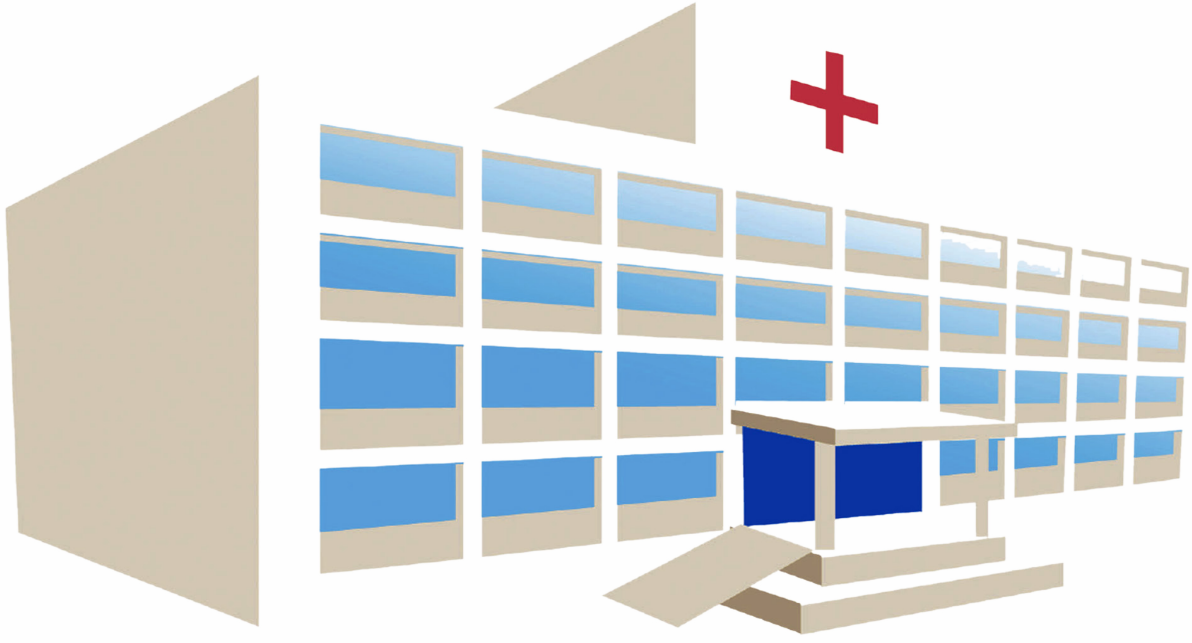

How 90.1-2010 Will Affect Healthcare Facilities

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ANSI/ASHRAE/IES Standard 90.1-2010, *Energy Standard for Buildings Except Low-Rise Residential Buildings*, includes more changes than any previous version of Standard 90.1 since at least 1999. These changes will affect the design, construction, and operation of all facilities; and the HVAC changes will be particularly significant for health-care facilities and labs. This article covers the changes that will have the greatest impact on most buildings, with emphasis on how they will affect health-care facilities.

Final energy simulation results representing approximately 80% of the U.S. building stock[1] predict that for uses that are covered by 90.1, buildings built to conform to 90.1-2010 will use 32.7% less energy compared to the same buildings built to conform to 90.1-2004. The same simulation predicts 25.6% energy savings if "plug" loads, most of which are not covered by 90.1, are included. Standard 90.1 was modified by 110 addenda for the 2010 edition. This article explains many of the changes to the mandatory and prescriptive requirements. The energy cost budget compliance path and Appendix G are not discussed in this article.

Scope

A major change to the scope of 90.1 is that the standard now covers "new equipment or building systems specifically identified in the standard that are part of industrial or manufacturing processes." For example, computer rooms prior to the 2010 standard were exempted from the prescriptive economizer requirements because they were considered to be a process, but they must comply with the economizer requirements in 90.1-2010.

Envelope Requirements (Chapter 5)

Research by ASHRAE and other organizations indicates that infiltration rates in real buildings are much higher than most designers use in calculations.[2] This research suggests that average buildings experience infiltration of approximately 1.5 cfm/ft^2 (7.6 L/s•ft^2) (0.0076 m/s) of exterior wall when exposed to a 0.30 in. w.c. (75 Pa) pressure differential, which is equivalent to the velocity pressure of a 25 mph (11.2 m/s) wind. Most HVAC engineers who I know use infiltration estimates much lower than this, even when converted to a 15 mph (7 m/s) wind; and the infiltration estimates of HVAC designers often exceed the convective/conductive heat loss of the building envelope.

Standard 90.1-2010 requires that "The entire *building envelope* shall be designed and constructed with a *continuous*

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air barrier." The standard goes on to require that all air barrier components must be clearly identified on the construction documents. Hopefully, this requirement will allow designers to reduce infiltration estimates and will save owners both first and operating costs. Proper installation is required to realize these savings.

Standard 90.1-2010 includes the first passive solar requirements in Standard 90.1 (*Figure 1*). It requires that the area of south-facing glazing must exceed both the area of east-facing glazing and the area of west-facing glazing (not added together; only exceed each individually). South is defined as ±45 degrees of due south. East and west are defined as ±30 degrees of due east or west. There are many exceptions to this requirement, including storefronts, shaded buildings, infill with a nearby building to the south, and alterations with no increase in glazing.

This addition to 90.1 has wide-reaching impacts on issues such as campus and city planning, because it encourages orienting buildings to be longer in the east/west direction than the north/south direction. Consider how awkward it would be to comply with this requirement in the freestanding building with the footprint shown in *Figure 2*. On the other hand, if the building in *Figure 2* were rotated 90-degrees, which is what the standard encourages, compliance would be easy and the building energy use would be reduced.

Another new requirement was added for a small area of skylights for large rooms with tall ceilings on the top floors of buildings in certain occupancy types and climate zones. The purpose of this change is to prevent large numbers of lights from being turned on or operated at full power in spaces where skylights could provide all or some of the needed illumination under most circumstances.

HVAC Requirements (Chapter 6)

Supply air temperature reset controls are required for multiple zone HVAC systems. They shall reset at least 25% between the supply air temperature and the design room temperature based on building loads or outdoor air temperature; or zone humidity. This was one of the largest energy-saving changes in 2010 for healthcare facilities, and in humid climates it requires careful consideration of appropriate control logic.

The fan power limitations have long been one of the most difficult provisions of 90.1 with which to comply. The fan power requirements of 90.1-2010 and 90.1-2007 are similar, and are viable for health care because they include allowances for items such as filters with high MERV ratings and pressure-controlled zones. For example, the basic requirement for variable air volume (VAV) systems is that they should not require more than 1.3 bhp per 1,000 cfm (27 kW per 1000 L/s) of supply air. This is extremely difficult to comply with in hospitals and similar facilities, and was, in my opinion, unreasonable in the 1999 through 2004 editions of 90.1. Under 90.1-2010, most hospital HVAC systems will qualify for the following bhp credits, typically resulting in a total allowance of about 2.3 bhp per 1,000 cfm (48 kW per 1000 L/s):

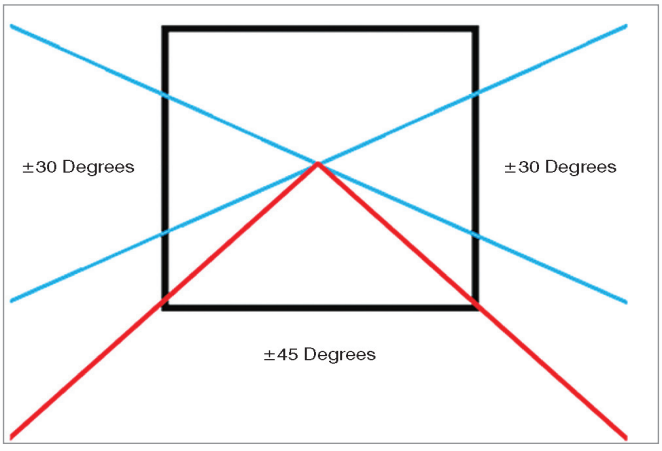

Figure 1: Solar orientation requirement (north is up).

- Fully ducted return and exhaust systems;
- Return or exhaust airflow control devices (in pressure-controlled rooms);
- Filter pressure drop allowance for each bank of filters with a MERV rating of more than 8; and
- Energy recovery devices (*Figure 3*).

The fan power allowance for energy recovery devices was changed to be "(2.2 × Energy Recovery Effectiveness) — 0.5 in. w.c. (125 Pa) for each airstream." This was intended to encourage designers to size energy recovery devices to provide high energy recovery effectiveness and low air pressure drop.

The 2007 requirement for energy recovery devices was 50% effectiveness and that energy recovery was required only for systems over 5,000 cfm (2360 L/s) that use more than 70% outside air. In the 2010 edition, a table was added that bases the requirements on flow rate, climate zone, and percentage of outside air. The result is that energy recovery is required for many more commercial HVAC systems. For hospitals in humid climates, nearly all air-handling systems will require energy recovery.

Reheat is one of the largest energy uses in hospitals. The same is true for laboratories and other buildings with high ventilation rate requirements. *Figure 4* compares the annual energy consumption of the large hospital model used for comparing the 2004 to the 2010 editions of Standard 90.1.

In 2010, many of the exceptions that permit reheat were eliminated (300 cfm [142 L/s] per air handler, 0.4 cfm/ft^2, [2 L/s•m^2]) and any air handler with any pressure controlled zones). The remaining exceptions are:

1. 30% of the *zone* design peak supply rate, or 50% if the flow rate is reduced to 20% in deadband;
2. The outdoor airflow rate required to meet the ventila-

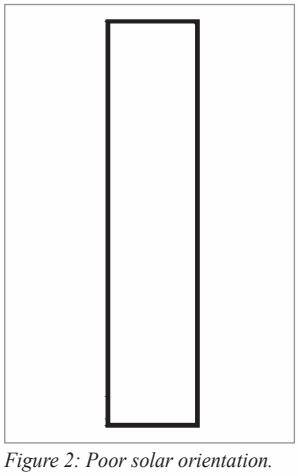
Figure 2: Poor solar orientation.

Zone	% *Outdoor Air* at Full Design Airflow Rate					
	≥30% and <40%	≥40% and < 50%	≥50% and <60%	≥60% and <70%	≥70% and <80%	≥80%
	Design Supply Fan Airflow Rate (cfm)					
3B, 3C, 4B, 4C, 5B	NR	NR	NR	NR	≥5000	≥5000
1 B, 2B,5C	NR	NR	≥26000	≥12000	≥5000	≥4000
6B	≥11 000	≥5500	≥4500	≥3500	≥2500	≥1500
1 A, 2A, 3A, 4A , 5A, 6A	≥5500	≥4500	≥3500	≥2000	≥1000	>0
7,8	≥2500	≥1000	>0	>0	>0	>0
NR-Not required						

Figure 3: Table 6.5.6.1, Energy Recovery Requirement in Standard 90.1-2010.

tion requirements of Section 6.2 of ASHRAE Standard 62.1 for the zone (this only applies to 100% outside airstreams that don't mix with additional heated air);

3. Any higher rate that can be demonstrated, to the satisfaction of the authority having jurisdiction, to reduce overall system annual energy usage by offsetting reheat/recool energy losses through a reduction in outdoor air intake for the system;
4. The airflow rate required to comply with applicable codes or accreditation Standards (e.g., pressure relationships or minimum air change rates);
5. Laboratory exhaust systems complying with 6.5.7.2; which requires buildings with lab exhaust systems totaling over 5,000 cfm (2360 L/s) to comply with one of three criteria that relate to VAV, energy recovery, and non- or semi-treated makeup air; and
6. *Zones* where at least 75% of the energy for reheating or for providing warm air in mixing systems is provided from a *site-recovered* (including condenser heat as described below) or *site-solar energy source*.

In Exception 1, an alternate was added for dual minimums on VAV boxes. This permits reheating up to 50% of the peak design flow rate if the minimum flow rate in deadband (no reheat) is 20% or less of the peak design flow rate.

The fourth exception is intended primarily for hospitals and laboratories that are mandated to provide ventilation rates that would otherwise make it impossible for them to comply with Standard 90.1. Notice that this replaced a total exemption for systems serving any pressure-controlled spaces. This will have a very large impact on healthcare facilities because it bans constant air volume central HVAC systems for most healthcare facilities.

Most healthcare facilities are required to comply with some edition of the Facilities Guideline Institute (FGI) *Guidelines for the Design and Construction of Healthcare Facilities*. The latest edition of those guidelines reference ASHRAE/ASHE Standard 170-2008, *Ventilation of Healthcare Facilities*. The net effect of the changes to Standard 90.1 when combined with these standards is that airflow rates to unoccupied pressure-controlled spaces such as operating rooms must be reduced to the amount necessary to maintain the required pressure relationship or 30% of the peak cooling flow rate, whichever is larger. For patient rooms, Standard 170 does not require ventilation when the rooms are unoccupied; which means that flow is limited to 30% of the peak cooling flow rate. This change alone caused the energy estimates for the *Advanced Energy Design Guide for Small Hospitals and Healthcare Facilities* to change from a 30% savings to a 40% savings.

Another change, that is intended to minimize reheat energy, limits the supply air temperature of reheated air to 20°F (11°C) above the space temperature setpoint if both the supply and the return/exhaust air openings are more than 6 ft (2 m) above the floor elevation. This is intended to minimize short-circuiting of reheated air into the return or exhaust system, before it can effectively heat or ventilate the space. Note that 90.1 does not use the more restrictive 15°F (8°C) limit that triggers higher outside air requirements in Standard 62.1. In Standard 90.1, 20°F (11°C) was chosen as a compromise between the requirement of Standard 62.1 and concerns about added costs for perimeter heating systems in cold climates.

Occupancies such as patient rooms or offices in cold climates that cannot meet their peak heating loads with their maximum allowed reheat flow rates may be required to add perimeter heat sources (typically fan-powered terminal air boxes or smooth radiant ceiling panels in healthcare occupancies, because of cleanliness concerns). Another alternative is to use envelope construction with low enough heat loss to be heated by the maximum flow rate that is permitted to be reheated.

90.1-2007 included an exception to the economizer requirements for systems: "Where more than 25% of the air designed to be supplied by the system is to spaces that are designed to be humidified above 35°F (2°C) dew-point temperature to satisfy process needs." Because of this, most healthcare facilities were not required to include economizers

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because of the humidity requirements in the FGI Guidelines.

In the 2010 standard, this economizer *exception* has been revised to: "In hospitals and ambulatory surgery centers, where more than 75% of the air designed to be supplied by the system is to spaces that are required to be humidified above 35°F [2°C] dew-point temperature to comply with applicable codes or accreditation Standards. In all other buildings, where more than 25% of the air designed to be supplied by the system is to spaces that are designed to be humidified above 35°F [2°C] dew-point temperature to satisfy process needs. This exception does not apply to *computer rooms*."

For many healthcare air-handling systems, this change will require economizers where they were not previously required. Also, for healthcare occupancies with some, but not over 75% of the air required to be humidified above 35°F (2°C), these changes will require water economizers. The revised economizer requirements also have a major impact on computer rooms, both in healthcare settings and in other settings.

Another consequence of this change is that many healthcare facilities that previously were exempt from the requirement for economizers will be required to use water economizers because of the requirement that: "Systems with hydronic cooling and humidification systems designed to maintain inside humidity at a dew-point temperature greater than 35°F [2°C] shall use a water economizer if an economizer is required by section 6.5.1."

Further, the water economizers must satisfy 100% of the expected cooling load at 45°F (7°C) dry bulb/40°F (4°C) wet bulb, which for some facilities might be the critical factor in sizing their cooling towers. A comparison of economizer options can be found in the *Advanced Energy Design Guide for Small Hospitals and Healthcare Facilities*.

Many larger facilities will still be exempt from the economizer requirement if they comply with Section 6.5.6.2.2, which contains requirements for the use of condenser heat for service water or space heating.

A related item is that once authorities upgrade to the 2010 FGI Guidelines or Standard 170, most of these facilities can again use air economizers. This is because Standard 170 only requires 20% relative humidity for most of the spaces that previously required 30% relative humidity and thus the dew-point temperature requirements will no longer exceed 35°F (2°C).

Standard 90.1-2007 also included exceptions to the economizer requirements for systems below certain cooling capacities and for all system sizes in Climate Zones 1a, 1b, 2a, 3a, and 4a. 90.1-2010 requires economizers for systems with 54,000 Btu/h (15 kW) or more of cooling capacity in all Climate Zones except 1a and 1b.

Standard 90.1-2010 includes several significant changes to the duct system sealing requirements. The Minimum Duct Seal Level table from 90.1-2007 was deleted, and all ducts are now required to be constructed to seal Class A, which requires sealing of all transverse joints, longitudinal seams, and duct wall penetrations. Shaft openings now require bushings or bearings

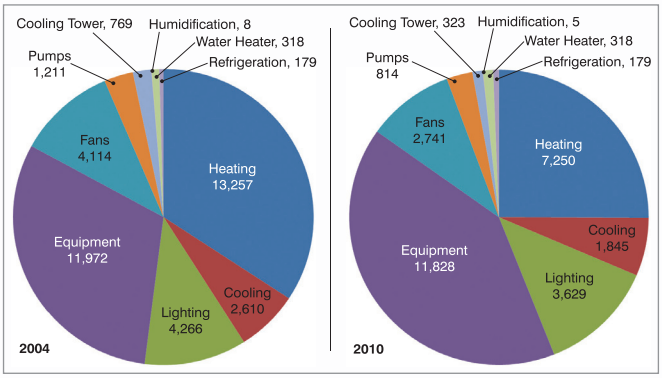

Figure 4: Typical hospital energy use (MMBtu/yr) breakdown (Chicago).[1]

to minimize leakage. 25% of duct systems above 3 in. w.c. (747 Pa) pressure class are required to be pressure tested, which was also required in previous versions of 90.1, and a provision was added stating that the owner or the owner's representative shall choose which sections are to be tested. The leakage class was set to 4 cfm/100 ft^2 (6 L/s•m^2) for all tested ducts, both round and rectangular. This is a change from prior editions of 90.1 and the 1985 SMACNA *HVAC Air Duct Leakage Test* manual, which specified 6 cfm/100 ft^2 (9 L/s•m^2) for rectangular ducts and 3 cfm/100 ft^2 (5 L/s•m^2) for round ducts.

Standard 90.1-2010 includes several miscellaneous added requirements including:

- Designers must calculate pump head requirements, but are not required to use maximum or minimum safety factors.
- A table was added for sizing of chilled water (including glycol) pipes.

For most engineers this will require pipes above 6 in. (150 mm) size to be slightly larger than they traditionally have been.

- Chilled water systems are required to use technologies, such as variable speed drives, to reduce pumping power at lower flow rates and the differential pressure setpoint must be reset based on valve positions in a manner similar to that required for VAV air systems.
- Insulation with a thermal resistance of at least R-3.5 is required on the backs of radiant heating panels.
- Single zone systems are required to reduce their airflow rates to 67% prior to reheating.
- Supply air temperature reset controls are required, but the owner can choose any reset schedule that is desired. This was one of the larger energy-saving provisions, so I hope that owners take advantage of it, especially in buildings such as hospitals that can save large amounts of reheat energy. This is also usually an inexpensive control logic change.
- Minimum efficiency requirements were added for variable refrigerant flow systems and for computer room air conditioners.

Power (Chapter 8)

At least 50% of all 125 volt 15 and 20 amp receptacles are required to be automatically switched, in private offices, open offices, and computer classrooms. There are exceptions for 24-

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hour uses and spaces where automatic shutoff would endanger the safety or security of the room or occupants. This can be controlled based on time of day, occupancy sensors, or other control or alarm systems that indicate an area is unoccupied. This provision and those in Chapter 10 were included because it will be difficult to get close to the national goal of net zero if we don't control the plug and equipment loads.

Lighting Requirements (Chapter 9)

The lighting power density (LPD) tables were adjusted. On average, the allowable lighting power densities dropped by about 10%. For healthcare facilities, the allowance for clinics dropped from 1 W/ft^2 to 0.87 W/ft^2 (10.7 W/m^2 to 9.3 W/m^2). For hospitals, it rose from 1.20 W/ft^2 to 1.21 W/ft^2 (12.9 W/m^2 to 13 W/m^2).

The room geometry adjustment is a new provision that helps when designing lighting for spaces with unusual proportions and spaces with high ceilings such as those encountered when renovating older buildings. The LPD can be adjusted for individual spaces when the room cavity ratio (RCR) for the empty room is greater than the RCR threshold for that space type as shown in Table 9.6.1.

Many addenda addressed lighting controls. The committee's approach was that the lighting power densities have been reduced nearly as much as possible, and the route to increased savings is to turn more lights off or reduce the power used for lighting when they aren't needed or less light is sufficient. This will result in a significant increase in the number of occupancy and vacancy sensing devices.

A requirement for third-party functional testing of these devices was added with the intent that owners are less likely to override controls if they function properly.

Prior to 2010, Standard 90.1 did not address daylighting. In the 2010 Standard, four addenda address daylighting and the associated lighting controls. Daylighting includes windows and overhead light from skylights and roof monitors.

Parking garage lighting control is now specifically addressed and requires a 30% minimum automatic lighting power reduction when no activity is detected for no more than 30 minutes. Lighting must be controlled in daylight transition zones (entrances and exits) so that the lighting is on during daylight hours and turned off at sunset. Daylighting control of luminaires within 20 ft (6 m) of any perimeter wall structure with at least 40% net opening-to-wall ratio is also a requirement.

Photo 1: Installation of geothermal pond heat exchanger for a new hospital.

Exterior lighting was divided into five categories (undeveloped and developed areas in national and state parks and rural areas, residential and mixed used residential areas, other, and major metropolitan areas) with different lighting power allowances for each. A requirement was added for exterior lights to be controlled by either astronomical timers or daylight sensors to shut off the lighting when sufficient daylight is available; and façade and landscape lighting between midnight or business closing, whichever is later, and 6 a.m. or business opening, whichever is earlier.

Other exterior lighting, including signage, must be controlled to reduce power use by at least 30% from one hour after midnight and 6 a.m. or when businesses are closed and during any period when no activity is detected for no longer than 15 minutes.

Whole-building shutoff (sweep) is now required for most buildings, with two of the exemptions being lighting in spaces where patient care is rendered and lighting required for 24- hour operation.

Internally illuminated exit sign power is limited to 5 W per face according to U.S. federal standards.

More lighting alterations projects must now meet the lighting alteration requirements. Those that involve 10% or more of the connected lighting load in a space or an area must now meet the lighting alterations requirements. This includes lamp and ballast retrofits. Standard 90.1-2007 required compliance if 50% or more of the luminaires were replaced.

Other Equipment (Chapter 10)

Domestic water booster systems are now prohibited from including pressure reducing valves through which all of their discharge water passes. This does not prohibit using PRVs in zones or individual floors, but does prohibit pumping all of the water to a high pressure and then reducing it at the booster pump.

Booster pump systems must also include a pressure sensor to start and/or control their speed. The sensor must be mounted remotely in the system, or logic must be included in the package that senses flow and simulates a remote sensor input. When there is no domestic water demand, booster pumps must automatically stop.

Elevator lighting systems are required to have a minimum efficacy of 35 lumens/W. This can be averaged among the fixtures so, for example, two T-8 lamps could be paired with 4 MR (multifaceted reflector) lamps, as long as the total lumens divided by the total input Watts equals 35 or greater.

Elevator fans and lights must automatically shut off if the elevator is unused for over 15 minutes. This requirement was added because many elevators run their fans and lights 24/7.

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Options for Additional Savings

For facilities up to 90,000 ft² (8361 m²), the *Advanced Energy Design Guide for Small Hospitals and Healthcare Facilities*[3] and the *Advanced Energy Design Guide for Large Hospitals* provide additional guidance. The overall savings for small healthcare facilities are similar to 90.1-2010. The large hospitals AEDG is a 50% savings guide, and goes beyond 90.1 energy savings.

ASHRAE/USGBC/IES Standard 189.1-2011, *Standard for the Design of High-Performance Green Buildings* will reference 90.1-2010 in its next revision, and includes additional suggestions that, in some cases, provide more energy savings than 90.1-2010.

The 90.1 committee considered additional requirements for condenser heat recovery for facilities such as hospitals, but wasn't able to complete those requirements prior to the publication deadline. In my experience, condenser energy recovery for reheat (not just domestic preheat) typically provides a three- to five-year return on investment for new hospitals and for retrofits that do not need to replace coils. It is one of the most economical means of going beyond the requirements of 90.1-2010, and the same equipment can fulfill the service water preheat requirements.

Another way to minimize reheat and conserve more energy is to use non-traditional systems such as a pond source geothermal system for a geothermal hospital that meets the *Advanced Energy Design Guide* 50% savings goal (*Photo 1*).[4]

The U.S. Department of Energy, ASHRAE, Illuminating Engineering Society, American Institute of Architects, American Society for Healthcare Engineering, and National Renewable Energy Laboratory recently completed the *Advanced Energy Design Guide for Large Healthcare Facilities,* which has as its goal an energy reduction of 50% compared to a hospital constructed to comply with 90.1-2004. It is available for free at http://tinyurl.com/82w78x8.

Get Involved

The 90.1 committee is currently working on the 2013 edition of the standard with the goal of including all proposals that are practical and that meet our economic criteria. Several of the items that we are working on currently were initiated by suggestions from non-committee members. Get involved! We welcome your suggestions.

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