and standardized interior layout, and
- Contribute to ecological health (provide healthier materials and reduce energy, water and resource use).

The Business Case

While few "green" hospitals have been built to date, evidence supporting the business case for high performance, healthy hospitals is highly encouraging. Reduction of operating costs, reduced risk and liability and improved performance in key health areas are all potential benefits that may come with designing hospitals under this new paradigm. Green building also demonstrates corporate responsibility in a social climate that increasingly demands it, and may make a facility more attractive to philanthropy, partnerships and public grants.

There is strong evidence that green buildings in general require ***little or no extra capital cost***, yet they have the potential for ***better capital infusion*** and have excellent life cycle economics associated with ***systems reliability*** and ***energy and resource savings***. Evidence also strongly suggests that green buildings in general enhance occupant performance, and that green *health-care* buildings are no exception, providing ***"human" benefits,*** to patients and staff members, while also benefiting the larger community. Despite the lack of current green hospital case studies, green designs and technologies from other building types are clearly transferable to hospitals. Best practices in building system design are directly applicable to mechanical and electrical systems in hospitals, as are material selection procedures. All of this evidence provides an ample inductive case for green hospitals, suggesting that we should manage risks, learn quickly, and spread the learning effectively throughout the industry.[25]

Little or no extra capital cost: According to a 2003 comparative study of California LEED-certified and non-certified buildings, cost premiums for green buildings typically range from zero to two percent. Life cycle savings, however, are typically 20 percent of total construction costs, representing a higher-than-tenfold return on the initial investment. The chart below shows the cost premiums of the buildings studied.[26]

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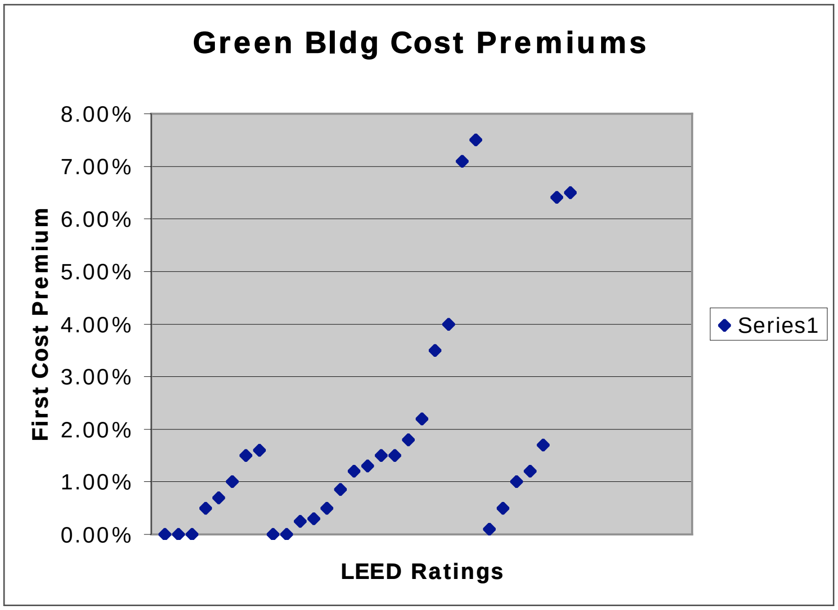
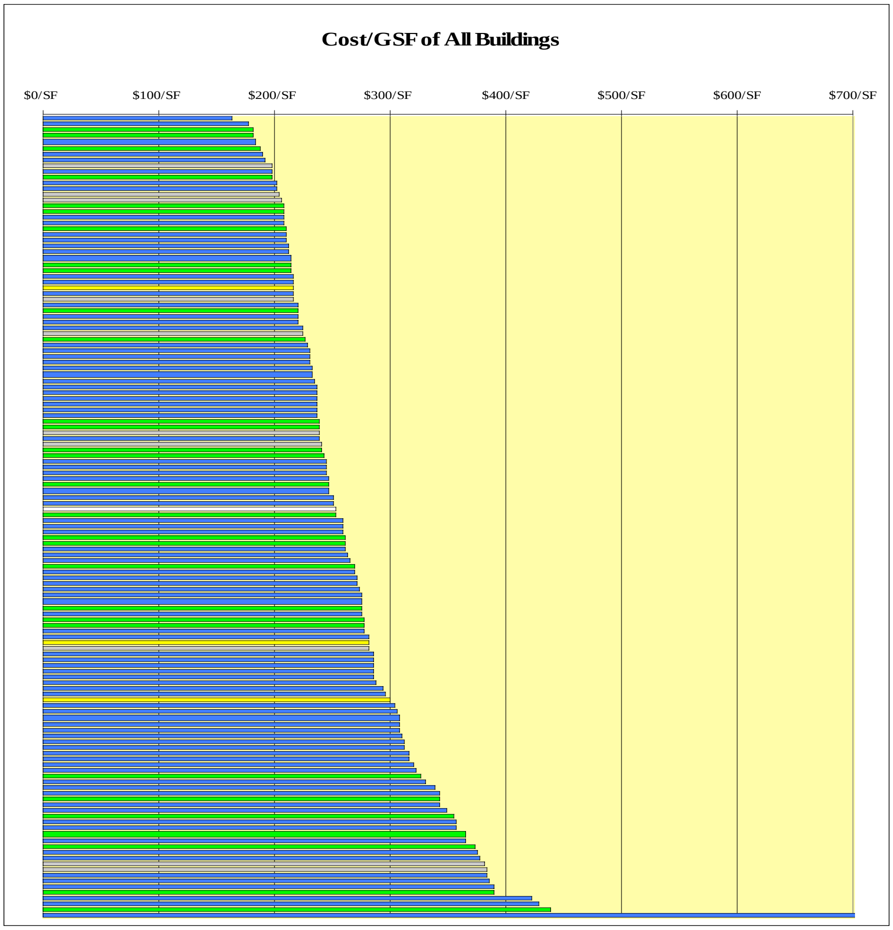
[25]Summarized from presentations by Amory Lovins and Robert Moroz, *Design for Health: Summit for Massachusetts Health Care Decision Makers*, 28 September 2004.
[26] Kats, Greg, et al, "The Costs and Financial Benefits of Green Buildings: A Report to California's Sustainable Building Task Force," October 2003.



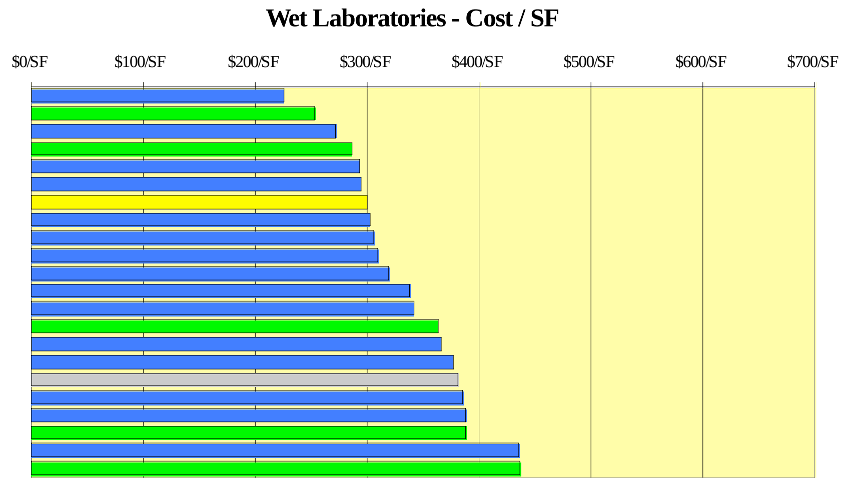
Another study, "Costing Green: A Comprehensive Cost Database and Budgeting Methodology" by Lisa Fay Matthiessen and Peter Morris of Davis Langdon Adamson, concluded:

" . . . [T]here is no 'one size fits all' answer to the question of the cost of green. A majority of the buildings we studied were able to achieve their goals for LEED certification without any additional funding. Others required additional funding, but only for specific sustainable features, such as the installation of a photovoltaic system. Additionally, our analysis suggested that the cost per square foot for buildings seeking LEED certification falls into the existing range of costs for buildings of similar program type.[27]

[27] Matthiessen, Lisa Fay and Peter Morris, "Costing Green: A Comprehensive Cost Database and Budgeting Methodology," 2004.



(a)



(b)

The graphs above, respectively, compare the cost per square foot for (a) all buildings in the study and (b) for wet labs only, from lowest to highest. Blue lines show non-LEED buildings; green lines indicate buildings attempting LEED Certified; silver lines indicate those seeking LEED Silver; and gold lines indicate those buildings seeking to achieve either LEED Gold or Platinum. *Reprinted with permission from Davis Langdon Adamson.*

Capital infusion

- Philanthropy—with 2,057 foundations listing "concern for the environment" as an area of interest and 48 of these listing "energy and the environment" as an area of focus, there is an indication that energy-efficient environmentally-responsible hospitals would have a fundraising advantage.

> **Kresge Green Building Initiative**
> In order to foster environmental sustainability, Kresge Foundation, known for its challenge grants for capital projects, provides incentive planning and bonus grants to encourage nonprofit leaders to consider the environmental impact of their facilities.

- Federal, state and city government grants—potential sources of funding for energy efficient, environmentally responsible hospitals include the U.S. Department of Energy, the U.S. Environmental Protection Agency, the U.S. Department of Defense, state governors' offices and city rebate and incentive programs.
- Public utility partnerships—utilities have at least two major reasons to partner with hospitals.
    - Reducing the demand for power (also called "demand-side management") costs less than providing additional power supply (by constructing new conventional power plants and infrastructure) because hospitals are big energy and water users they offer a good opportunity for demand-side management.
    - Hospitals fall within the "best user" profile for combined cooling heating and power (CCHP) because they have large, coincident electrical and thermal loads and 24/7 year round operation. Because CCHP can be about 85 percent efficient at converting primary fuel to useful energy compared to utilities' traditional (29 percent fuel conversion efficiency) power service model,[1] utilities may be interested in building, at their own expense, high efficiency CCHP plants for hospital clients, in lieu of providing traditional power services. Likewise, hospitals use large amounts of water, making them an incredible burden on the water and sewer infrastructure.

Better systems reliability and quality

- CCHP energy systems provide on-site power generation, which is not only more efficient, but also more reliable—it can be backed up by the grid, but is not dependent on the grid in the event of a grid failure due to natural or terrorist causes; moreover, both the CCHP and the grid can provide 100 percent of a hospital's needs (total connected load), allowing for full backup, not just life-safety systems backup.
- Local power generation can also provide better quality power—that is, power with fewer sags and surges, which is optimal for sensitive digital equipment.

Energy and Resource Savings: Hospitals can save significant amounts of energy by employing high-performance, integrated systems, including:

- Heat recovery;
- CO2 concentration-driven ventilation control;
- High-performance building envelope (including shading, climate- and orientation-appropriate glazing, insulation, and heat reflection);
- Daylighting (integrated with lighting controls);

- Integrated access floors and displacement ventilation;
- Automated measurement and control systems; and
- Efficient medical electronics:[28]
    - Existing models are seldom designed for efficiency, or turned off;
    - Offices have solved this problem with their data equipment; labs and even chip fabrication plants ("chip fabs") are starting to; why not medical facilities?
    - In a chip-fab cleanroom, a saved electric watt can easily be worth $10 in present value (due mainly to the space-conditioning load created); what's that number in a hospital?
    - If the hospital's purchasing department doesn't demand the most efficient equipment possible, the equipment manufacturers probably won't design to that value.

Case Study: Dell Children's Medical Center of Central Texas (CMCCT)[1]
Because reducing power demand ("demand-side management") costs less than constructing new conventional power plants, and because hospitals (with their large, coincident electrical and thermal loads and 24/7 operation) have the best user profile for combined heat and power (CHP), the Austin, TX utility, Austin Energy, constructed, at its own expense, a high efficiency CHP plant for the Dell CMCCT. This win-win partnership supported capital reinvestment in a green building that will reap major benefits:

- Gross capital Savings of $6.8M resulted from not building a central plant.
- CMCCT reinvested $2M of these savings into building energy conservation measures (which will have a 4.9 year payback).
- CMCCT reinvested $3.8M in other green initiatives that may benefit clinical outcomes, staff recruitment, retention and productivity, environmental responsibility and community relations.
- CMCCT reaped net savings of $1.0M .

The costs associated with evidence-based "human" benefits: Evidence-based research suggests that high-performance "green" hospitals can enhance clinical outcomes, improve staff recruitment and retention, reduce absenteeism, improve safety, promote a cleaner environment, and improve community relationships and public image**.** These evidence-based benefits have significant financial implications. First, a better-performing hospital with a better public image should be able to increase its competitive market share. Second, reduced staff turnover and absenteeism and fewer accidents reduce operational costs. Finally, better clinical outcomes reduce liability and societal costs—for instance, consider the costs of nosocomial infections:[29]

- Surgical infections cost $15,300 and add 7.2 days to length of stay (LOS).
- Bone marrow transplant infections cost $22,000 and add 9.5 days to LOS.
- A new tuberculosis patient costs $100,000.

Given these statistics, what is the value of design measures (air handling systems, single occupancy rooms, etc.) that have significant potential to reduce these infections?

Perceptions about the costs of green building: There is a definite perception that the traditional way of building a hospital ("brown building") costs less than "green building," and therefore "green"

[29] Spengler, John D. and John F. McCarthy, *Design for Health: Summit for Massachusetts Health Care Decision Makers*, 28 September 2004.

buildings have to prove that they are worth the extra cost—yet current building practices are not based on definitive research showing that they are either the most effective or the most inexpensive methods. If a conventional building develops air quality problems, it is likely to ultimately incur repair and maintenance costs not foreseen in the initial design, defeating the economy-of-lower-first costs argument. Moreover, as described earlier, first costs may actually not be higher for high performance green buildings[30]—again, this needs further study.

Challenges

Undoubtedly hospitals face challenges to adopting new design standards. In addition to real or perceived financial challenges for higher upfront costs, there is a learning curve for the design team and it is critical to have or create upper management support. For high performance, healthy design to be as successful and cost-effective as possible, it must be integrated into the design at the outset. Budgeted upfront costs that are critical to the integrated whole system, cannot be "value-engineered" out (each component of the whole-system design is inherently linked to each other component; therefore, changing one component will disrupt the entire system).

Retrofits and renovations comprise the bulk of hospital construction projects, but because of the physical constraints of the existing building, certain green architectural features (such as deep daylighting or provision of views) are harder to achieve than they are in new projects. However, greening an existing facility *can* focus on systems, finishes, and operational improvements. For instance, recent technologies and materials and systems make improved indoor air quality more easily achievable.

Quite possibly the biggest challenge to hospital administrators and designers alike is an institutional aversion to change. Especially in an industry where life is at stake, veering from standard practice implies risk, even if "standard practice" is less effective, less efficient, and more costly than other possible design strategies. Given the risks associated with change, few hospitals want to be "test cases" and so there are few examples for other hospitals to follow.

One of the goals of this Design for Health Summit was to address these challenges and propose solutions to overcoming them.

[30] Matthiessen, Lisa Fay and Peter Morris, "Costing Green: A Comprehensive Cost Database and Budgeting Methodology," 2004.

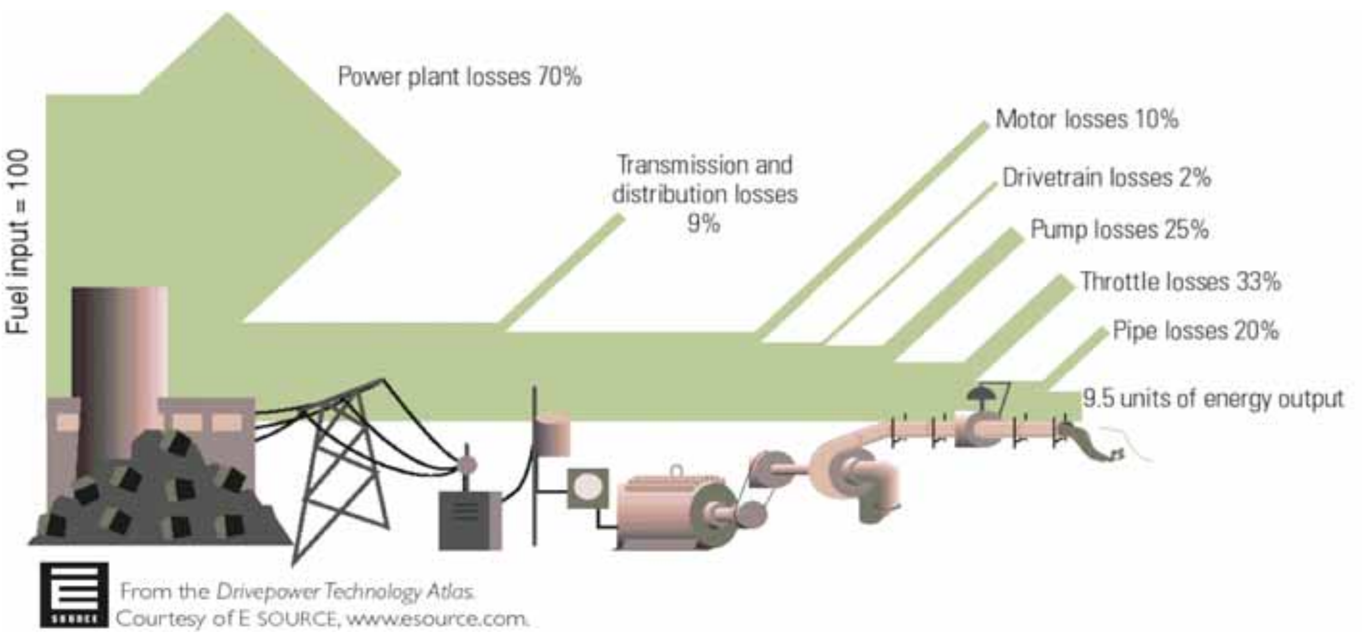
Summit Recommendations: Initiatives

Summit participants developed the following recommendations collaboratively during breakout and plenary sessions.

Collaborative Boston Community/Regional Initiatives

Boston area hospitals, working collaboratively, can leverage greater sustainability than any individual hospital acting alone. This collaborative effort can also provide tremendous leadership nationwide. Summit recommendations included:

1. Form a **"Green Hospital Champions Council"** with representatives from interested Boston and other Massachusetts hospitals. Start with Summit participants, who showed interest in a Council, following the Summit. The governor's and Boston mayor's offices may be helpful collaborators.
    a. Work to collectively understand how institutional planners think and how institutions align priorities. Toward this goal, include on the Council, members from various hospital fields.
    b. Establish Group Purchasing Organizations (GPOs) to transform markets by significantly increasing demand for non-polluting healthy construction materials and hospital operational products as well as efficient medical equipment. Use collaborative buying power to get manufacturers to produce more efficient medical equipment.
    c. Work toward enhancing efficiency in a significant number of regional hospitals. This will not only benefit the hospitals, but will benefit the broader community by reducing regional power generation and its associated pollution, and infrastructure upgrades (new power plants). As shown in the diagram below, saving one unit of energy at one hospital can save 10 units of fuel at the power plant, thus even the easiest achievable energy savings at several hospitals will have a large multiplicative effect at the power plant.



    d. Engage in public/private partnerships.

   e. Work with the Boston Mayor's Office, Massachusetts Governor's Office, Massachusetts Technology Collaborative, and Massachusetts utility companies to establish and act on green building incentives, tax/rate credits, and methods to capitalize cost savings (for example, work collectively to make cogeneration feasible for Boston hospitals).
   f. Collaborate to assist Champions' Council-member hospitals in adopting the Green Guidelines for Health Care.
   g. Develop a regional collaborative that can create consensus opinions and can provide critical feedback, work with standard setting organizations such as the Joint Commission on Accreditation of Healthcare Organizations (JCAHO), to enhance the effectiveness of current regulations, generate better regulations, and help facilitate the adoption of green guidelines. Regulations and practices should be informed by research and retrospective analysis.
   h. Work with the Medical Academic and Scientific Community Organization, Inc. (MASCO) to spread sustainability initiatives to a broader network of facilities.
   i. Spread the wealth of knowledge here in Massachusetts to elsewhere in the country—serve by example.

   Implementation strategy: with buy-in from their hospital leadership, several "green champions" from Boston area hospitals could organize and co-facilitate this initiative with the support from HCWH and possibly other groups.

2. Establish a web-based, searchable **Information Exchange and Case Studies Database**. This could be an interactive website for posting and commenting on evidence based research, cost data, green technologies, products, materials and systems. It could also provide case studies of green hospital projects and references for architects and engineers with expertise in high-performance green hospital design. It could be a discussion forum for green hospital design and engineering expertise.
   a. Model green hospitals are needed to set the standard for others. Data on the financial case, improved performance, etc., must be widely communicated.
   b. Get reliable, hard data and empirical evidence as soon as possible for the benefits of green healthcare design by identifying and prioritizing data needs and initiating follow-up studies.
   c. Identify outdated and unscientific industry standards.
   d. Facilitate research to evaluate the safety and performance of "green" versus status quo standards.

   Implementation strategy: A non-profit organization could be funded to set up and manage this database. (For instance, RMI/HCWH could begin constructing it on the existing Summit weblink.)

3. Provide **public education** about precaution, prevention, and environmental factors for health, healthy building design, and operations. This program could serve to educate the public about personal actions and lifestyle choices and to create increased demand for the healthy hospital initiatives at Massachusetts hospitals, thereby encouraging their success.

   Implementation strategy: This initiative could be accomplished by a collaborative effort of Boston area hospitals or by individual hospital outreach programs (see Hospital Policy Initiatives section, below) or by a public health nonprofit that is funded for this project.

4. Organize an **intensive design workshop** (or workshops) specifically for engineers and architects who are currently on hospital design teams. An outcome of this workshop could be a "how-to" manual (a report describing performance standards and design methodologies for achieving them) for designing high-performance green healthcare facilities, with particular focus on ventilation and indoor air quality. By involving engineering and design experts experienced in optimal-efficiency design, this workshop could help alleviate the problem of engineers unnecessarily upsizing equipment as insurance against potential user complaints. The report could also serve as an updated guideline for architects and engineers of *future* hospital projects.

Implementation strategy: Several hospitals with upcoming construction projects could jointly fund this workshop, and the team that facilitated the Boston Hospital Summit could facilitate it.

Individual Hospital Policy Initiatives

These initiatives are for hospital administrators and departmental staff to carry out in each individual hospital. The initiatives represent an overall Summit recommendation for hospitals to commit to a cultural change toward expecting and demanding environmental health, sustainability, safety, and ongoing improvement. As outlined by Summit speakers Greg Doyle (Director of Buildings and Operations, Massachusetts General Hospital) and George Player, (Director of Engineering, Brigham & Women's Hospital), the ambitions of this approach include reducing a hospital's energy use, waste and cost, enhancing occupant health and productivity, improving the patient experience and gaining public approval.[31]

Progress toward these goals is already being made: since the Boston Design for Health Summit, several hospitals have committed to adopting the GGHC for their new hospital building projects; these include Beverly Hospital, Brigham and Women's Hospital, Children's Hospital Boston, Dana Farber Cancer Institute, and Spaulding Rehabilitation Hospital.

> *"You must have commitments simultaneously at all levels of an organization. This is something that cannot be achieved by a top-down process. It must be a bottom-up process, and a middle process, and the top must support these initiatives. We also must have the commitments of our sponsors and of our boards."*
>
> – Lloyd Dean, MA, President and CEO of Catholic Healthcare West, from the proceedings of *Setting Healthcare's Environmental Agenda,* October 16, 2000

As discussed during the Summit, gaining institutional commitment involves:
- Investment rather than enforcement,
- Facilitating rewards rather than fighting a burden,
- Promoting health rather than meeting compliance goals, and
- Conscience rather than compliance.

This level of commitment will be necessary to successfully achieve the following policy initiatives.

1. **General mission statement/policy framework:** Establish a hospital-wide mission statement and policy framework connecting human health (for patients, staff, and the larger community) and the environment. The ensuing policies should embody the precautionary principle[32] and commit to green building practices—including adopting the Green Guideline for Heath Care (GGHC) for future projects. These policies must be consistent with, and incorporated into, the institution's overall vision and policies and should be developed through consensus-building within the organization.

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[31] Doyle, Greg and George Player, *Design for Health: Summit for Massachusetts Health Care Decision Makers*, 28 September 2004.

[32] As defined at Wingspread: "When an activity raises threats of harm to human health and health of the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically." Precautionary action is anticipatory, preventive. It increases options, protects and promotes health and whole-system resilience and integrity—Ted Schettler, presentation, *Design for Health: Summit for Massachusetts Health Care Decision Makers*, 28 September 2004.

a. Engage and involve major hospital decision makers (CFOs, department heads, board members—particularly the finance committee, trustees, and other leaders) as advocates for a leadership structure that promotes sustainability, integrating diverse stakeholders within the institution in the decision process.
b. Each hospital needs to adopt an implementation strategy that will be effective for its own senior management.
c. Start with internal strategic planning sessions with department heads to determine scope and timeline of the effort, and to establish benchmarks of progress.
d. Hospitals need to create and "own" their definition of an optimum healing environment, then integrate all the relevant departments and issues in a framework that works for the particular hospital (by forming a committee of departmental representatives, for example).
e. Each hospital should adopt an institutional chemical policy statement for product and material procurement that fits with the hospital's mission (e.g., a cancer institute may adopt a no-carcinogen purchase policy).
f. Develop procurement strategies that embody the precautionary principle and green building practices (see #4, below). Work with vendors who share the goals of the organization.
g. Update standards at hospital facilities to reflect environmentally preferable operational processes.
h. Include green design and sustainability issues in planning discussions that deal with market share, economics, accessibility to different types of care (acute, ambulatory), size and placement of facilities, etc. Include in these discussions appropriate stakeholders, such as the financial community.
i. Incorporate sustainability/green building issues in the long-term business plan of the hospital's real estate portfolio.
j. Incorporate sustainability as an institutional performance metric for:
    i. Facility design and construction,
    ii. Internal operations (including procurement, energy use, etc.), and
    iii. Impact on the community and surrounding environment (including noise, traffic, emissions, waste and effluent, toxicity of materials used, etc.).
k. Develop "green teams" to influence specific projects, including future high performance buildings and renovations. In addition to advocating green construction, this team should facilitate communication and collaboration between the design team and operations staff.
l. Consider a voluntary International Organization for Standardization (ISO) review using the GGHC.
m. Join Hospitals for a Healthy Environment (H2E).

Implementation strategy: One possible implementation strategy is to create an "advocacy group," an internal team (with at least one full-time person) with expertise in green building and healthcare operations, who would have the authority from senior leadership to guide and oversee implementation of programs across the facility. Implementing the precautionary principle, as outlined by Ted Schettler of the Science and Environmental Health Network, involves:

- Establishing a general duty to act with precaution,
- Setting goals,
- Using science wisely (choosing the right disciplines and working across disciplines),
- Enhancing information flows,
- Creating early warning systems,
- Locating responsibility in the system,
- Choosing the least harmful alternative,
- Engaging in democratic decision-making processes, and
- Explicitly incorporating values.

2. **Education policies:** Focusing on sustainability and best environmental practices, provide education and outreach to hospital management and staff, trustees, and board members, using existing communications tools such as meetings, newsletters and internal websites.
   a. **Internal education**
      i. Bring in appropriate experts to provide departmental education. Consider holding an "Energy Awareness Day" with guest speakers from the EPA, the local utility, vendors, etc.
      ii. Hold worker training on environmental safety and green design to increase health and safety, while also reducing energy use. Continue training on a monthly or quarterly basis for staff; running the engineering control room can ensure proper operation of new equipment, technologies, and operating strategies.
      iii. Hold employee training sessions to explain proper protocols for how to operate systems for optimal individual comfort and to avoid staff making makeshift local "fixes" to address comfort problems, which can sidetrack indoor air quality and system effectiveness.
      iv. Establish mandatory GGHC training for department leadership.
      v. Study the connections between infection control and worker habits and improve with education, training, and an improved work environment.
   b. **Public education:**
      i. Create public education and outreach programs, and marketing strategies, based on best environmental practices and sustainability.
      ii. Facilitate physician-to-patient-level discussion about healthy choices for lifestyle and environmental health.

   Implementation strategy: Make the coordination of sustainability education part of the job of an individual or team (it could be part of the human resources department's work).

3. **Energy, water, and other resource efficiency policies:**[33]
   a. Create incentives and empower employees and stakeholders to take ownership of energy efficiency and conservation strategies and to develop new ones. Have heads of staff make rounds to ask employees for their suggestions of how to make the facility safer and more effective.
   b. Provide incentives to employees for water efficiency; work with the utilities to pursue incentive programs for efficiency efforts. If water is reused for irrigation and cooling towers, rather than being sent to the sewage treatment system, get the appropriate fee abatement from the utility.
   c. Some conservation measures, such as turning off lab fume-hoods when not in use, may be worth assigning as a staff person's job task. (A typical fume-hood, left on 24 hours a day, 7 days a week, consumes 3.5 times the energy of an average house, or $3,800 annually in heating, cooling and fan energy.)[34]
   d. Employ departmental energy and water sub-metering for accountability.
   e. Plan hospital programming to eliminate unnecessary energy usage and costs such as one room's energy needs driving a whole wing's requirements (for example, avoid locating a physician sleep room on a wing that is otherwise unused all night long).
   f. For medical office buildings (MOBs) where the tenant doctors are charged for utilities, the associated hospital or medical group to which the doctors belong could provide a manual of energy- and resource-saving strategies and materials.

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[33] For specific energy-saving measures, see the following section: Engineered Systems Initiatives.
[34] Woolliams, Jessica and John D. Spengler, presentation, *Design for Health: Summit for Massachusetts Health Care Decision Makers*, 28 September 2004.

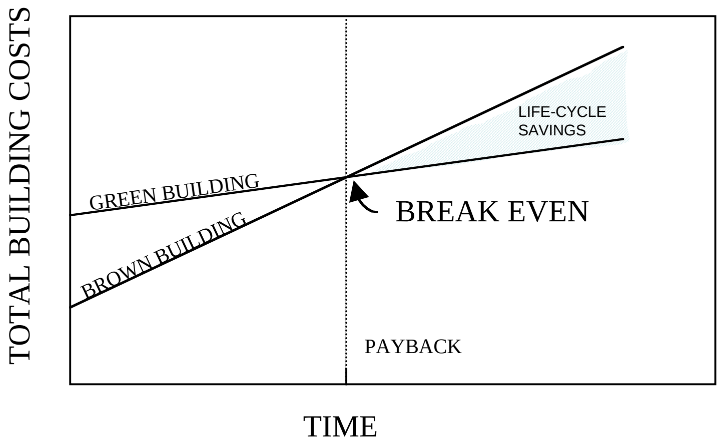
Implementation strategy: Make this part of the job of the operations/engineering staff; note the costs (added staff time) and savings associated with this operational commitment.

4. **Purchasing policies:** Develop, promote, and execute an extensive environmental-and-human-health-preferable purchasing program for all departments, including clinical, facilities operation, housekeeping, construction, research, and contracted departments. Note that products can compromise indoor air quality due to all of the following factors: carcinogens, mutagens and teratogens; toxins; sensitizers and allergens; infectious aerosols; irritants; and odors.
   a. Assess building material selection with regard to indoor air quality, especially for chemically sensitive hospital patients or staff. Use GGHC, LEED and/or ASHE material standards.
   b. Provide green material education to project managers, contractors, and maintenance/operations workers to assure the healthfulness of materials that may not go through purchasing departments.
   c. Use the Construction Specification Institute (CSI) format, develop a standardized purchasing specification for green products and update it continually; include this information in project manuals (See the *GreenSpec* directory for green product listings by CSI designation).
   d. Evaluate material safety data sheets (MSDSs) for products and chemicals.
   e. Shift the burden of toxicity disclosure to manufacturers.
   f. Adopt the Green Seal labeling criteria for purchasing cleaning materials.
   g. Conduct materials management reviews and health and safety reviews.
   h. Reduce solid waste and its toxicity:[35]
      i. Replace single use disposables (SUDs) with reusable products,
      ii. Replace toxic products, such as those containing mercury and polyvinyl chloride (PVC) with safer alternatives,
      iii. Sort medical waste to minimize incineration, autoclaving and landfilling PVC items,
      iv. Increase recycling,
      v. Minimize construction waste,
      vi. Avoid the purchase of mercury-containing equipment and replace existing mercury-containing equipment,
      vii. Provide training on mercury pollution prevention,
      viii. Distribute only non-mercury thermometers to patients and sponsoring mercury thermometer exchange within the community, and
      ix. Establish fluorescent bulb and battery recycling programs.

Implementation strategy: If this is not part of the core competency of the current Purchasing Department staff, work with advocacy groups such as HCWH or with private consultants (or bring a qualified person on staff) who can address the toxicity issues described above.

5. **Construction policies:** Use life cycle cost accounting (rather than first-costs alone) for all future construction, renovation, and purchasing projects. As depicted in the graph below, even if high performance "green" buildings, products, and systems cost more up front, they typically reap ongoing operational savings—the longer they are in service, the more money they save.

[35] Guenther, Robin, presentation, *Design for Health: Summit for Massachusetts Health Care Decision Makers*, 28 September 2004.



Green Building Costs & Investment Returns

According to a recent study of California LEED-certified buildings, cost premiums for green buildings typically range from 0 to 2 percent, while life cycle savings are typically 20 percent of total construction costs, representing a higher-than-tenfold return on the initial investment

—Greg Kats, et al., *The Costs and Benefits of Green Building: A Report to California's Sustainable Building Task Force, October 2003*

a. Life cycle metrics for building finish materials should include longevity/durability of the material, maintenance requirements, replacement costs, etc.
b. Consider operational cost implications of products (note payback periods of higher performance products); include considerations of future resource costs (e.g., energy, water, time, etc.).
c. Link capital and operations budgets (or earmark operational savings) so that operational savings can pay for increased capital costs of higher-performance, healthier products and systems.
d. Green purchasing teams may need to identify and quantify the benefits of green products and systems and "sell" their merits within the institution to help shift the mindset of management from first costing to life cycle costing.
e. For medical office buildings that are leased rather than owned, develop a lease arrangement based on life cycle costing, including the operational savings from green design. (For example, prior to building completion, a consortium of future tenants could help finance the additional costs of high performance systems in exchange for a lower lease rate.)

Performance-based fees

In addition to the regular fee structure for project design teams, provide incentive fees for high performance buildings. If the actual performance of the completed building exceeds a set, agreed-upon standard, the design team reaps a percentage of the savings, whereas if building performance falls short, the team must pay a certain rebate to the owner.

Implementation strategy: For construction projects, the hospital could require the contracted design team to base design and specification decisions on life cycle costing, more than on first costs. The hospital could also incentivize high-performance by making part of the design team's fee contingent on the performance of the building, a fee-structure known as performance-based fees.

The operational and purchasing policy changes would need to become part of the role of the hospital staff.

6. **Hospital policies for collecting evidence, data, and case study information:** Develop and implement a rigorous, effective evaluation and accounting process for sustainability improvements.
   a. Considering whole building systems (not just individual components), evaluate and document cost/benefit data for high performance "green" (vs. conventional) hospitals. Include incremental first costs, operating costs (energy and water), maintenance costs, end-of-life disposal costs and replacement costs (for equipment, systems, finishes, and other products).[36] Establish a plan for evaluating human impacts and associated costs: staff productivity/retention, patient results, medical error, and nosocomial infection rates, other risks and liabilities.[37] Record and publicize this evidence as it relates to the business case for greening healthcare construction.
   b. For example, establish practices for quantifying "good" air quality and measure corresponding productivity at different levels of air quality. Assess changes in air quality and productivity when green retrofits are done.
   c. The following approach was recommended: inventory the current conditions in healthcare buildings to establish a starting baseline before sustainability improvements are begun, assess the inventory, set priorities, develop effective strategies, implement those strategies, measure results (use assessment tools to institute a continuous measurement and verification process for all systems and equipment), and finally, create feedback loops to make sure the data gathered is used in decision-making. Make results accessible as case study data for other hospitals.
   d. Require post-occupancy evaluations as an integral component of measuring and verifying green building performance and to develop data for future decision-making and systems design.

   Implementation strategy: Implementing a rigorous plan to measure, evaluate, and document the results of sustainability improvements, for both new construction/renovation and operations, will require strong commitment from upper leadership, staff members who are assigned and dedicated to the tasks, and possibly outside funding. The National Institute of Health (NIH) may be a potential funder of endeavors to assess the costs and benefits of "greening" hospitals.

Architecture/Design Initiatives

The following initiatives provide specific recommendations, targeted at hospital design teams (both internal staff and contractors) and hospital decision-makers, for improving the health, safety, effectiveness, and resource/energy efficiency of hospital buildings.

Implementation strategy: With the mandate from senior leadership, hospital facility architects or project managers, and their construction/renovation consultants, should pursue implementation of the following recommendations:

[36] One Summit participant recommended documenting cost/savings data by LEED point.
[37] Dr. Samuel Wilson, Deputy Director of the National Institute of Environmental Health Sciences, suggested that the National Institute of Health (NIH) might be a potential funding source for this evaluation.

1. Use an **upfront, integrated, holistic design process** for new construction and major renovation projects:
   a. Include all institutional stakeholders early in the process (owner, architects, engineers, users, etc.); this is critical for proper programming and for opportunity identification during conceptual design.
   b. Broaden the integrated planning approach to include city and state leaders, city planners, community perspectives, public approval authorities, etc., especially for masterplanning efforts affecting the public (for example, consider public transportation options relevant to facility location).
   c. Senior management must support the integrated green approach for it to work.

2. **"Green" the design team:**
   a. Implement a *performance-based* fee structure (see text box, above).
   b. Screen design professionals for green credentials.
   c. Identify and recognize green design champions within the organization and include them on design project teams.

3. Design hospital spaces for **flexibility and modularity** to accommodate the rapid changes in treatment, information technology, expansion or renovation:
   a. Allow for integration of departments, diagnostics, research, etc.
   b. Provide abundant electrical outlets to allow for future changes in equipment and layout.
   c. Use portable units for specialized equipment (such as maternity Jacuzzis) so as not to limit the flexibility of the room.

Biologically inspired design:

- References diversity and connects to life outdoors,
- Supports social interaction and human condition,
- Introduces natural light and fresh air; pure water and less waste,
- Uses organic forms and fluid lines to ease flow; reduce stress,
- Creates textured palette; material depth, visual and tactile environment,
- Combines green materials to reflect outdoor space, diversity, and range, and
- Provides human scale w/ multi-sensory immersion of elements.

4. Promote a **healthy indoor environment** for staff and patients. Evidence suggests that a "healthy" environment will reduce stress (promoting productivity and healing for patients and staff) and improve safety, while also contributing to ecological and community health. Attributes of a "healthy environment," as suggested by evidence-based research and productivity studies, include color choices, daylight and glare-free electric lighting, views of and access to nature, soft design forms, operable windows and other means for personal environmental control, social support, natural and non-toxic materials, good acoustics, good ergonomics, and good air quality.
   a. Provide individual environmental controls for a more comfortable and ergonomically sensitive environment for staff and patients.
      i. Provide operable windows in patient rooms, combined with "smart" computerized controls to shut-off mechanical systems when windows are opened and to address containment of pollutants, terrorism threats and energy use.
      ii. Provide adjustable ergonomics to reduce fatigue and stress and to enhance safety.
      iii. Provide more effective lighting with adjustable controls for changing user needs, especially to accommodate use of new lab equipment.

   b. Assess building material selection and installation processes for impacts on indoor air quality (set high standards of indoor air quality to accommodate hospital patients and staff who may be chemically sensitized individuals), then write specifications to accommodate best products and practices. Pay particular attention to potential sources of indoor air quality problems that would impact chemically sensitized individuals.
   c. Use green materials that provide the same or higher degree of performance while reducing toxicity and waste (find alternates to disposable and toxic products and materials), and enhancing durability, ergonomics, acoustics, and maintenance.

5. **Reduce construction/demolition waste:** Reuse materials removed during renovations to reduce the waste stream and the resultant environmental toxicity.[38]

6. **Lighting design:** In addition to high performance lighting design (putting light where it is needed, lighting for safety, visual acuity, glare reduction, etc.), consider the implications of lighting for both patient health *and* health care workers' alertness. The internal circadian clock, which is set externally by visible light, controls hormone production and human bodily functions—exposure to light produces serotonin, dopamine and GABA, and exposure to darkness produces melatonin, norepinephrin and acetylcholine. Evidence suggests that the higher rate of breast cancer in shift workers (and, in general, for women in industrialized countries) could be related to reduced melatonin production associated with exposure to light during both day and night. Therefore important design considerations include minimizing light trespass in patient room windows keeping patient-area night-lighting to a minimum and to red spectrum light, while using blue spectrum light in work areas to promote staff alertness. During the daytime, provide glare-free daylight and views to natural landscape; provide electric light dimming linked to daylight levels, light surfaces rather than volumes of space and use light-colored finishes to bounce light. **Benefits of this approach:** In addition to the evidence-based health benefits, performance benefits of eye-strain reduction and better visual acuity for optimal task performance, electric lighting energy use can be reduced by 25–50 percent with advanced light sources, design strategies and controls, and by 75 percent with the addition of daylighting.[39]

7. Design **lighting strategies** in the right order to optimize effectiveness and efficiency:
   a. Improve the visual quality of the task,
   b. Improve geometry of the space, cavity reflectance,
   c. Improve lighting quality (cut veiling reflections and discomfort glare),
   d. Optimize lighting quantity,
   e. Harvest and distribute daylight,
   f. Optimize luminaries, and
   g. Use controls, maintenance and training.

8. **Inpatient room/department design:**[40]
   a. The following benefits have been associated with the provision of single occupancy patient rooms:
      i. Infection control,
      ii. Patient comfort and privacy, and
      iii. Improved hospital image and marketing.
   b. Acuity-adaptable patient room (adaptable to varying levels of progressive and acute care) provide the following benefits:

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[38] Refer to *WasteSpec,* Triangle J Council of Governments; download: www.tjcog.dst.nc.us/cdwaste.htm#wastespec.
[39] Clanton, Nancy, presentation, *Design for Health: Summit for Massachusetts Health Care Decision Makers*, 28 September 2004.
[40] Mombourquette, Arthur, presentation, *Design for Health: Summit for Massachusetts Health Care Decision Makers*, 28 September 2004.

i. Adaptability,
ii. Flexibility in patient management,
iii. Reduction in patient transport from room to room, and
iv. Ability to anticipate changing technology and care patterns.

c. Other important inpatient department design considerations include:
i. Sound levels in patient rooms and communal areas, especially at night,
ii. Nursing staff workflow and communications,
iii. Access to natural day light/views for patients and staff,
iv. Visual supervision: central nursing staff station vs. proximate location,
v. Effects of shift work: risks, ergonomics, etc.,
vi. Equipment in patient rooms: use, impact, space limits, and
vii. Improved ventilation systems.

9. **Nursing station design considerations:**[41]
   a. Visibility of patient rooms,
   b. Walking distance for staff,
   c. Proximity of supplies, equipment and technology,
   d. Adequate storage space,
   e. Adaptability,
   f. Layout and signage that is easy to navigate, and
   g. Convenient access to hand wash sinks.

Engineered Systems Initiatives

The following recommendations, specific to the design and operations of energy and mechanical systems for hospitals, can dramatically reduce energy consumption, make heating, ventilation and air conditioning (HVAC) operations more healthful and effective, and significantly reduce hospital operational costs (and in some cases first costs).

Implementation strategy: These recommendations are targeted to individual hospitals. With the mandate from senior leadership, hospital facility engineers and their construction/renovation consultants should pursue implementation of the following recommendations.

1. Provide adequate **operations & maintenance (O&M) resources** to hire and train personnel. Avoid reducing maintenance positions to trim operational budgets, which usually backfires because inadequately maintained systems are less efficient and increase energy costs. Provide training manuals for mechanical systems operators and education and incentives for staff to achieve better performing systems with greater energy efficiency.

2. In cooperation with the distribution utility, develop a **combined cooling, heating, and power (CCHP)** system to provide efficient energy supply and premium reliability. Start with a CCHP feasibility study to analyze the costs, benefits and barriers. Utility cooperation is necessary to arrange the grid interconnection in a way that supports the use of CCHP to enhance customer reliability. Utility connection requirements for CCHP vary widely and tend to be complex and costly. The most cost-effective CCHP system will harness *both* the reliability benefits of standby operation and the energy savings of parallel operation. However, this requires CCHP sources to operate in an island mode (i.e., separated from the grid, to serve loads during a grid outage, yet present utility practice typically discourages any sort of islanding).

[41] Ibid.

3. Initiate a **continuous commissioning program** (upfront commissioning followed by periodic commissioning throughout the life of the building) to optimize energy equipment performance, system performance, and overall energy efficiency. Include an operator education component and continuous measurement and feedback to inform decision-making.

4. Employ smart **energy methodology** in the right order**:**
   a. Reduce loads first
      i. Optimize building envelope,
      ii. Provide efficient lighting systems, appliances, equipment, and
      iii. Commission (and re-commission) the building.
   b. Use integrated design
      i. Integrate heating, ventilation and air conditioning and daylighting systems,
      ii. Utilize waste heat,
      iii. Improve mechanical system efficiency, and
      iv. Design systems to modulate with varying loads.
   c. Finally, consider supply side improvements such as on-site renewable energy.

5. Design **space cooling strategies** in the right order to optimize effectiveness and efficiency:
   a. Cool the people, not the building.
   b. Expand the comfort envelope with behavioral changes (dress, proper operation of cooling equipment, etc.)
   c. Minimize unwanted heat gains.
   d. Differentiate summer versus winter loads (use more refined air/water chilling systems).
   e. Facilitate passive cooling (i.e., ventilative, radiative, ground-coupled, or water-coupled).
   f. Utilize active non-refrigerative cooling (i.e., evaporative, desiccant, absorption, hybrids).
   g. Provide super-efficient refrigerative cooling.
   h. Utilize thermal storage and controls to manage loads and avoid on-peak demand.
   i. Achieve resultant cumulative energy saving of up to 90 percent, along with better comfort, lower capital cost, and better reliability.

6. **Pumping loop design:** Use big, short straight pipes rather than skinny, long, crooked pipes (lay out the pipes first, then the equipment). This could reduce pumping energy by 90 percent![42]

7. **Waste heat:** Install heat exchangers to capture heat from wastewater and use elsewhere—this is especially applicable to the waste steam from process water (sterilizers, autoclaves, etc.).

8. **Ventilation strategies for indoor air quality and energy efficiency:**
   a. Use **monitoring controls** (such as spore traps and carbon dioxide sensors) to inform air flow rates and thereby enhance indoor air quality, infection control, and energy efficiency for both existing and new buildings. Provide particle sampling in spaces adjacent to construction zones. Periodically verify the performance of the monitoring controls.
   b. Explore ways to provide **100 percent outside air** for infection control, while still improving energy efficiency. Design more efficient HVAC systems that adapt to the 100 percent outside air demand (e.g., compartmentalize the hospital and only provide certain areas with 100 percent outside air during off hours). Make full use of heat recovery, efficient dehumidification and ventilation flow controls.
   c. Identify good target areas for **natural ventilation** and explore alternative strategies, such as supply air windows, trickle vent, etc.

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[42] Benefits achieved in an exemplary industrial plant included 92 percent less pumping energy, lower capital cost, 70 kW lower heat loss from the pipes, less space, weight, noise and easier maintenance. Saving one unit of friction in the pipe saves 10 units of fuel at the power plant, due to power generation and transmission losses—Amory Lovins, presentation, *Design for Health: Summit for Massachusetts Health Care Decision Makers*, 28 September 2004.

9. **Displacement ventilation:**[43] Study whether displacement ventilation, which can enhance both health and energy efficiency, is appropriate for each hospital department application. Advantages include:

a. By *displacing* stale air with fresh air, rather than the conventional process of *diluting* stale air by mixing it with ducted fresh air from above, displacement ventilation can enhance air quality, while reducing energy use.
b. Once thought to increase capital cost (if built like specialized raised-floor computer centers), displacement ventilation is now known to have comparable or lower total capital cost in offices—so why not in hospitals?
c. It can reduce or eliminate ducts, which can save floor-to-floor space.
d. By removing ducts, it avoids their pressure drop, resulting in smaller fans, less fan heat for the chiller to remove, and therefore smaller chillers.
e. Displacement ventilation reduces chiller lift and improves efficiency because supply air is 65°F not 55°F.
f. Displacement ventilation can eliminate air-handling noise.
g. It is not necessary to drizzle air up through floor; fresh air can be supplied at baseboard level, avoiding issues of spills and sanitation problems.
h. Displacement ventilation should permit major reductions in air changes/hour.

10. **Air handling in laboratories** (and other contaminant areas):[44] Laboratory design standards are currently based on air changes per hour (ACH) and at least six organizations have different recommended design standards,[45] but, as pointed out by the American National Standards Institute (ANSI) and the American Industrial Hygiene Association (AIHA), "air changes per hour is not the appropriate concept for designing contaminant control systems. Contaminants should be controlled at the source." Or as stated in "Industrial Ventilation" by the American Conference of Governmental Industrial Hygienists (ACGIH) p.7–5: "'Air changes per hour' or 'air changes per minute' is a poor basis for ventilation criteria where environmental control of hazards, heat, and/or odors is required. The required ventilation depends on the problem, not the size of the room in which it occurs."

a. **Design for energy efficiency and reduced lab hazards**. An important case study at Harvard School of Public Health (SPH), "Challenging Lab Standards SPH2—2nd Floor," could set new standards for reducing lab hazards and environmental pollutants, while dramatically improving energy savings, using the following design strategies:[46]
    i. Solicit an environmental health and safety industrial hygienist to conduct a hazard assessment for each laboratory based on chemical inventories and laboratory standard operating protocols (SOPs) provided by end-users.

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[43] Lovins, Amory, presentation, *Design for Health: Summit for Massachusetts Health Care Decision Makers*, 28 September 2004.

[44] For more information, see Labs 21 Environmental Performance Criteria, http://www.labs21century.gov/toolkit/epc.htm; also see "High-Efficiency Laboratory Ventilation: Benefits and Opportunities," by Tom Lunneberg, *E-Source Tech Update*, March 1998.

[45] Organizations with recommendations for air changes per hour (ACH) include:

- ASHRAE Applications Handbook, p. 13.8 (6-10 ACH).
- NFPA 45, National Fire Protection Association, p. 45-26 (4-8 ACH).
- OSHA 29 CFR-1910, Occupational Safety & Health Administration, US Dept of Labor, p. 484 (4-12 ACH).
- Prudent Practices, National Research Council, p. 192 (6-12 ACH).
- NIH Design Policy & Guidelines section D.7.10, National Institute of Health, p. 17 (6 ACH).
- Industrial Ventilation, American Conference of Governmental Industrial Hygienists.
- ANSI / AIHA Z9.5-2003, American National Standards Institute, American Industrial Hygiene Assn.

--Woolliams, Jessica and John D. Spengler, presentation, *Design for Health: Summit for Massachusetts Health Care Decision Makers*, 28 September 2004.

[46] Woolliams, Jessica and John D. Spengler, presentation, *Design for Health: Summit for Massachusetts Health Care Decision Makers*, 28 September 2004.

ii. Size heating ventilation and air conditioning (HVAC) ductwork and equipment for six air changes per hour (ACH).
iii. Balance HVAC system to two ACH.
iv. In each laboratory, install volatile organic compound (VOC) sensors, with Proportional Integral Derivative (PID) control, and connect them to the Building Automated Control (BAC) system.
v. Program the VOC sensors for local and remote alarm notification (audible & visual).
vi. Program HVAC Variable Air Volume (VAV) dampers to increase ACH to maximum design (six ACH) if VOC sensor(s) are in alarm mode.

b. **Variable air volume**: In a feasibility study using the Labs 21 design standard for a Harvard 35-year-old, 68,000-square-foot, 52 percent lab building (with 26 fume hoods), it was estimated that upgrading to a variable air volume HVAC system with heat recovery would save $48,000/year (10 percent of utility costs), with a 4.25 year payback.[47]
c. **Laminar air flow:**[48] New clean room and lab air-handling designs can probably overcome perceived capital- and energy-cost penalties in applying **laminar airflow** to medical facility design as the Centers for Disease Control and Prevention (CDC) and the Healthcare Infection Control Practices Advisory Committee (HICPAC) recommend.
d. **100 percent outside air:** As in the new UC/Davis Medical Center hospital, 100 percent outside air may actually *reduce* capital cost by simplifying the design, while providing better air quality, although this might be more difficult in more humid climates.

11. Labs—special considerations: Lab facilities have commonly become obsolete when their physical environment cannot service revolutionary new clinical testing procedures. Labs today need robust mechanical and electrical systems, provisions for automation, local exhaust, temperature and humidity control, and provisions for spill containment. One option is to put UV lamps and carbon filters in air-handling units, although care must be taken with the potential for ducts and filters to become growth media for fungi, etc.

12. **Fume hoods:** Save significant energy by using high performance variable air volume (VAV) fume hoods or low-flow constant-volume fume hoods, reducing their operating time (turning them off when not in use), using auxiliary air hoods, and using heat recovery systems. The quantity of air exhausted can be reduced by limiting the face opening, reducing face velocity, using variable air volume controls, and by using special local exhaust hoods and ductless hoods.[49]

13. **Operating rooms:** As with labs, operating room requirements have evolved. Standard temperatures have changed from 68–72°F to 55–65°F and room size has grown from 400 square feet to more than 600 square feet with ceiling heights going from 12.5 to 16 feet. Air filtration requirements have become increasingly stringent and supplementary disinfection (UV lights in ductwork and mechanical

[47] The full list of options included:
- Constant Volume with Heat Recovery: $20,000/ yr savings, 4.8-year payback.
- Constant Volume with Usage Based Control: $18,500 /yr, 2.9-yr payback.
- Constant Volume with Usage Based Control and Heat Recovery: $32,000 /yr, 4.7-yr payback.
- Variable Air Volume: $33,500/yr, 3.3-yr payback.
- Variable Air Volume with Heat Recovery: $48,000/yr, 4.25-yr payback.
- Constant Volume with Low Flow Fume Hoods: $28,072, 7.85-yr payback.

--Woolliams, Jessica and John D. Spengler, presentation, *Design for Health: Summit for Massachusetts Health Care Decision Makers*, 28 September 2004.

[48] Definition of laminar air flow: a flow of air uniformly parallel from ceiling to floor, or wall to wall in a room or workstation, moving with uniform velocity and a minimum of turbulence—Chemistry dictionary, www.chemicool.com/definition/laminar_air_flow.html.

[49] DiBerardinis, Louis, presentation, *Design for Health: Summit for Massachusetts Health Care Decision Makers*, 28 September 2004.

equipment) has become common. Considering these design constraints, the following recommendations address efficiency and effectiveness:

a. Energy efficiency *and* high performance could result from performing thermodynamic modeling to assess standards for air change rate per hour. Consider cooling the patient locally, rather than designing the mechanical system to over-cool the entire room.
b. Design for infection control performance and provide the most effective and efficient locations for exhaust vents.
c. Use a diversity factor when calculating load demands for surgical suites. Most mechanical systems are over-designed to handle all potential loads even though all the loads are never simultaneously on.
d. Utilize redundancy by sharing air-handling units for multiple operating rooms. Shift air handling between spaces (this is analogous to using variable-frequency drives).

14. Specify the most **energy efficient hospital equipment** (and demand higher performance equipment from suppliers if not readily available). Consider that most emergency department equipment operates on different frequencies than building management systems (BMS).

15. Use **high-end isolation valves** to isolate areas that need mechanical servicing, without shutting down an entire floor.

16. **Think "ahead" of regulations** (and utility/disposal service fees). For instance, use mercury-free lamps and HCFC- and CFC-free HVAC systems; recover discharge water for reuse.

17. **Water efficiency methodology:**[50] Water efficiency can produce a 40 percent return on investment (ROI) or (by using an outside contractor) it can reduce operating expenses without a capital investment. Identify all water sources and institute efficient water use and wastewater reduction:
    a. Reduce flow/frequency (for new construction, use most-efficient fixtures, harvest rainwater for use, rather than sending it elsewhere for treatment). Treat the hospital as its own watershed.
    b. Reuse/Recycle (collect condensate, gray water, and rainwater to use for cooling tower and irrigation and/or for non-potable domestic use (toilet flushing),
    c. Replace (e.g., replace inefficient/leaky fixtures and equipment, sealed/closed-system cooling, etc.).
18. **Specific water efficiency opportunities:** Hospital water use is typically 25 percent "domestic" (sinks, showers and toilets/urinals) and 75 percent "process," including non-potable uses (boilers/chillers, cooling towers, condenser water, irrigation, steam system, etc.), equipment requiring potable water (food services, refrigeration equipment, medical air/vacuum systems, operating room equipment, ambulatory surgery, autoclaves, film processing for radiology, radiation oncology, bio reactors, analytical lab equipment, instrument washers, cage/cart washers, laundry, etc.), and water purification systems (reverse osmosis/stills). Efficiency opportunities include:

    a. Domestic
        i. Replace 3.5-gallons-per-flush (gpf) toilets with 1.6 gpf toilets,
        ii. Reduce high-flow faucets and showerheads (replace 2.5-gallons-per-minute (gpm) faucets with 1.5-gpm variety),
        iii. Repair leaky fixtures (leaky toilets and showerheads can waste 350 and 1000 gallons each week!),
        iv. Install waterless urinals, and
        v. Install motion-activated sinks for hand washing.
    b. Process equipment
        vi. Replace water cooled equipment,

[50] Loranger, Robert, presentation, *Design for Health: Summit for Massachusetts Health Care Decision Makers,* 28 September 2004.

vii. Use alternate source of water for cooling,
viii. Recover waste water and reuse,
ix. Improve efficiency of water-using equipment,
x. Run full loads in sanitizers, dishwashers, sterilizers and autoclaves, and laundry washing machines (consistent with health code),
xi. Install automatic valves on film process, autoclave, and sterilizing equipment to stop water flow when not in use—use temperature control valves.

c. Plant operations

xii. Install non-potable well,
xiii. Reuse cooling tower/boiler blowdown,
xiv. Install xeriscape (zero- or low-water-use, well-adapted landscaping),
xv. Recover condensate and reuse, and
xvi. Eliminate water-cooled equipment.

Implementation strategy for water efficiency: Implementing water efficiency requires a dedication of staff time to (a) benchmark existing conditions, (b) set water use reduction goals, and (c) develop and implement a water conservation management plan. If facility managers are too busy to implement these measures, and if capital is scarce while operating budgets are also being cut, then hire an outside contractor who will install water efficiency measures and be paid through the operational savings (performance-based contracts). Alternatively, use creative funding approaches, such as a utility expense reduction program, which is treated as an operating expense requiring no capital budget.[51]

[51] Ibid.

Conclusions and Next Steps

The Summit discussions and post-Summit participant feedback pointed to some critical issues and needs associated with greening healthcare facilities. These include a need for collaboration and cooperation within the healthcare community—especially between hospitals, but also including governmental- and non-governmental organizations, and community members. Also needed are: the creation and circulation of successful case studies, more data supporting the business case for green hospital construction, more evidence-based research, and information regarding engineering and design advancements for healthcare construction. Hospital staff, architects, and engineers need ongoing education and technical/design guidance, and, as some participants suggested, they need additional forums (such as additional summits) to glean information and to network with their peers. Finally, as pointed out in most every Summit work session, one of the most essential steps for hospitals to green their facilities is for them to establish senior leadership commitment and hospital culture change.

Follow-up from the Summit

Further Research and Workshops: As noted above, the Summit identified many critical issues that need further awareness and research. There are several efforts already underway to address these needs. The cost-estimating firm Davis Langdon is following up its "Costing Green" study (which compared the costs of green versus standard buildings) with a study specifically targeting healthcare buildings. As noted during the Summit, NIH may also be interested in funding further research into the costs and benefits of "greening" hospitals (although such a study has not yet been proposed). The AIA College of Fellows recently awarded the 2005/2006 Latrobe Fellowship to fund research to further examine the link between healthcare facility design and faster healing rates in patients. Finally, outcomes of the Design for Health Summit informed the planning and design of an upcoming workshop: Green Healthcare Institutions: Health, Environment, and Economics, which is being sponsored by the National Academies' Institute of Medicine and will be held in Washington DC, 10–11 January, 2006.[52]

Collaborative Initiatives: After the Summit, there was considerable interest in the Boston Hospital Champions Council idea, but due to constraints on the time of key hospital decision-makers, it became difficult for hospitals to make the commitment to participate. This underscores the reality that unless hospitals allocate personnel specifically to greening efforts, there will be conflicting priorities.

What has evolved, however, is a burgeoning "Lunch and Learn" program for the architectural design community, facilitated by Health Care without Harm, in which hospital designers can learn about green design strategies and products, and can exchange ideas with each other. Design firms are also encouraged to invite their hospital clients. These sessions are held once per month, either at architectural firms during lunchtime or at 5:30 p.m. at the Boston Society of Architects. The lunch sessions have attracted an average of 35–40 participants and the evening sessions, about 12–14. Presenters have included Barbra Batshalom, Bill Ravanesi, Robin Guenther, and Paul Lipske, Sustainable Step of New England. Topics have included strategic questioning, sustainability 101, the GGHC, the business case for high performance hospital design, and case studies of early adopters of high performance hospital design. Regularly attending firms have included: Steffian Bradley Associates, Boston Properties, Perkins and Will, and Payette Associates.

Individual Hospital Initiatives: Following the Summit, several individual hospitals committed to adopting the GGHC for their new construction projects. These include: Beverly Hospital, Brigham and Women's Hospital, Children's Hospital Boston, Dana Farber Cancer Institute, and Spaulding

[52] The workshop will be held in the National Academies' building, Keck 100, 500 5th Street NW, Washington DC, Registration is free (see www.iom.edu/ehsrt for more information).

Rehabilitation Hospital. Representing senior leadership commitment at these major hospitals, and forecasting a better-educated architectural design community, this could be a big step toward healthier hospital construction in Boston. Moreover, given the nationally respected status of Boston hospitals, this ripple of change could have ongoing impact in ever-widening circles.

Appendix A: Additional Breakout Session Material

A-1: The Business Case – A Breakout Session Discussion

The most prevalent notion in the market today is that green buildings cost more. First, the question "cost more than what?" must be carefully answered. Do green buildings cost more than the exact same building without the green features, more than the capital budget, or more than comparable buildings of the same size and complexity? Bob Moroz, in his Summit presentation on The Dell Children's Hospital of Texas, (Seton Health Systems, Austin, Texas) demonstrated how offloading the cost of a central heating and chiller plant ($6 million of a $150 million capital project) through a contract with Austin Energy allowed for a series of incremental capital cost increases to improve building performance (and achieve a LEED® Platinum rating) with little to no perceived difference in the total construction cost. In this example, a green building costs no more than the capital budget.

In the absence of green buildings to study, early financial models have predicted that sustainable buildings would carry cost premiums that related to their "level" of sustainability. More recent studies, based upon completed buildings, have shown that the anticipated cost premiums have been largely overstated. In its 2003 White Paper on Sustainability, *Building Design & Construction* magazine concluded that many "green" buildings cost no more than their "brown" equivalents.[53] Gregory H. Kats reviewed more than 100 completed LEED® certified office and school buildings and concluded that the average first cost premium is slightly less than two percent.[54] More important, these studies point to a consistent set of key factors that affect building costs:

- The earlier the green features are incorporated in design, the lower the cost.
- Costs decline with increasing experience, and as market transformation occurs.
- Green buildings provide financial benefits that brown buildings do not.

Kats outlined the benefits of green buildings as follows: "the financial benefits are in lower operating costs, lower environmental costs, and increased productivity and health. Over 20 years, the benefits are over 10 times the additional costs."

The 2004 Davis Langdon study concluded: "Sustainability is a program issue rather than an added requirement; perhaps the most important thing to remember is that …(it) is not a below-the-line item."[55] This study, which compared completed green and brown laboratory buildings, found no correlation between construction cost and level of sustainable design features. Instead, it concluded:

- There is a very large variation in costs of buildings, even within the same building program type, and
- There are low cost and high cost green buildings; there are low cost and high cost non-green buildings.

In summary, there is no conclusive data that, in the aggregate, green buildings cost more than their brown equivalents. Participants agreed that if green strategies are isolated that cost more than their brown equivalents but deliver operational savings, then the operational savings must be included in the equation.

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[53] "White Paper on Sustainability," *Building Design & Construction Magazine,* November 2003.
[54] Kats, Gregory H., "The Costs and Financial Benefits of Green Buildings: A Report to California's Sustainable Building Task Force," October, 2003; for full report, see www.cap-e.com.
[55] Matthiessen, Lisa Fay and Peter Morris, "Costing Green: A Comprehensive Cost Database and Budgeting Methodology," October 2004, for full report, see www.greenerbuildings.com.

Operational savings include energy and water efficiency savings, or material selections that reduce maintenance costs.

It is in the relationship between buildings and health that the intersection with the business case for "evidence-based design" is most evident. Participants reviewed "The Business Case for Better Buildings," a study published by the Center for Health Design, that used a series of Pebble Project research findings to project financial payback related to constructing buildings that reduce stress, and improve safety.[56] The study extrapolated research findings to create the Fable Hospital, a building that projected additional first costs to achieve a safer, less stressful, healthier environment, which in turn achieved a series of financial benefits.

Summit participants agreed that the Fable Hospital study provides important initial data to use in quantification of benefits. Reduced staff illness and absenteeism, improved staff performance (reduced medical error), reduced hospital acquired infections, and improved staff recruitment and retention are all benefits that can be quantified through continued research and measurement. The benefits from sustainable design strategies need to be defined, quantified, and communicated through industry, much the way the Fable Hospital project has accomplished quantification of evidence-based design strategies.

Until there are enough "green" healthcare buildings to study and the business case is proven, sustainable healthcare construction will be accomplished by a select group of industry leaders. Summit participants agreed that the Boston area includes a number of institutions that strive to be market leaders, and the time was ripe for leaders to move forward with sustainable building. Participants were encouraged to heed Amory Lovins's Summit warning: "If you wait until the data is in and the business case is proven, you will forfeit leadership."

[56] Berry, Leonard, et al, "The Business Case for Better Buildings," *Frontiers of Health Services Management*, 21(1) pp 4-24. Full report: http://www.healthdesign.org/aboutus/press/releases/frontiers_0904.pdf.

A-2: Strategies for super-efficient HVAC design[57]

Efficient laboratory HVAC design can produce tremendous energy savings while creating a healthier hospital environment. The secret is simply designing the system in the right order and focusing on whole system design—optimizing the whole system for multiple benefits, not isolated components for single benefits.

- Step one: design out toxicity in the first place through material selection.
- Step two: use a low face-velocity design with big pipes and small pumps. This will reduce the frictional losses and allow the mechanical equipment to be downsized.
- Step three: avoid the gross over-sizing that comes from rule-of-thumb designs. This is where the cost savings come from—smaller equipment is cheaper to buy, creates smaller parasitic heat loads, and requires less maintenance.

Step one is discussed throughout this report and in the *GGHC* sections on Materials & Resources and Environmental Quality. Step three is self-explanatory yet influenced by step two, which is discussed more thoroughly below.

Air handling fundamentals: Step two, which consequently leads to equipment downsizing, increased efficiency, and deferred capital costs, is grounded in the fundamental thermodynamics equation shown below. This equation identifies the key strategies that are addressed in efficient HVAC design: (1) reduce flow rate, (2) reduce pressure drop, and (3) increase equipment efficiency***:***

$$\text{Fan motor power (hp)} = \frac{\dot{Q}(CFM) \times \Delta P(inches)}{6{,}345 \times \eta_{fan} \times \eta_{drive} \times \eta_{motor}},$$

when:
$\dot{Q}$ = volumetric flow rate in the system;
ΔP = pressure drop in the system;
η_{fan} = fan efficiency;
η_{drive} = drive efficiency; and
η_{motor} = motor efficiency.

(1) Reduce flow rate: Hospital HVAC design typically relies on recommended air changes per hour (note: there are currently six different organizations with different design recommendations). However, by using demand-controlled filtration,[58] air could be supplied only when needed—based on a real-time measure of contamination, not thermal loads. This strategy would maintain the required clean conditions while reducing flow rate. Furthermore, using displacement ventilation, as used in raised-floor computer centers, will maintain laminar flow and push the contaminants out of the rooms rather than diluting them in place. This concept is illustrated in the figure below.

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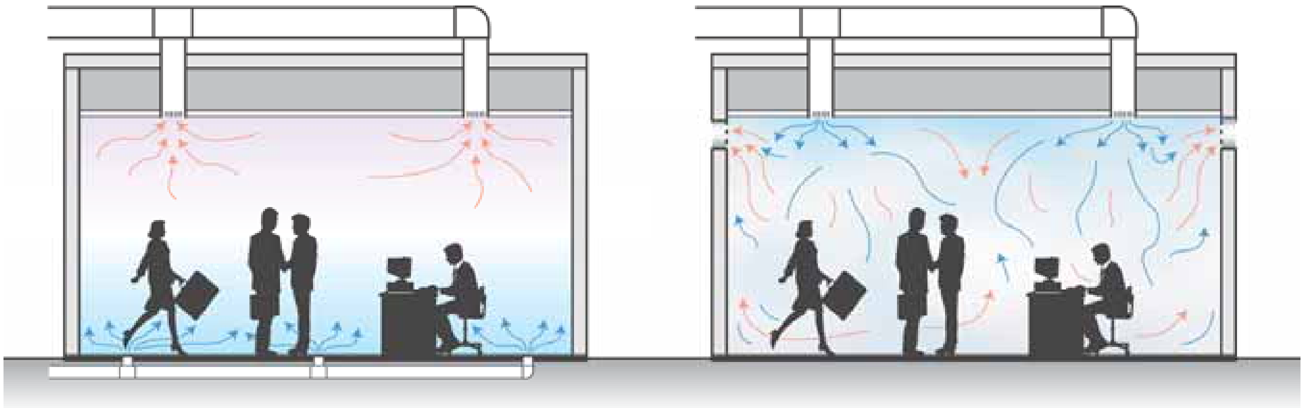
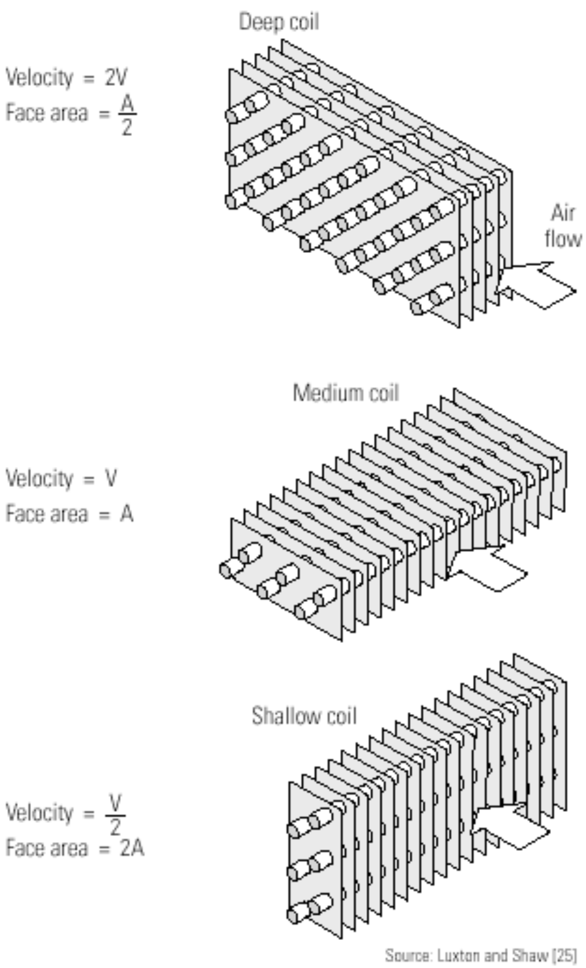
[57] Lovins, Amory, presentation, *Design for Health: Summit for Massachusetts Health Care Decision Makers*, 28 September 2004.
[58] Demand-controlled filtration manages ventilation rates in response to real-time particle-count measurements. For more information, see http://hightech.lbl.gov/dc-filtration.html.



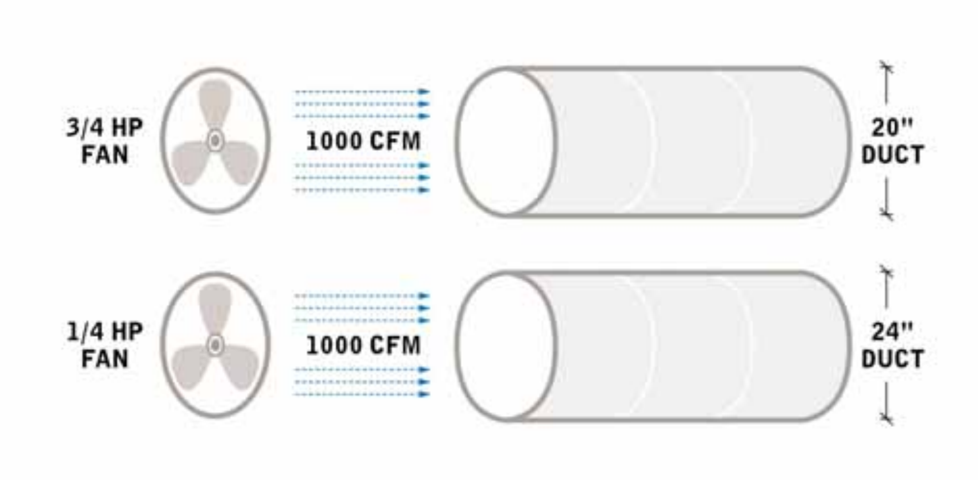
Further rethinking of several mechanical design conventions based on engineering fundamentals can contribute to vastly more efficient design. For example, replacing the traditional high-velocity, low face-area coil layout with a low-face velocity design can reduce the pressure drop by up to 95 percent, increase dehumidification by 29 percent, provide better comfort, and require a smaller chiller and fan. See illustration below.



(2) Reduce pressure drop: Just like the coil configuration example illustrated above, many HVAC systems are designed with little regard for pressure drop (how hard the pumps will have to work to move the fluid). The piping and ductwork is undersized and follows a bending, circuitous route, which means large pumps and motors are needed to accommodate the extra pressure head (the resistance or force that the pumps have to overcome to move a fluid). Efficient HVAC design includes ducts and pipes that have large cross-sectional areas and short, straight layouts (minimal length and bends reduce unnecessary friction). While transporting a fluid, pressure drop is proportional to duct length and inversely to the fifth power of duct diameter (see equation below). Therefore, less power is required to push air through short, fat pipes than through long, skinny pipes. The result is a system that is more efficient, introduces smaller parasitic heat loads from oversized pumps, and is cheaper to install (smaller equipment).

Pressure drop $\propto \frac{L}{\phi^5}$,

When:
L = duct length and
ϕ = duct diameter.



(3) Install efficient fans, pumps and motors: The money that is saved by downsizing the mechanical systems can then be invested in efficient pumps, motors, and direct-drive fans to further save operational energy. The result is a system that is more efficient to run, cheaper to install, and quieter.

Whole system cooling design (an example): The Atlantic lobster has large, obvious chunks of meat in the tail and claws, but it contains a roughly equivalent amount of meat hidden in the crevices. This is a good lesson for HVAC system efficiency. Although most efficiency efforts focus on the large energy consuming components (i.e., the chillers), there are equal amounts of savings to be found in the other system components. The following example illustrates that although chiller efficiencies alone can save a substantial amount of energy (~0.27 kW/t), optimizing the additional components of the system results in savings three times as much (~0.89 kW/t). The result of applying whole system design to a standard cooling system is energy savings of over 65 percent and reduced first-costs, achieved with state-of-the-shelf technologies:

System Component	**Standard Efficiency (kW/t)**	**Available Efficiency (kW/t)**	**How?**
Supply fan	0.6	.061	Select high-efficiency, vaneaxial fans with variable speed drive
Chilled water pump	0.16	.018	Use low pressure piping and an efficient variable-primary-flow (VPF) pump to eliminate secondary pumping
Chiller	0.75	0.481	Use a 1–2° F approach temperature and optimized impeller speed
Condenser water pump	0.14	0.018	Use low pressure piping and an efficient pump
Cooling tower	0.1	0.012	Specify a big fill area for a big slow fan with variable-speed drive
TOTAL (COP)	1.75 (2.01)	0.590 (5.78)	*65%* more efficient system, better comfort, increased uptime, and less capital cost

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Health Care Without Harm • Rocky Mountain Institute • Massachusetts Hospital Association
Massachusetts Health & Educational Facilities Authority • Center for Maximum Potential Building Systems
Massachusetts Technology Collaborative • Green Round Table

Appendix C: Agenda

Design for Health:
Summit for Massachusetts Healthcare Decision Makers

28th –29th, September 2004
Massachusetts Medical Society
Waltham Woods Conference Center
860 Winter Street, Waltham, MA
(781) 434-7499

Summary of the Summit:

Design for Health introduces a series of roundtable work sessions, focused on specific topics relevant to hospital design and operations. Targeted topics address environmental health, indoor air quality, energy, water, community, products and waste streams, and healing environments, with clearly defined performance and policy recommendations associated with each topic area culminating from the two-day gathering.

Professionals with expertise in healthcare design, high-performance green design, and environmental health will facilitate the roundtables, enabling Summit participants to creatively develop their ideas about effective policies and guidelines. A goal of the Summit is to establish a blueprint for how whole-systems thinking can achieve radically higher levels of whole building performance while simultaneously enhancing patient healing, staff retention and productivity, and hospital financial security. Anticipated topics include establishing overarching goals to improve hospital design, and overarching policies and next steps to accelerate the healthcare industry's transition towards high performance healing environments.

This blueprint will serve as a roadmap of the Summit's recommendations – highlighting opportunities to create sustainable healthcare facilities and overcome barriers – will be issued by the end of the year. Copies of the report will be distributed to all Summit attendees, and to representatives of other health-care related organizations and media entities.

Design for Health Summit

Tuesday, 28th September, 2004

7:30 am **Registration**: Continental breakfast

8:15 am **Welcome**: Bill Ravanesi, Boston Campaign Director, Health Care Without Harm and Alexis Karolides, AIA, Principal, Rocky Mountain Institute

8:40 am **Opening Remarks**: Dr. Samuel H. Wilson, Deputy Director, National Institute of Environmental Health Sciences, National Institutes of Health, Department of Health and Human Services

8:50 am **Keynote**: Amory Lovins, CEO of Rocky Mountain Institute: The Triple Bottom Line for hospitals: healthier people, healthier environment, healthier financials. The talk will focus on how energy-efficient, high performance buildings with clean, reliable power can meet all three goals.

9:50 am **Break**

10:15 am **Case Study**: Robert Moroz, Vice President, Network Facilities for Seton Healthcare Network in Central Texas

10:45 am **Regional Context**: Barbra Batshalom, Executive Director, The Green Roundtable

11:00 am **"Green Guide for Health Care" Overview**: Robin Guenther, AIA, Guenther 5 Architects (NYC) and Gail Vittori, Co-director, Center for Maximum Potential Building Systems (Austin, TX).

12:00 pm **Luncheon Speaker, Connecting the Dots:** Charlotte Brody, RN Co-Executive Director Health Care Without Harm

1:00 pm **Breakout Session One—Defining Strategies**. Topical working teams for interactive brainstorming sessions. Attendees will be pre-assigned to one of seven breakout groups.

Topics	**Facilitators/ Presenters/Scribes**
1. Precautionary Principle / Environmental Health	Facilitator: Charlotte Brody Presenter: Dr. Ted Schettler Presenter: Dr. Samuel H. Wilson Scribe: Cathy Crumbley
2. Indoor Air Quality / Infection Control/ Risk Minimization	Facilitator: Jack McCarthy Presenter: Jack Spengler Scribe: Kevin Settlemyre
3. Energy / Resource Efficiency & Energy Waste	Facilitator: Joel Swisher Presenter: Amory Lovins Presenter: George Player Scribe: Alex Chase

4. Site / Community / Footprint	Facilitator: Barbra Batshalom Presenter: Robert Moroz Presenter: Arthur Mombourquette Scribe: Peg Hill
5. Materials / Products and Waste Streams	Facilitator: Gail Vittori Presenter: Mark Rossi Scribe: Janet Brown
6. The Healing Environment / Indoor Environmental Quality	Facilitator: Alexis Karolides Presenter: Robin Guenther Presenter: Nancy Clanton Scribe: Dan Arons
7. Water Efficiency	Facilitator: David DelPorto Presenter: Robert Loranger Scribe: Jamie Harvie

3:00 pm **Break**

3:20 pm **Plenary Discussion and Integration Session**: Teams post flip chart pages, quickly present key concepts.

4:30 pm **End of Day Remarks**: Preparation for Wednesday

5:00 pm **Reception**

Wednesday, 29th September, 2004

7:45 am **Continental Breakfast**

8:45 am **Keynote**: Sandra Steingraber, biologist and poet, author of *Living Downstream: An Ecologist Looks at Cancer and the Environment* and *Post Diagnosis.*

9:45 am **A Green Building Policy Perspective**: Mayor Thomas Menino, City of Boston

10:00 am **Break**

10:15 am **Overview:** Intended outcomes for Day Two.

10:30 am **Breakout Session Two—Healthcare Facilities:** Reconfigure into hospital facility type breakout groups.

Topic	**Facilitators/ Presenters /Scribes**
1. Inpatient Unit	Facilitator: Gail Vittori Presenter: Arthur Mombourquette Scribe: Peg Hill
2. Surgical Suite	Facilitator: Jack McCarthy Presenter: Chuck Labins Scribe: Alex Chase
3. Emergency Department / Diagnostic & Treatment Areas	Facilitator: Barbra Batshalom Presenter: Robin Guenther Scribe: Kevin Settlemyre
4. Outpatient / Medical Office Buildings	Facilitator: Alexis Karolides Presenter: Dan Arons Scribe: Mark Rossi
5. Cancer Centers	Facilitator: Dr. Samuel H. Wilson Presenter: Michael McGowan Scribe: Jamie Harvie
6. Laboratories	Facilitator: Jessica Woolliams Presenter: Jack Spengler Presenter: Louis DiBerardinis Presenter: Anand Seth Scribe: Michelle Mondazzi
7. Management & Operations	Facilitator: Robert Moroz Presenter: Greg Doyle Presenter: George Player Scribe: Janet Brown

12:00 pm **Lunch**

12:30 pm **Lunch Presentation**: Douglas Foy, Secretary of Commonwealth Development, Office of Community Development, State of Massachusetts

1:00 pm **Breakout Session Three—Shaping the Recommendations** (Breakout Session One from previous day reconvene)

3:00 pm **Break**

3:30 PM **Plenary Discussion and Integration Session**: Teams post flip chart pages, quickly present key concepts.

5:00 PM **Concluding Remarks and Next Steps**: Description of RMI/HCWH Deliverable, how it will be disseminated, discussion of how it will be used and what could be implemented.

5:30 PM **End of Summit**

For comfort we recommend business casual dress.

Appendix D: Summaries of Relevant Studies

D-1: Selected Studies Documenting the Health Benefits of Contact with Nature

STUDY: Stress reduction of ICU nurses and views of nature
SOURCE: Ovitt, Margaret A. 1996. "The effect of a view of nature on performance and stress reduction of ICU nurses." Unpublished master's thesis, Department of Landscape Architecture, Graduate College of the University of Illinois at Urbana-Champaign.
SUMMARY: This study examined the role that a view of nature might play in the workday environment of ICU nurses. The research took place at the ICUs of two Midwestern medical centers. One ICU had a lounge with large windows overlooking mature trees and buildings; the other lounge was windowless. The nurses were asked to do a task and rate themselves on an Affect Grid that measured arousal and mood while they were giving patient care in the morning. After their noon break in their lounges, they were asked to repeat the task and self-rating. The group with the window had significantly reduced stress levels made fewer errors on the task than the group with the windowless lounge.
DATA: The group with the windows had roughly 40% fewer errors on the letter-deletion task after spending their lunch break in the lounge than the group with no windows. The nurses who spent their break in the window lounge reported a 25% reduction in arousal (stress) from morning to afternoon, while there was no change in self-reported arousal from the nurses with no windows.

The text of the summaries below are from: Ulrich, Roger S. "Biophilia, Biophobia and Natural Landscapes" from *The Biophilia Hypothesis*, Island Press: 1993, pp. 73-137.

STUDY: Patient recovery and views of nature
ORIGINAL SOURCE: Ulrich, R.S. 1984. "View Through a Window May Influence Recovery from Surgery." *Science* 224:420-421.
SUMMARY: A study examined patients recovering from gall bladder surgery in a Pennsylvania hospital to evaluate whether assignment to a room with a window view of a natural setting might have therapeutic influences (Ulrich 1984). Recovery data were compared for pairs of patients who were closely matched for variables that could influence recovery such as age, sex, weight, tobacco use, and previous hospitalization. The patients were assigned essentially randomly to rooms that were identical except for window view: one member of each pair overlooked a small stand of deciduous trees; the other had a view of a brown brick wall. Patients with the natural window view had shorter postoperative hospital stays, had fewer negative comments in nurses' notes ("patient is upset," "needs much encouragement"), and tended to have lower scores for minor post-surgical complications such as persistent headache or nausea requiring medication. Moreover, the wall-view patients required many more injects of potent painkillers, whereas the tree-view patients more frequently received weak oral analgesics such as acetaminophen.

STUDY: Patient window view preference
ORIGINAL SOURCE: Verderber, S. 1986. "Dimensions of Person-Window Transactions in the Hospital Environment." *Environment and Behavior* 18:450-466.
SUMMARY: ...findings from a questionnaire study of patients who were severely disabled by accidents or illness (and hence were presumably stressed) suggest than an especially highly preferred category of hospital window views included scenes dominated by natural content (Verderber 1986).

STUDY: Patient recovery and nature images
ORIGINAL SOURCE: Ulrich, R.S., and O. Lunden. 1990. "Effects of Nature and Abstract Pictures on Patients Recovering from Open Heart Surgery." Paper presented at the International Congress of Behavioral Medicine, 27-30 June, Uppsala, Sweden.

SUMMARY: ...Outi Lunden and I (1990) investigated whether exposure to visual stimulation in hospital intensive care units, including simulated natural views, promotes wellness with respect to the postoperative courses of open-heart surgery patients. At Uppsala University Hospital in Sweden, 166 patients who had undergone open-heart surgery involving a heart pump were randomly assigned to a visual stimulation condition consisting of a nature picture (either an open view with water or a moderately enclosed forest scene), an abstract picture dominated by either curvilinear or rectilinear forms, or a control condition consisting of either a white panel or no picture at all. Our findings suggest that the patients exposed to the open view of water experience much less postoperative anxiety than the control groups and the groups exposed to the other types of pictures. The comparatively enclosed forest setting with shadowed areas did not reduce anxiety significantly compared to the control conditions. The rectilinear abstract picture was associated with higher anxiety than the control conditions. Future reports stemming from this research will present findings based on a wide variety of indicators of wellness both physiological (such as blood pressure) and behavioral (such as use of painkillers and post-surgical length of stay).

STUDY: Stress reduction and contact with nature

ORIGINAL SOURCE: Hartig, T., M. Mang, and G.W. Evans. 1991. "Restorative Effects of Natural Environment Experiences." *Environment and Behavior* 23:3-26.

SUMMARY: Hartig and his associates have reported the restorative effects of experiencing a park-like nature area while controlling for certain stress-reducing variables such as physical exercise (Hartig, Mang, and Evans 1991). They first produced stress in individuals with a demanding cognitive task and then measured recovery effects of either (1) a forty-minute walk in an urban fringe nature area dominated by trees and other vegetation, (2) walking for an equivalent period in a comparatively attractive, safe urban area, or (3) reading magazines or listening to music for forty minutes. Their findings suggest that people randomly assigned to the nature walk reported more positively toned emotional states than those assigned to the other two conditions -- and performed better on a cognitive task (proofreading).

STUDY: Stress reducing effects of viewing nature

ORIGINAL SOURCE: Ulrich, R.S., R.F. Simons. B.D. Losito, E. Fiorito, M.A. Miles, and M. Zelson. 1991. "Stress Recovery During Exposure to Natural and Urban Environments." *Journal of Environmental Psychology* 11:201-230.

SUMMARY: In a study that used a number of measurements techniques for assessing the stress-reducing effects of experiencing natural versus urban environments, 120 persons were first show a stressful movie and then randomly assigned to a recovery condition that consisted of viewing one of six different color/sound videotapes of natural settings or urban environments lacking in nature (Ulrich et al. 1991). Data concerning stress recovery during the environmental presentations were obtained from self-ratings of affective states and four physiological measures: heart rate, skin conductance, muscle tension (frontalis), and pulse transit time (a noninvasive measure that correlates highly with systolic blood pressure). Findings from all measures, verbal and physiological, converged in indicating that recuperation from stress was much faster and more thorough when people were exposed to the natural settings (a grassy, park-like landscape and a setting with a prominent water feature).

STUDY: Prisoner health and views of nature

ORIGINAL SOURCE: Moore, E.O. 1982. "A Prison Environment's Effect on Health Care Service Demands." *Journal of Environmental Systems* 11:17-34.

SUMMARY: In a prison study, Moore (1982) examined the need for healthcare services by inmates whose cells looked out onto the prison yard versus those who had a view of nearby farmlands and forests. He reported that the inmates with natural views were less likely to report for sick call.

STUDY: Stress symptoms and views of nature
ORIGINAL SOURCE: West, M.J. 1985. "Landscape views and Stress Responses in the Prison Environment." Unpublished master's thesis, Department of Landscape Architecture, University of Washington.
SUMMARY: Likewise, West (1985) found that cell window views of nature -- compared to views of prison walls, buildings, or other prisoners in cells -- were associated with lower frequencies of health-related stress symptoms such as headaches and digestive upsets.

D-2: The role of hospital design in the recruitment, retention and performance of NHS nurses in England (CABE Study)

SOURCE: PricewaterhouseCoopers LLP, et al, “The role of hospital design in the recruitment, retention and performance of NHS nurses in England,” commissioned by the Commission for Architecture and the Built Environment (CABE), July 2004. Download the full report from the following web link: http://www.healthyhospitals.org.uk/diagnosis/HH_Full_report_Appendices.pdf

Abstract (excerpted from full report)

This research was commissioned by the Commission for Architecture and the Built Environment (CABE) and carried out by PricewaterhouseCoopers LLP (PwC) in association with the University of Sheffield and Queen Margaret University College, Edinburgh between September 2—3 and April 2004.

The primary aim of the research was to explore whether hospital design has an influence on the recruitment, retention and performance of NHS nurses in England, and to further examine which aspects of design matter to nursing staff.

The research methodology involved a mix of qualitative focus groups with nurses throughout England and a large scale quantitative survey of Directors of Nursing.

Overall the research found that design *does* matter to nurses, and has the greatest influence on their workplace performance, followed by recruitment and then retention.

In terms of specific aspects of design, the internal environment and the functionality of the environment appears to mater most. Examples of specific aspects which are important to nurses include building and unit layout, space in which to work, environmental control and interior design such as lighting and use of colour.

D-3: The Business Case for Better Buildings (Fable Study)

SOURCE: Berry, Leonard L., PhD, Derek Parker, Russell C. Coile, Jr., D. Kirk Hamilton, David D. O'Neill, J.D., and Blair L. Sadler, J.D., "The Business Case for Better Buildings," *Frontiers of Health Services Management*, 21(1) pp 4-24. Download the full report from the following web link: http://www.healthdesign.org/aboutus/press/releases/frontiers_0904.pdf

Summary (excerpted from full report)

The buildings in which customers receive services are inherently part of the service experience. Given the high stress of illness, healthcare facility designs are especially likely to have a meaningful impact on customers. In the past, a handful of visionary "healing environments" such as the Lucille Packard Children's Hospital at Stanford University in Palo Alto, California; Griffin Hospital in Derby, Connecticut; Woodwinds Health Campus in St. Paul, Minnesota; and San Diego Children's Hospital were built by values-driven chief executive officers and boards and aided by philanthropy when costs per square foot exceeded typical construction costs. Designers theorized that such facilities might have a positive impact on patients' health outcomes and satisfaction. But limited evidence existed to show that such exemplary health facilities were superior to conventional designs in actually improving patient outcomes and experiences and the organization's bottom line. More evidence was needed to assess the impact of innovative health facility designs. Beginning in 2000, a research collaborative of progressive healthcare organizations voluntarily came together with The Center for Health Design to evaluate their new buildings. Various "Pebble Projects" are now engaged in three-year programs of evaluation, using comparative research instruments and outcome measures. Pebble Projects include hospital replacements, critical care units, cancer units, nursing stations, and ambulatory care centers. The Pebble experiences are synthesized here in a composite 300-bed "Fable Hospital" to present evidence in support of the business case for better buildings as a key component of better, safer, and less wasteful healthcare. The evidence indicates that the one-time incremental costs of designing and building optimal facilities can be quickly repaid through operational savings and increased revenue and result in substantial, measurable, and sustainable financial benefits. The one-time incremental costs of designing and building optimal facilities can be quickly repaid.

D-4: The Role of the Physical Environment in the Hospital of the 21st Century: A Once-in-a-Lifetime Opportunity

SOURCE: Ulrich, Roger, Craig Zimring, Xiaobo Quan, Anjali Joseph, Ruchi Choudhary, "The Role of the Physical Environment in the Hospital of the 21st Century: A Once-in-a-Lifetime Opportunity," 2004. Download the full report at: http://www.healthdesign.org/research/reports/physical_environ.php

Summary (excerpted from full report)

A visit to a U.S. hospital is dangerous and stressful for patients, families and staff members. Medical errors and hospital-acquired infections are among the leading causes of death in the United States, each killing more Americans than AIDS, breast cancer, or automobile accidents (Institute of Medicine, 2000; 2001). According to the Institute of Medicine in its landmark Quality Chasm report: "The frustration levels of both patients and clinicians have probably never been higher. Yet the problems remain. Health care today harms too frequently and routinely fails to deliver its potential benefits" (IOM, 2001). Problems with U.S. health care not only influence patients; they impact staff. Registered nurses have a turnover rate averaging 20 percent.

At the same time, the United States is facing one of the largest hospital building booms in US history. As a result of a confluence of the need to replace aging 1970s hospitals, population shifts in the United States, the graying of the baby boom generation, and the introduction of new technologies, the United States will spend more than $16 billion for hospital construction in 2004, and this will rise to more than $20 billion per year by the end of the decade. These hospitals will remain in place for decades.

This once-in-lifetime construction program provides an opportunity to rethink hospital design, and especially to consider how improved hospital design can help reduce staff stress and fatigue and increase effectiveness in delivering care, improve patient safety, reduce patient and family stress and improve outcomes and improve overall healthcare quality.

Just as medicine has increasingly moved toward "evidence-based medicine," where clinical choices are informed by research, healthcare design is increasingly guided by rigorous research linking the physical environment of hospitals to patients and staff outcomes and is moving toward "evidence-based design". This report assesses the state of the science that links characteristics of the physical setting to patient and staff outcomes:
What can research tell us about "good" and "bad" hospital design?
Is there compelling scientifically credible evidence that design genuinely impacts staff and clinical outcomes?
Can improved design make hospitals less risky and stressful for patients, their families, and for staff?

In this project, research teams from Texas A&M University and Georgia Tech combed through several thousand scientific articles and identified more than 600 studies - most in top peer-reviewed journals - that establish how hospital design can impact clinical outcomes. The team found scientific studies that document the impact of a range of design characteristics, such as single-rooms versus multi-bed rooms, reduced noise, improved lighting, better ventilation, better ergonomic designs, supportive workplaces and improved layout that can help reduce errors, reduce stress, improve sleep, reduce pain and drugs, and improve other outcomes. The team discovered that, not only is there a very large body of evidence to guide hospital design, but a very strong one. A growing scientific literature is confirming that the conventional ways that hospitals are designed contributes to stress and danger, or more positively, that this level of risk and stress is unnecessary: improved physical settings can be an important tool in making hospitals safer, more healing, and better places to work.

Appendix E: Presentations

Most of the following presentations can be downloaded from the Design for Health Summit website: http://www.noharm.org/designforhealth.

Tuesday, September 28, 2004

Samuel H. Wilson, M.D.
"Environmental Health: A Response Based on Partnership, Planning, and Environmental Stewardship"
Amory B. Lovins
"The Triple Bottom Line for Hospitals: healthier people, healthier environments, healthier financials"
Robert P. Moroz, AIA
"Case Study: The LEED Initiative at the Dell Children's Medical Center of Central Texas: The business case for high performance hospitals"
Barbra Batshalom
"Statewide Trends for Green Building: The Context for Emerging Sustainability"
Robin Guenther, AIA
"Green Guide for Health Care"

Breakout Group 1: Precautionary Principle; Samuel H. Wilson M.D.
Breakout Group 2: Indoor Air Quality, Infection Control, Risk Management; John D. Spengler, PhD.
Breakout Group 3: Energy/Resource Efficiency & Energy Waste; Amory Lovins and George Player
Breakout Group 4: Site/Community/Footprint; Arthur Mombourquette
Breakout Group 5: Lighting Healing Environments; Nancy Clanton
Breakout Group 6: The Healing Environment; Robin Guenther
Breakout Group 7: Economics of Water; David Del Porto
Breakout Group 7: Water Supply and Usage; Robert Loranger

Wednesday, September 29, 2004

Douglas Foy
"Developing the Common Wealth"
Sandra Steingraber
"The Pirates of Illiopolis"

Breakout Group 1: Inpatient Unit; Arthur Mombourquette
Breakout Group 2: Surgical Suites; Chuck Labins
Breakout Group 3: Labs; Jessica Wooliams and Jack Spengler
Breakout Group 4: Personal Protection; Louis DiBerardinis
Breakout Group 5: Clinical Laboratories; Anand K. Seth
Breakout Group 6: Management and Operation; Greg Doyle and George Player

Comments from participants of the Design for Health Summit:

“Ground breaking work!
“[A] very important beginning.”
“Culture change is the next step.”
“Make sure as broad an audience as possible sees and learns the results, attitudes, [and] recommendations of this Summit.”
“This is an excellent conference – very well organized and focused on drawing conclusions elicited from participants.”
“This was a terrific two day conference. Keep it going, take it to other parts of the country and come back to New England.”
“Plan another summit next year to expand knowledge and reinforce healthcare institutions who are incorporating the green planning guide principles and actions.”
“We spend a lot of time on whether “green” has an extra cost or not. That is not valuable for two reasons – 1) There is the cost of not doing high performance in lost marketability and other factors; 2) By labeling it “green” we invite it to be signaled out and seen as a risk.”
“Well done – there’s a great need for more examples and case studies.”
Comments about making the “business case”: *“Organize each specialty to formulate financial aspects of each topic for a “how to” for each aspect of this Summit. This would substantially promote these issues.”*
“[We need] cost benefit information and discussion.”

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