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Exploring the Changing Practice of Architecture • A publication of AIA Seattle | Winter 2009/10 Vol.2 No.4

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# Healing the Hospital

## Energy Use and Indoor Air Quality in American and Scandinavian Hospitals

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*University of Washington's Integrated Design Lab, part of the BetterBricks Lab Network*

ABOVE: Staff will spend more time in hospitals than any other user group, making it vital that they have opportunities to relate to the exterior environment. A skylight bathes this nurse's station in daylight, giving staff members a connection to the day's natural rhythms. Akershus, Oslo, Norway, Architect: CF Møller, 2008. OPPOSITE PAGE: A courtyard in this Norwegian hospital provides dozens of interior spaces with views and daylight, as well as opportunities to step outside directly from patient rooms. St. Olav's Women and Children's Centre, Trondheim, Norway, Architect: MedPlan AS, 2006.

**America's healthcare infrastructure is in dire need of re-evaluation for both interior environmental quality and energy performance. The Integrated Design Lab, a research and market transformation arm of the University of Washington's College of Built Environments funded by the Northwest Energy Efficiency Alliance's BetterBricks program, has investigated methods to radically reduce energy consumption in hospitals in ways that will meet the 2030 Challenge. Their findings, plus investigations into new Scandinavian hospital models, follow.**

If public discussion is any indicator, America's healthcare system is not meeting the nation's needs. Americans spend the most per capita on healthcare of any nation, yet there is little correlation between money spent and patient outcomes.

As a group of architects and building researchers in the Pacific Northwest, we at the Integrated Design Lab are interested in how hospital buildings can be improved to better serve people and the environment.

We have learned that in hospital design, as in healthcare spending, more is not necessarily better. Hospitals use a lot of energy: about three to four times what a typical office building uses per square foot. And its indoor air quality is Intimately linked to energy performance.

What follows is a summary of our findings on these two subjects, as well as our study of hospitals in Scandinavia, a region that began rethinking hospital design in the 1980s with inspirational results.

### Energy Use

Healthcare facilities use a startling amount of energy. Put in terms of the most commonly-used metric, the Energy Use Index (EUI), hospitals in the Pacific Northwest use 260-280 KBtu/sf/year. Hospitals, it turns out, are the second most energy consumptive building type, just behind fast food restaurants. Translated into total energy, hospitals account for approximately 4% of all energy used nationwide. Hospitals are densely occupied, operate constantly, and contain energy-intensive equipment and infrastructure.

One of the biggest opportunities for energy reduction in hospitals is in heating and cooling. A typical mid-sized hospital in the Pacific Northwest produces enough heat from people, lights, and major equipment to meet most heating needs year round, without any additional heat production. Yet, 40-50% of the total energy demand is typically put to heating space.

Some areas of a hospital demand very cool air, especially in technically driven spaces. In typical hospital HVAC systems, incoming air is delivered by a multi-zone, overhead, ducted air system. Spaces needing the coolest air set the temperature of all air delivered to an entire zone. Spaces that need warmer air must reheat it at the delivery point, usually using an electric heating coil in the air handling unit. Such a system means that fresh air is cooled on intake and then reheated, demanding energy consumption at multiple points. Our building energy simulations have revealed that reheating consumes over 30% of a hospital's energy. This is no small irony when one considers that enough heat is already present within the building from people, lights, and equipment to meet most heating needs without using any additional energy.

In more detailed analysis of energy use in hospitals, our group conducted research using energy model simulations of a typical 225-bed, 520,000sf, acute care hospital, and with it began to examine the energy savings created by a wide range of efficiency strategies. We applied several "bundles" of energy-saving strategies to our simulation. The results were sobering: it took the addition of five bundles of energy-saving strategies for our simulated hospital to meet the 50% reduction in energy use that could achieve the 2030 Challenge goal for 2008.

From this simulation research we took away six major points:
1) The need to reduce or eliminate re-heat energy consumption;
2) Waste heat recovery is needed: transfer waste heat to where it can be useful instead of rejecting it into the environment;
3) Additional HVAC system efficiency is required;
4) A central design goal should be to zone similar loads in close proximity. Careful building design can reduce peak heating and cooling loads, especially at the building perimeter; these reduced loads then result in a smaller, more efficient system. De-centralized systems can accommodate varying zonal load characteristics.
5) Currently, energy-saving efforts are limited by code requirements related to minimum air-flow and air delivery mechanisms. The healthcare sector should press for a reevaluation of state codes relating to air flow, so that hospital designers can take advantage of today's more energy-efficient options for air handling, such as displacement or natural ventilation.
6) Operational efficiency and maintenance must be reviewed throughout the project.


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ABOVE: In Scandinavia, daylight is considered a necessity for every regularly-occupied space. This interior "street" in Oslo's Rikshospitalet is the building's main travel route. Top and side lighting illuminates the volume, allowing adjacent offices (right) to borrow daylight. Rikshospitalet, Oslo, Norway, Architect: MedPlan AS, 2001.

The biggest lesson gleaned from our research is that a design that significantly reduces energy is a project that integrates its systems. Such a design requires commitment from the entire design and ownership team at the earliest planning stages. An integrated design delivery process is the most effective method for reaching this goal. By allowing for closer, earlier integration of the entire project team, all parties—architects, engineers, utility representatives, operators and owners— will work in concert to achieve high performance goals, setting them early in the design process and testing them for performance, not only through design and construction, but through the life of the building.

**Environmental Quality**

There is ample evidence to suggest that environmental quality is just as important as energy efficiency in achieving a successful, high performance hospital design.

Elements such as daylight, view, and fresh air connect patients to the natural environment, and this connection is beneficial to both patients and staff. These elements have strong implications for building form. Decreasing the distance to available windows and increasing the building's perimeter brings the building occupant closer to daylight and view. These amenities in turn promote health and productivity: access to daylight regulates the human wake-sleep cycle, views can promote healing and a sense of well-being, and control of operable windows has been shown to widen the range of temperatures an occupant considers comfortable while lessening the burden on the building's mechanical system.

**Innovations in Scandinavia**

Re-thinking energy use and the interior quality of hospitals to the degree we have shown may seem unimaginable, but international models provide a roadmap for such transformations. New hospitals in Scandinavia, in particular, exhibit many strategies appropriate for the Pacific Northwest.

As early as the 1980s, Northern Europe began to re-examine the typical post-war hospital form: a deep-span, multi-floor, nearly windowless, diagnostic and treatment block topped with a hotel-like patient tower. Beginning in Scandinavia, designers turned this typical form on its side, placing diagnostic and treatment facilities on one side of the hospital and patient rooms on the other, connected by a long central spine. This model allows for most spaces to relate directly to the building's exterior. And, it significantly reduces the time patients spend in elevators—an event-prone space where patients cannot as easily be assisted if they suddenly require it.

Today, Scandinavian hospitals continue to develop new forms, exploring the potential of unbundled campuses, for instance, or space planning and mechanicals that allow for extreme flexibility of use over the hospital's lifespan.

The changing Scandinavian hospital form, from the traditional base+tower typology to a horizontal one that provides a connection between occupant and environment, yields the benefits of natural light, views, and personal control of operable windows. These buildings also have mechanical systems that dramatically reduce the energy necessary for operation; the newest of these hospitals use 25% of the energy used by typical Pacific Northwest hospitals. A short list of technologies that some of these hospitals employ includes severely limiting re-heat, reducing air change rates, combining displacement ventilation with radiant heating and cooling, recovering heat from all internal heat sources, and relying on ground-source heat pumping for the majority of additional heating and cooling needs.

There are clearly lessons for us to learn from these mechanical system examples. One of the biggest ideas that can be observed from Scandinavian hospitals is their efficient recovery of heat from all available sources. Thermodynamics are used to their fullest potential; heating and cooling are employed only where needed, recovered when exhausted.

When observed closely, Scandinavian hospitals are inspiring examples for our future hospital development. They are not only energy efficient, but embody excellent indoor environmental qualities that make them superior places to heal, work, and visit. ■

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1) For a full summary of the modeled changes see Burpee, Heather, Hatten, M., Loveland, J., and Price, S. "High Performance Hospital Partnerships: Reaching the 2030 Challenge and Improving the Health and Healing Environment." Paper presented at the annual American Society for Healthcare Engineering (ASHE) Conference on Health Facility Planning, Design and Construction (PDC). Phoenix, AZ, March 8-11, 2009. Section "Strategies Considered in the SHEC Research Project."