TRANE

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energy-saving strategies for

LEED® Energy and Atmosphere Credit 1 (EAc1)

Interest in the Leadership in Energy and Environmental Design (LEED) Green Building Rating System is accelerating and gaining support from various industries. Currently, the U.S. Green Building Council (USGBC) has more than 14,000 members and nearly 50,000 LEED Accredited Professionals (APs). There has been a similar growth in LEED building projects: over 6000 LEED-NC registered buildings and nearly 1000 LEED-NC certified buildings.

In response to requests from many of our customers, this EN will quantify the impact of various energy-saving HVAC strategies toward achieving LEED points under the "Optimize Energy Performance" credit (Energy & Atmosphere credit 1, or EAc1).

Advanced Energy Design Guides

There is more than one way to achieve LEED points under EA credit 1. The first path is the *whole-building energy simulation* approach that was used for this newsletter. The second path is the *prescriptive* approach, which involves complying with the criteria established by the Advanced Energy Design Guide series. Four EAc1 points are awarded if the project fully complies with all applicable criteria for the climate zone in which the building is located.

The Advanced Energy Design Guide series was jointly developed by ASHRAE, AIA, IESNA, USGBC, and the U.S. Department of Energy. To date, there are design guides for small office, small retail, and K-12 school buildings.

Electronic versions of these guides are available for free download at www.ashrae.org/freeaedg.

In addition to heightened interest in energy efficiency, there has been another change that has brought more attention to this particular LEED credit. As of June 2007, all LEED projects are required to achieve at least two points under the "Optimize Energy Performance" credit.

For new building projects registered under LEED-NC (new construction and major renovations), this means that the project must reduce the overall building energy cost by at least 14 percent. This does *not* mean that every piece of equipment must be 14 percent more efficient—rather, it means that the overall building energy cost needs to be at least 14 percent less than a baseline building, as defined by ASHRAE Standard 90.1-2004 (Figure 1).

Figure 1. Allocation of EAc1 points in LEED-NC (version 2.2)

	new building	major renovation	LEED points
Reduction of overall building energy cost compared to ASHRAE 90.1-2004 baseline building	10.5%	3.5%	1
	14	7	2
	17.5	10.5	3
	21	14	4
	24.5	17.5	5
	28	21	6
	31.5	24.5	7
	35	28	8
	38.5	31.5	9
	42	35	10

The LEED EAc1 "Golden Rule": First, Reduce the Load. To minimize overall building energy cost, design teams should use a holistic (or integrated) approach that considers the interaction of building orientation and envelope construction with lighting and HVAC systems. For example, improvements to the building envelope and more efficient lighting systems can reduce the building cooling load, which often has the added effect of reducing HVAC energy cost.

At a minimum, consider the following strategies*:

- **Glazing**: Minimize glazing which faces east or west, shade exterior glazing, use insulating low-e glass, and make all glazing as small as possible (consistent with the use of daylighting).
- **Daylighting/Lighting**: Design the building envelope and glazing so the sun provides interior lighting at the perimeter of the building, and design efficient, supplemental interior lighting that modulates when it is not needed.
- **Envelope**: Design and construct the exterior enclosure to be as airtight as possible.

*For more information, see the *ASHRAE Green Guide,* the *Advanced Energy Design Guide* series, and *The ASHRAE Guide for Buildings in Hot and Humid Climates*.

Example: Whole-Building Energy Simulation for LEED-NC EAc1.
For this EN, a whole-building energy simulation was performed* for an example 270,000 ft^2 office building. As required by LEED-NC, the "baseline" building was modeled according to Appendix G of ASHRAE Standard 90.1-2004, with 25 percent of the baseline building energy cost attributed to plug loads. For a building of this size, Appendix G requires the baseline to be a chilled-water, variable-air-volume (VAV) system.

The "proposed" building was modeled with five different HVAC systems to determine the impact of various energy-saving strategies. Before reviewing the results, it is important to clarify the scope and intent of this particular analysis:

- First, this study was limited to modeling *only* HVAC-related strategies. Improvements to the building envelope, lighting or plug load reductions, or cross-cutting strategies like shading or daylighting were not modeled. While we strongly recommend that these types of strategies are investigated, there are many projects that are characterized by the traditional separation of architecture and engineering activities. In this case, the mechanical engineer is often given the assignment to achieve EAc1 points, perhaps with the rest of the building just meeting the minimum requirements of ASHRAE 90.1-2004. Therefore, the intent of this analysis was to focus on the impact of HVAC-related energy-saving strategies. (The other, non-HVAC strategies would certainly help achieve even greater savings.)
- Second, while there are many potential HVAC system types, this study was limited to the five HVAC systems that are most *commonly* used for this type of building in the U.S. marketplace today. For example, small, packaged-rooftop units (probably the most common system used in the U.S.) would not likely be used in a multi-story office building.
- Finally, the target goal for this study was to achieve at least two EAc1 points (at least 14 percent building energy cost savings) for each system type. While more points could likely be achieved with the use of additional energy-saving strategies, the scope of this study was to demonstrate which strategies were needed to achieve the minimum two EAc1 points.

For each of the five HVAC system types, this EN includes a table indicating which energy-saving strategies were used to achieve the resultant savings shown in the corresponding chart.

For example, the building equipped with a rooftop VAV system achieved about 25 percent energy cost savings in St. Louis, compared to the baseline building for that climate zone (Figure 2). To accomplish this, the system used a high-efficiency, rooftop unit, employed the ventilation optimization and improved supply-air-temperature reset control sequences, used parallel fan-powered VAV terminals in the perimeter zones, and included an airside economizer (see chart on page 3). As mentioned, more savings could likely be achieved with additional energy-saving strategies. For example, cold-air distribution may also save energy in St. Louis, but for this example, this strategy was not needed to reach the minimum threshold of 14 percent.

Energy Policy Act of 2005

The Energy Policy Act of 2005 allows commercial building owners or leaseholders to earn a significant tax deduction—up to $1.80 per square foot of the building—by making their building more energy efficient. (This deduction, originally set to expire 12/31/2007, was extended through 12/31/2008 by the Tax Relief & Health Care Act of 2006.)

The U.S. Internal Revenue Service (IRS) requires that the claimed energy savings must be certified through the use of computer modeling. Trane's TRACE™ 700™ software was the first simulation program to be accepted by the IRS for energy savings certification.

If computer modeling has already been completed for a LEED project, the additional work to document the energy savings for a tax deduction is likely worth the financial benefit.

For more information about the tax deductions for energy-efficient commercial buildings, visit http://www.eere.energy.gov/buildings/info/tax_incentives.html or reference "Clarifying EPAct 2005" ASHRAE Journal, March 2007, page 70.

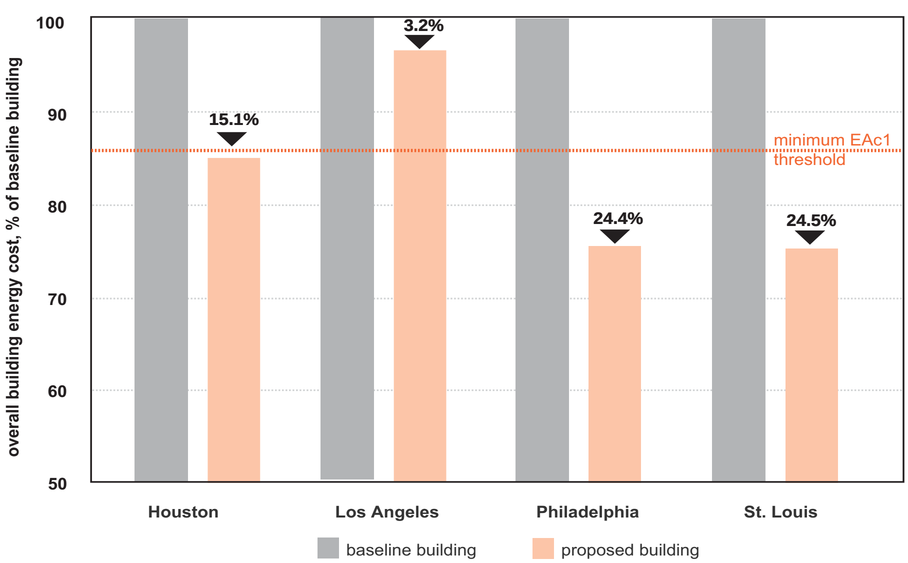
* A 2005 Engineers Newsletter (volume 34-3, "Model for Success: Energy Analysis for LEED Certification") provides more detailed discussion of the whole-building energy simulation approach for achieving LEED points for EAc1.

System 1: Rooftop VAV System.

When the "proposed" building was equipped with a rooftop VAV system, the following energy-saving strategies were implemented to achieve the energy cost savings shown in Figure 2.

	Houston	Los Angeles	Philadelphia	St. Louis
High-efficiency rooftop unit (9.7 EER)	X	X	X	X
Ventilation optimization[1] (demand-controlled ventilation at zone level + ventilation reset at system level)	X	X	X	X
Improved supply-air-temperature reset	X	X	X	X
Parallel, fan-powered VAV (serving perimeter zones)	X	X	X	X
Cold-air distribution[2] (52ºF supply air + 1ºF increase in space cooling setpoint)	X	X		
Airside economizer	X	X	X	X

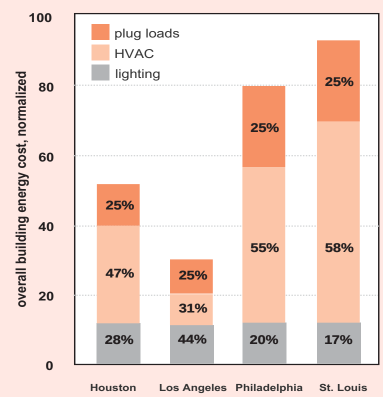
Figure 2. Energy simulation results for a rooftop VAV system



Do these results mean that rooftop VAV systems cannot be used on LEED projects in Los Angeles? No, but it does emphasize a point made earlier.

Figure 3 shows the breakdown of energy cost for the baseline building in each location. The amount of energy used for lighting is the same in all locations, but the amount of energy used for HVAC varies by climate. The total amount of energy used to cool and heat this example building is not as large in Los Angeles as it is for the other locations.

Figure 3. How Big is the HVAC Piece of the Pie?



Because lighting energy is the same in all locations,and because LEED-NC requires plug loads to account for 25 percent of each location's baseline building energy cost, the percentage of building energy cost that is attributable to HVAC is much lower in Los Angeles (only 31 percent of the total, compared to 50 to 60 percent in the other locations).

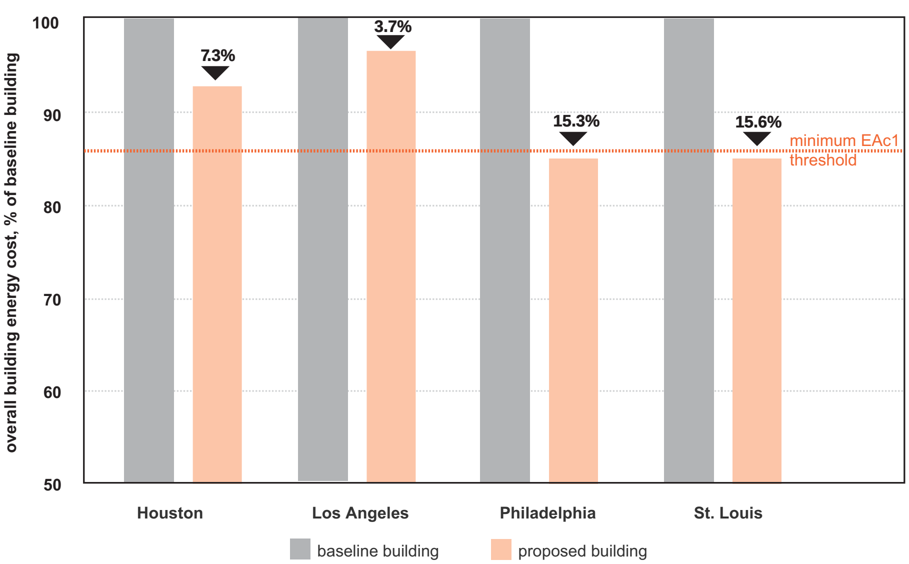
What does this mean? To achieve the minimum two EAc1 points, the total building energy cost must be at least 14 percent less than the baseline building. Because this study was limited to only HVAC-related strategies, the energy used by lighting and plug loads does not change. Therefore, to reduce overall building energy cost by 14 percent in Los Angeles, HVAC energy would need to be reduced by nearly 50 percent!

Rooftop VAV systems can be used on LEED projects in any of these locations but, in climates like Los Angeles, improvements to the building envelope, more efficient lighting, and cross-cutting strategies like shading and daylighting are *critical*.

System 2: Self-Contained VAV System. A self-contained VAV system includes packaged, water-cooled, DX units that are typically installed in a small mechanical room on each floor of the building. When the "proposed" building was equipped with a self-contained VAV system, the following energy-saving strategies were implemented to achieve the energy cost savings shown in Figure 4.

	Houston	Los Angeles	Philadelphia	St. Louis
Ventilation optimization[1] (demand-controlled ventilation at zone level + ventilation reset at system level)	X	X	X	X
Improved supply-air-temperature reset	X	X	X	X
Lower condenser flow rate[3] (12ºF delta T)	X	X	X	X
Parallel, fan-powered VAV (serving perimeter zones)	X	X	X	X
Cold-air distribution[2] (50ºF supply air + 1ºF increase in space cooling setpoint)	X	X		
Exhaust-air energy recovery (total-energy wheel)	X			
Waterside economizer	X	X	X	X
Optimized tower control		X		

Figure 4. Energy simulation results for a self-contained VAV system

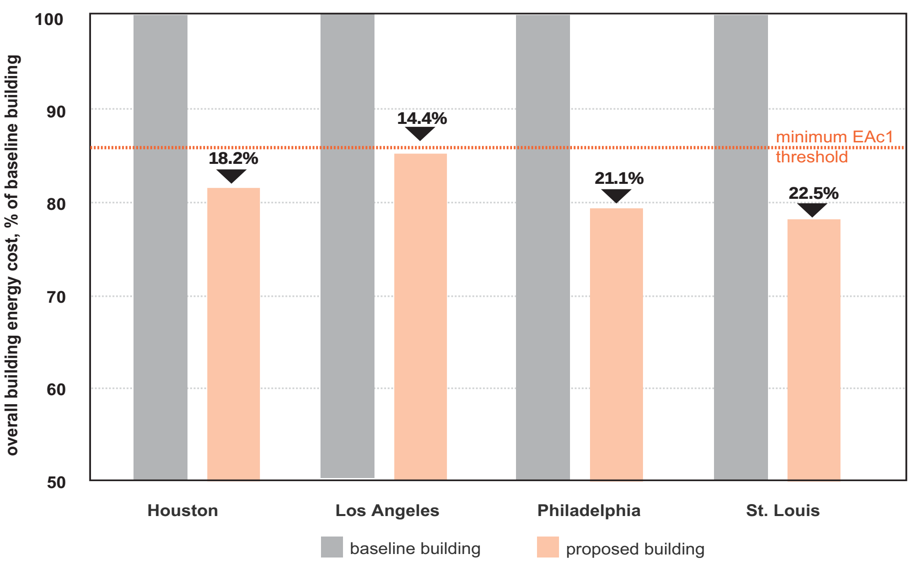


System 3: Chilled-Water, Fan-Coil System. In a fan-coil system, chilled water and hot water are produced at a central location and pumped throughout the building to individual fan-coil units that are installed in or near each zone. Typically, a dedicated outdoor-air system is used to condition all of the ventilation air, and then deliver it either directly to each zone or to each fan-coil unit. When the "proposed" building was equipped with a chilled-water fan-coil system, the following energy-saving strategies were implemented to achieve the energy cost savings shown in Figure 5.

	Houston	Los Angeles	Philadelphia	St. Louis
Lower condenser flow rate[3] (15ºF delta T)	X	X	X	X
Lower evaporator flow rate[3] (14ºF delta T)	X	X	X	X
High-efficiency, water-cooled, centrifugal chiller (0.59 kW/ton or 0.48 kW/ton for Los Angeles*)	X	X	X	X
Chiller-tower optimization control[5]	X	X	X	X
Multiple-speed fans in fan-coils	X	X	X	X
Deliver conditioned OA cold (rather than "neutral") directly to spaces[4]	X	X	X	X
Demand-controlled ventilation		X		
Exhaust-air energy recovery (total-energy wheel in dedicated OA unit)	X		X	X
Waterside economizer (plate-and-frame heat exchanger)		X	X	X

*ASHRAE 90.1-2004 requires 0.69 kW/ton (or 0.52 kW/ton for Los Angeles) for a centrifugal chiller operating at these differing water temperatures and flow rates

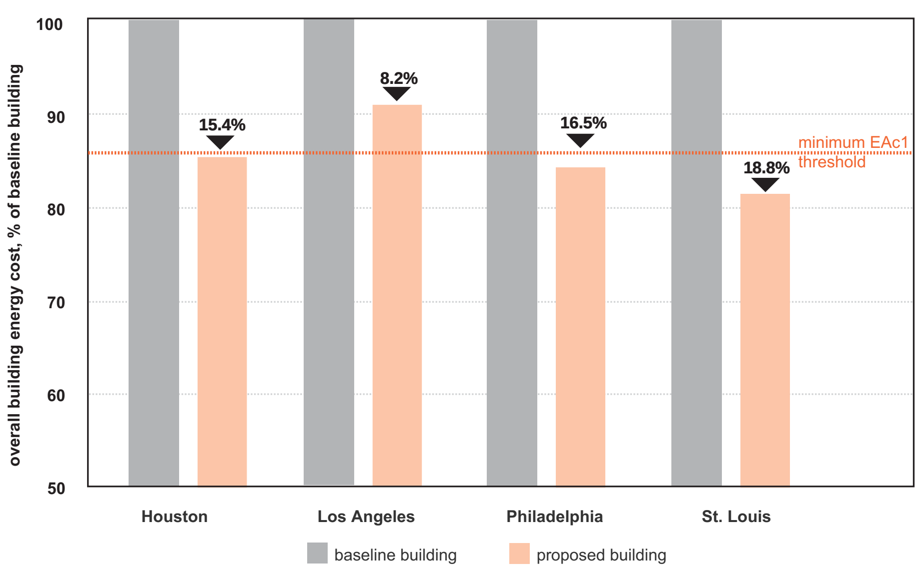
Figure 5. Energy simulation results for a chilled-water, fan-coil system



System 4: Water-Source Heat-Pump (WSHP) System. In a conventional WSHP system, all of the heat pumps are connected to a common water loop, as is a cooling tower and a hot-water boiler. As in the fan-coil system, a dedicated outdoor-air system is used to condition all of the ventilation air. When the "proposed" building was equipped with a water-source heat-pump system, the following energy-saving strategies were implemented to achieve the energy cost savings shown in Figure 6.

	Houston	Los Angeles	Philadelphia	St. Louis
High-efficiency, water-source heat pumps (15.7 EER)	X	X	X	X
Loop temperature optimization control sequence[4]	X	X	X	X
Deliver conditioned OA cold (rather than "neutral") directly to spaces[4]	X	X	X	X
Cycle WSHP fans with load[4]		X		
Exhaust-air energy recovery (total-energy wheel in dedicated OA unit)	X		X	X
Demand-controlled ventilation		X		
Waterside economizer		X		

Figure 6. Energy simulation results for a water-source heat-pump system

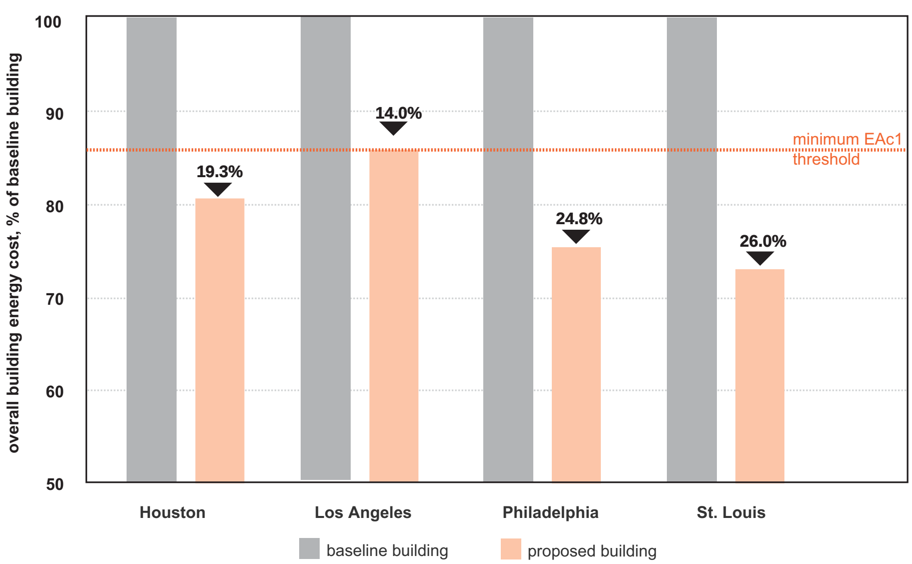


System 5: Chilled-Water, VAV System. Recall that Standard 90.1 requires the baseline building for this example to use a chilled-water VAV system. When the chilled-water VAV system in the "proposed" building was equipped with the following energy-saving strategies, it achieved the energy cost savings shown in Figure 7.

	Houston	Los Angeles	Philadelphia	St. Louis
Lower condenser flow rate[3] (15ºF delta T)	X	X	X	X
Lower evaporator flow rate[3] (14ºF delta T)	X	X	X	X
High-efficiency, water-cooled, centrifugal chiller (0.59 kW/ton or 0.48 kW/ton for Los Angeles*)	X	X	X	X
Chiller-tower optimization control[5]	X	X	X	X
High-efficiency, airfoil supply fans	X	X	X	X
Ventilation optimization[1] (demand-controlled ventilation at zone level + ventilation reset at system level)	X	X	X	X
Improved supply-air-temperature reset	X	X	X	X
Parallel, fan-powered VAV (serving perimeter zones)		X	X	X
Cold-air distribution[2] (48ºF supply air + 1ºF increase in space cooling setpoint)		X	X	X
Airside economizer		X		

*ASHRAE 90.1-2004 requires 0.69 kW/ton (or 0.52 kW/ton for Los Angeles) for a centrifugal chiller operating at these differing water temperatures and lower flow rates

Figure 7. Energy simulation results for a chilled-water VAV system



Summary. The impact of any energy-saving strategy on the operating cost of a specific building depends on climate, building usage, and utility costs. Building analysis tools (like TRACE™ 700) can be used to analyze these strategies and convert energy savings to real operating cost dollars that can be used to help: 1) make financial decisions about reducing operating costs, 2) achieve points toward LEED certification, and 3) qualify for tax deductions under the U.S. Energy Policy Act (see sidebar page 2).

The results from this example analysis cannot be submitted for your specific LEED project, since the USGBC requires the actual building to be modeled in order to document the projected energy savings. But these results will provide some guidance regarding energy-saving strategies that should be investigated for the HVAC system you are considering for your project.

Be careful not to discard any of the system choices investigated in this Newsletter because the results did not achieve 14 percent energy-cost savings in some cases. Actual savings depends on the layout and usage of the specific building, climate, and baseline system requirements. Remember, this example was a fairly large building, so the baseline building was equipped with a chilled-water VAV system. For smaller buildings, the baseline system will be different.

Finally, there are other energy-saving strategies (such as geothermal or thermal storage[6]) that were not included in this particular study.

Any of these systems can be used on a LEED project. However, in certain situations load reduction strategies (orientation, envelope, and lighting) may be needed to reach the 14 percent minimum threshold (see sidebar on page 3). These are strategies that should be investigated anyway to increase energy cost savings and EAc1 points.

For instance, if the 14 percent savings has already been achieved through load reduction strategies, all of these systems would deliver additional energy cost savings and achieve even more EAc1 points.

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References.

[1] For a discussion of the **ventilation optimization** and **supply-air-temperature reset** control strategies for a VAV system, see the 2006 Engineers Newsletter (volume 35-4) titled "Energy-saving control strategies for rooftop VAV systems."

[2] For a discussion of **cold-air distribution** in a VAV system, see the 2000 Engineers Newsletter (volume 29-2) titled "Cold air makes good sense."

[3] For a discussion of **lower flow rates** in a chilled-water system, see the 1997 Engineers Newsletter (volume 26-2) titled "How low-flow systems can help you give your customers what they want."

[4] For a discussion of **delivering conditioned OA cold** rather than "neutral", **cycling WSHP fans** with the load, and the **loop temperature optimization** control sequence for WSHP systems, see the 2007 Engineers Newsletter (volume 36-2) titled "Energy-saving strategies for water-source heat pump systems."

[5] For a discussion of the chiller-tower optimization control strategy, see the 1995 Engineers Newsletter (volume 24-1) titled "Tower water temperature ... control it how?"

[6] For a discussion of using ice storage to achieve EA credit 1 points for LEED-NC, see the 2007 Engineers Newsletter (volume 36-3) titled "Ice storage as part of a LEED building design."

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