Green Energy in New Construction: Maximize Energy Savings and Minimize Cost

By Joseph Ventresca, MS Energy, LEED AP

People often use the term "green energy" to refer to alternative energy technologies. But green energy doesn't guarantee maximum energy savings at a minimum cost—a common misconception.

For school business officials, green energy means getting the lowest energy bills for the lowest construction cost, which translates into maximizing green energy savings while minimizing its cost.

To better understand strategies for optimizing green energy for your building, consider an automobile analogy. When you are buying a car with fuel efficiency in mind, you don't have to become an expert in alternative automotive power technologies; you just look for the car with the highest miles-per-gallon (mpg) rating at the lowest price. The mpg represents the energy-efficiency rating.

For school business officials who deal with facilities, the energy-efficiency rating for buildings (the mpg if you will) is designated in British thermal units of energy per square foot (Btu/ft^2). Because Btu/ft^2 ratings are typically unwieldy, it's simpler to use the percentage of improvement over the *base energy code*, which is the American Society of Heating, Refrigerating, and Air-Conditioning Engineers' Standard 90.1.

The Leadership in Energy and Environmental Design (LEED) green building rating system awards energy points, or "credits," based on the percentage improve-

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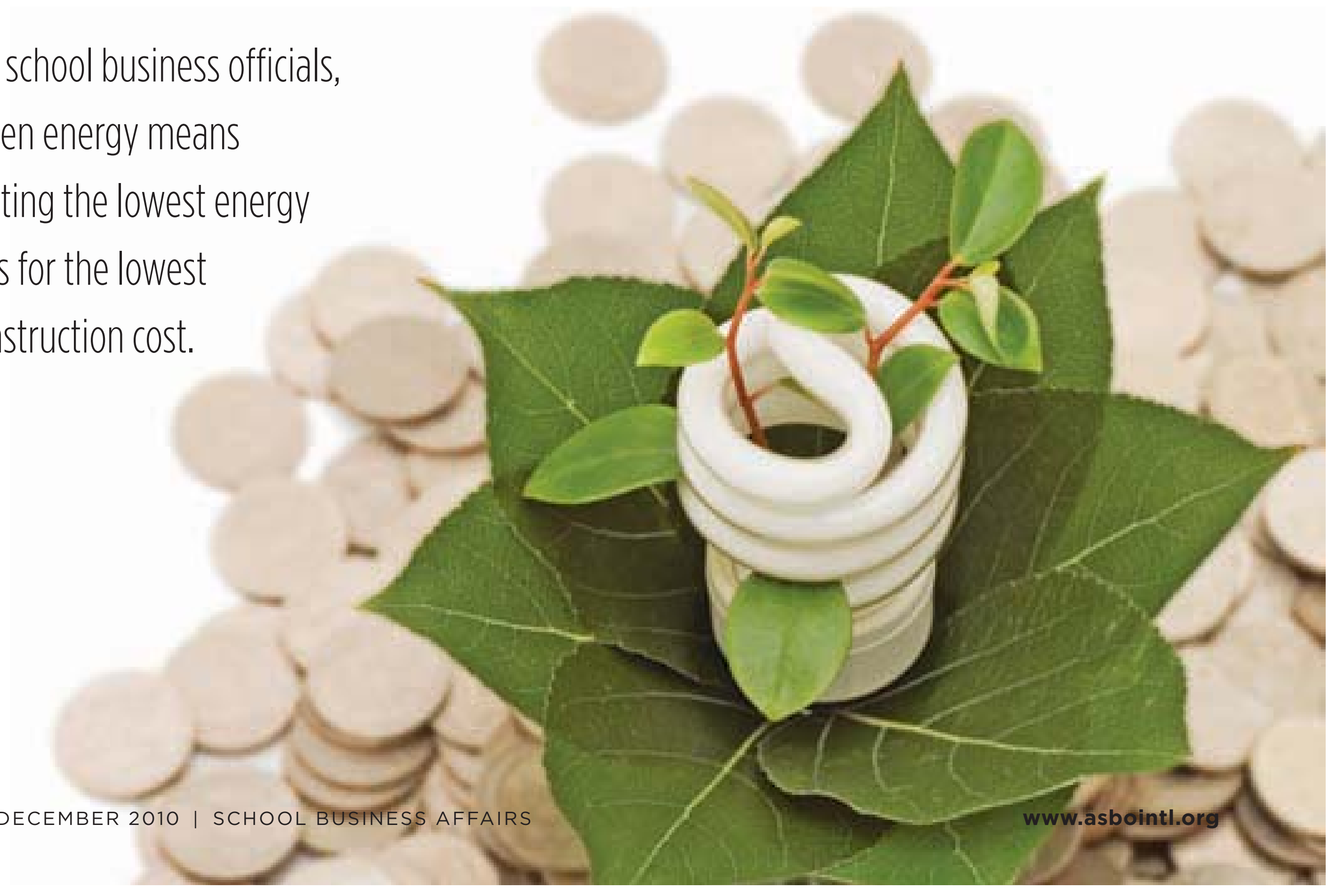

ment over the base energy code. While the number of possible energy points varies with the LEED version, achieving all points translates to roughly 42% to 48% more energy efficiency than the base energy code.

LEED certification alone does not guarantee optimal energy efficiency. LEED has many accomplishments to its credit and has transformed the market toward greener construction. But like any tool, it will not perform as intended if it is misapplied.

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For example, a *New York Times* article states, "The Federal Building in downtown . . . features an extensive use of natural light . . . has LEED certification . . . but . . . is hardly a model of energy efficiency" (Novarro 2009). And an article in the March 2009 issue of *Building Design+Construction* carries the headline "Study Shows 30% above ASHRAE Energy Efficiency Difficult to Reach in Buildings, 50% Unreachable."

However, today, 50% is not "unreachable." Cost-effectively achieving 40% to 50% efficiency over the energy code is possible today. I was the building owner's energy consultant for a recently constructed 100,000-square-foot commercial office building in the Midwest designed to achieve all 10 possible LEED (version 2.2) energy points, for a 42% to 45% energy savings over the 90.1-2004 energy code. This savings was *before* adding any solar electricity, and it was accomplished for *the same or a lower cost* than originally estimated for achieving 5 to 7 LEED energy points.

Optimize Energy Efficiency

To achieve maximum energy efficiency at the lowest cost, energy efficiency must be optimized. According to John Holdren, Ph.D., President Obama's top science adviser, "When you look at the options . . . the cleanest, fastest, cheapest, safest, surest energy supply option continues to be increasing the efficiency of energy end use" (Kolbert 2009).

It is also well stated in the Charleston (South Carolina) sustainability plan: "If one views efficiency as an energy resource, then it costs three to ten times less than any other energy resource, including renewable energy" (Charleston Green Committee 2009, pp. 43–44).

Returning to the automobile analogy, suppose your "car architect" designs an "energy-efficient" eight-passenger van. This vehicle is rated at 15 mpg and is considered energy efficient because it has a six-speed transmission. You realize you need lower gasoline bills because you'll have this vehicle for several years (like your building). So, you consider a similar vehicle certified by the (fictional) U.S. Green Car Products Council that is a V6 and is 20% more efficient, getting 18 mpg.

To obtain maximum green energy, you add solar collectors, increasing the mpg by 2.5% (the same as required by LEED v2.2 to earn a renewable energy point) to bring it all the way up to 18.45 mpg.

By optimizing energy efficiency, you could get a 25-mpg rating in a less expensive car like a Civic and still carry your family of four comfortably. Or for about the same price, you could buy a slightly smaller, five-passenger van hybrid that boasts 34 mpg. For even less, you could purchase a 51-mpg Prius. (All examples are based on 2010 Environmental Protection Agency "city" ratings for miles per gallon and Kelley Blue Book prices). The highest mpg efficiency for the lowest cost is your green energy goal.

The only way to achieve energy efficiency in a car or in a building is to diligently optimize the energy efficiency of every aspect of the design, from start to finish. To accomplish this goal, you must follow a rigorous procedure proven to achieve results.

Perform Energy Simulations

At the beginning of the conceptual design phase, develop a base computer energy simulation of the building that meets the energy code according to LEED simulation criteria. Including this exercise at the outset makes energy efficiency a high priority from day one. This first simulation will not match the building's final design perfectly, but it will have representative thermodynamic features, such as square footage and percentage of window glass.

This early simulation allows for the integration of energy-efficiency improvements at minimum cost. By the time the project reaches the schematic design stage, it is too late to optimize energy efficiency because too many parameters have already been set, and changing them is expensive. Unfortunately, energy simulations, even for LEED buildings, are typically not done until design development or even later. As a result, many energy-efficiency opportunities are missed.

For the base simulation and all subsequent ones, list each area of energy use: lighting, cooling, heating, conveyance energy, plug loads, and miscellaneous energy. Then, set an ambitious goal to reduce the overall energy cost by 50% or more. Aggressively pursue efficiency improvements for each energy use to reduce it by 50% or more. If you don't quite reach the goal, you'll still do well; if you start with a lower goal, you'll fail.

After you have the base simulation, simulate or evaluate the cost and savings of every option that will reduce energy costs with an estimated payback of 15 years or fewer. Don't limit yourself to only those items with short paybacks; even with a 15-year payback, energy investments in improving the building's energy efficiency make good economic sense because of the long life of the building.

The important financial metric is the "years until positive cash flow." While public-sector capital financing is different from private-sector mortgages, let's assume a regular private-sector mortgage for illustration. To calculate the years to positive cash flow, the first year's saving is simply the cost of the measure divided by 15. The cost of the measure adds a fixed annual amount to the mortgage payment. The annual energy savings will increase as energy costs continue to rise, so the annual savings on energy bills will equal or exceed the additional mortgage cost in three years or fewer. This outcome is true regardless of the technology specifics of the measure because this analysis is independent of those specifics.

Even with a worst-case scenario of 3 years to positive cash flow and a 15-year simple payback, the actual increase in money paid on the mortgage from operating funds for the first 3 years is insignificant. The average simple payback for all the efficiency improvements will be much shorter than 15 years because some improvements will have short payback times.

A real eye-opener is developing the numbers for the years to positive cash flow for the specific project budget. It paves the way for aggressive energy efficiency by showing how it is an investment that generates a flow of cash, not a regular cost of construction. If you can't afford energy efficiency as part of the capital budget construction cost, then you surely can't afford the increased operating cost of higher energy bills: that is even worse. And you definitely can't afford to return later to add energy efficiency to the building, as retrofitting will cost 2 to 10 times more.

The conventional practice is to consider paybacks of 3 to 7 years, so some architects and engineers may resist evaluating all energy investments with paybacks as long as 15 years. Shorter paybacks are the rule because most commercial buildings designed by architects are speculative buildings, which the developers will immediately resell. To make a profit, the developer must hold construction costs to the bare minimum. The energy bills are of no concern because they are passed on to the tenants.

For schools and public buildings, which are owner occupied for 30 to 100 years, it makes good economic sense to evaluate all options with paybacks of up to 15 years. This evaluation is especially important if you are considering solar or wind power because the simple payback of those technologies will be significantly longer than 15 years. Designing a solar- and wind-ready building costs little, gives the flexibility of adding those technologies at any time in the future as their cost continues to decline, and keeps the design emphasis on efficiency improvements to the building.

A common yet critical error in evaluating energy-efficiency options is making the first simulated energy improvement an efficient HVAC (heating, ventilating, and air conditioning) system or a renewable energy source. These items will reduce utility bills, but they will not make the building itself more efficient, and they use up the budget. This mistake also causes all subsequent efficiency improvements to show very long paybacks.

Select a package of those options with the best paybacks and simulate it as the final efficient building.

This result is the effect of simulation interactions caused by the assumed order of implementation. Therefore, the only correct way to perform the simulations is to hold the base energy code–compliant HVAC system constant and exclude any renewable energy options until after all building energy-efficiency options have been simulated and evaluated. Then select a package of those options with the best paybacks and simulate it as the final efficient building. Only then should improvements to the HVAC "plants" and supplemental renewable energy be added. This methodology will result in the optimal cost-effective design solution.

Hire an Energy Consultant

An effective strategy for maximizing energy efficiency is to hire an independent energy consultant as the owner's representative for overseeing and achieving energy efficiency. This individual should have extensive experience with energy simulation and have previously achieved 40%–50% energy efficiency, cost-effectively.

The energy consultant reports directly to the owner and should be responsible for simulating, evaluating, and tracking progress to achieve the energy-efficiency goal. The energy consultant regularly updates the owner on the energy-efficiency status throughout the term of the project. Regular updates are critical, since an aggressive goal embraced at the beginning is often inadvertently neglected or watered down in the face of the multitude of issues and financial pressures inherent in designing a building, especially a green building.

Another important advantage of using an independent energy consultant is that it gives the owner the freedom to include trusted architects and engineers on the design team, even without having yet achieved a high-efficiency design. An energy consultant specializing in energy simulation and cost-benefit analysis can be an asset to the architecture and engineering firm, and can also be less expensive because that is all the energy consultant does; unlike the architect and engineer who must design and specify every aspect of the building.

Often, owners think they have an energy consultant through a commissioning agent. However, a commissioning agent's role is to catch errors to ensure that the building is constructed and operates as designed. This function does not improve the energy efficiency of the design in any way.

Adding an effective energy optimization consultant to the design team will pay for itself quickly in reduced energy bills; it pays for itself immediately through a tax incentive.

For commercial buildings, a federal tax deduction of up to $1.80 per square foot is available to owners (or designers in the case of government-owned facilities) of new or existing buildings designed to save 50% of the energy cost beyond the 90.1-2001 energy code. This tax incentive is based on a sliding scale, so achieving 40%–50% saves considerably more than achieving 15%–30% and easily pays for an independent energy consultant who is directly responsible to the owner for achieving optimal energy efficiency.

A Step-by-Step Process

In summary, when considering energy efficiency, follow these steps:

1. Define green energy as achieving maximum energy efficiency at minimum cost.
2. Set an aggressive goal to achieve 50% energy reduction beyond the energy code for every area of building energy use.
3. Perform energy simulations at the outset of the conceptual design phase to assess all energy-efficiency options with paybacks of 15 years or fewer, and do so before any improvements to the heating and cooling plants or before adding renewable energy technologies.
4. Select an experienced design team that includes an independent energy consultant who represents the owner for achieving optimal energy efficiency.

By following this procedure, you will realize the maximum energy savings at the minimum cost; hence, you will achieve green energy for your next building project.

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