Rethinking Design for Energy Performance

For BetterBricks
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ABSTRACT

The term "integrated design" is often used and describes a wide range of activities. The Northwest Energy Efficiency Alliance, through its BetterBricks program, has for several years strengthened the connection between integrated design and improved energy performance in buildings. This article explores integrated design activities and links integrated design to continuing improvements in energy performance in buildings.

INTEGRATED DESIGN

Recently, New Buildings Institute Advanced Buildings published a collection of specific design solutions that can improve energy performance. Their "Advanced Buildings: Core Performance Guide" is based on over 30,000 runs of building energy models plus substantial building research. The guide is a credible basis for design decisions. Using the prescriptive, pre-analyzed strategies in this guide, a design team might expect to obtain reductions in energy utilization of 20-30 percent compared to a code-driven design—and to do this without additional energy modeling. Behind the prescriptions is an assumption that a formal, integrated design process is not required to achieve a reasonable degree of energy efficiency.

On the other hand, the design profession both promotes and uses integrated design to create value in many aspects of building development; energy is only one aspect that has benefited from better design practice.

For several years the Northwest Energy Efficiency Alliance has gathered evidence connecting improvements in the design process (specifically improvements in the integrated design approach) with improvements in the energy performance of commercial buildings.

The USGBC views this connection as an essential part of sustainable design. Accomplishing LEED™ certification depends on the practice of involving targeted experts, sometimes including stakeholders outside the design team in the design process. The USGBC helped establish the design charrette (a meeting created to help experts work together) as central to project success.

In the past few years, the search for solutions has yielded a significant number of specific ideas and has helped designers better understand the wiles of energy flow in buildings. The catalog of ideas now available to design teams concerned with energy efficiency, and the application of proven ideas, do not necessarily require a full-fledged integrated design effort. But this collection of ideas is not sufficient to meet current goals for energy utilization, nor is it sufficient to lift North American practice to a competitive level with the European Union. The European Union has faced higher energy costs for decades, and buildings there perform better than buildings here by a factor of two. As energy costs in North America increase, this will give the European Union a considerable business advantage.

So, it is not "either/or;" instead it is a question of which projects benefit most from a more limited, prescriptive, energy-focused approach and which from a formal integrated design process.

DESIGN SYNERGIES

The core of integrated design is the *search for synergies*; i.e., strategies with resultant benefits greater than the sum of individual design decisions. See Figure 1. The context for this search always includes the marketplace (with a balance between cost and expectation).

The difference lies in the approach to design—energy-aware vs.

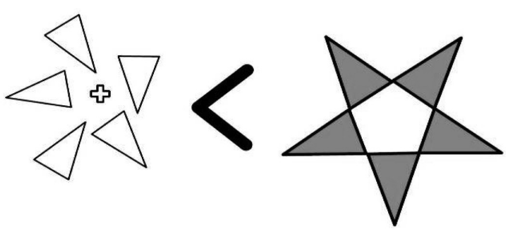

Figure 1. Search for Synergies. (© 2006 Energy Studies in Buildings Laboratory, University of Oregon, and Konstrukt.)

traditional. The context of an integrated design process is similar to the context of conventional design in that both must respect limits in time, budget, and risk. However, at the heart of the integrated design process is a *disciplined, iterative, open-minded* analysis of all the major components and options; that is, in effect, it is a team search for synergies. G.Z. Brown (at the University of Oregon, Energy Studies in Buildings Laboratory) calls it "optimization without borders," a useful way to think about design synergies. This is the key practice that distinguishes energy-focused integrated design.

Figure 2 looks schematically at the cross-optimization thinking process, where the iterative interplay of all four elements contributes to a final solution. The process of optimization, for each project, consists of suggesting improvements in each component and asking what impact each improvement might have on the other components.

SYNERGIES AND ENERGY USE

Consider the following non-integrated alternatives to a traditional design approach. The first alternative consists of reducing energy use

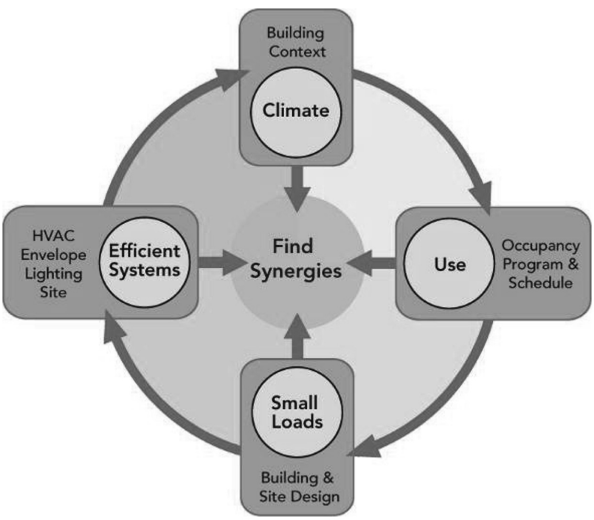

Figure 2. Logical Parts for Disassembling a Design Problem. (© 2006 Energy Studies in Buildings Laboratory, University of Oregon, and Konstrukt.)

by procuring more efficient system components. The second alternative consists of reducing building loads. For example, a "passive house" in Europe may use 10 percent of the energy required by a traditional house for heating and cooling. Passive approaches in commercial buildings are less effective because the ratio of exterior skin to interior floor area is lower, but they can save significant energy nonetheless.

Now re-integrate these alternatives. For both residential and commercial buildings, the combination of both alternatives—first reducing loads then procuring more efficient systems, in that order—can create a synergy that provides much higher energy performance at little or no increase in cost.

Figure 3 represents a traditional building or code-driven design.

Figure 4 indicates the expected energy use if we could procure building systems that were significantly more efficient.

The typical conventional approach to reducing energy consumption is to design more efficient mechanical, electrical, and plumbing (MEP) systems. This has the advantage of reducing operating costs but usually comes with an increase in construction cost (which reinforces the idea that energy efficiency is not affordable). Also, efficient MEP equipment (alone) is usually not sufficient to meet more stringent requirements, such as those used by the California university systems that require surpassing Title 24 (California energy code) by 15 percent or more.

Reaching the integrated solution is a two-step process. First, start not with systems but with *loads*. Consider aspects of the design, such as increasing daylight, optimizing site orientation, collecting planned uses by schedule, or optimizing envelope performance to reduce loads. See Figure 5. The result is a need for smaller MEP systems that use less energy. In addition, smaller MEP systems result in lower construction costs for mechanical systems.

Next, apply system efficiency to reduce energy use even further. By combining the two approaches, you achieve even greater operational savings while managing first cost. See Figure 6.

SYNERGIES AND COST

Mechanical, electrical, and plumbing (MEP) systems are a significant portion of the cost of most buildings. The game (or art) of step-

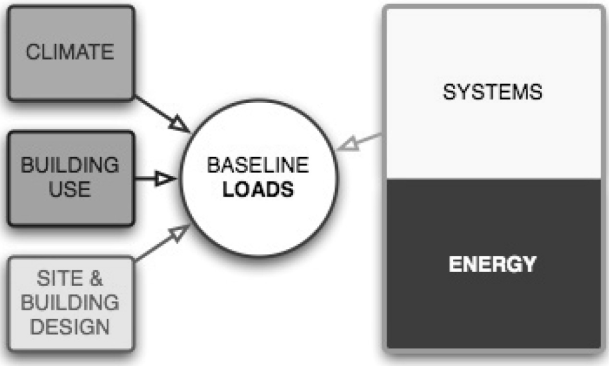

Figure 3. Conventional Building Energy Model. (© 2006 Energy Studies in Buildings Laboratory, University of Oregon, and Konstrukt.)

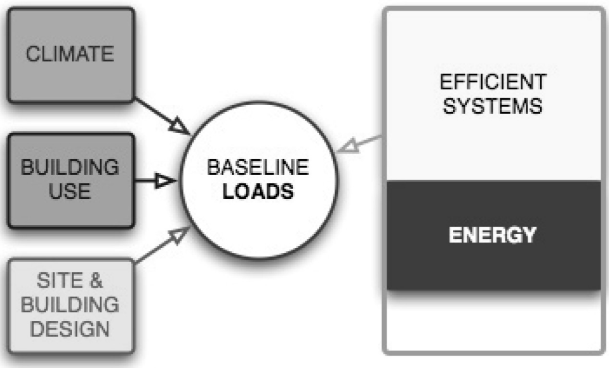

Figure 4. Optimized HVAC Systems in Conventional Building. (© 2006 Energy Studies in Buildings Laboratory, University of Oregon, and Konstrukt.)

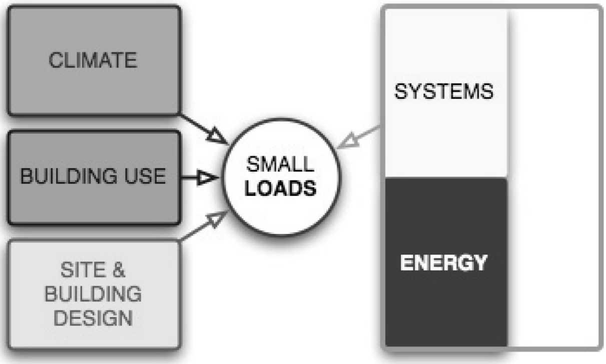

Figure 5. Optimized Building Loads with Smaller HVAC Systems. (© 2006 Energy Studies in Buildings Laboratory, University of Oregon, and Konstrukt.)

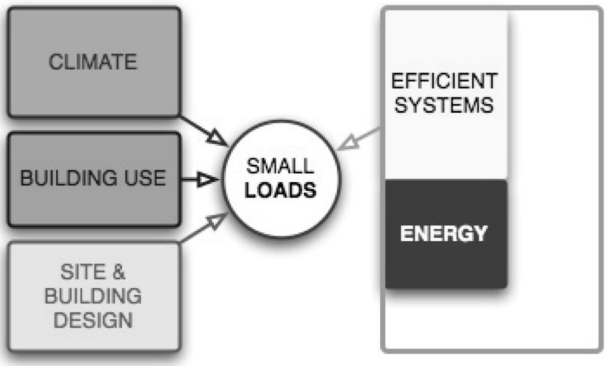

Figure 6. Optimized Building Loads and Optimized HVAC Systems. (© 2006 Energy Studies in Buildings Laboratory, University of Oregon, and Konstrukt.)

ping back the capacity of MEP systems for a given building area offers a means of funding other features of a building. The simplest example involves an investment in the insulating quality of an exterior wall. If this investment enables you to reduce the capacity of a mechanical component, you discover the possibility of creating a building for the same cost and with better energy performance.

If you can take the next step to eliminate a system (e.g., to eliminate the cooling system), then significant funds become available for alternative approaches to storing cool (i.e., managing comfort) inside a building.

Traditional design relates specific aspects of a proposed building to specific design phases. We have historically connected the completion of schematic design with a description of the proposed building that includes construction type, site massing, orientation, etc. Now, with energy performance added as a criterion, trade-offs in cost between MEP components and building performance must be addressed along with construction type, site massing, etc. Key energy decisions are shifted to the schematic design phase.

When key design decisions are made out of order, whether these are energy related or not, the design process itself fails, because detailed design work is lost whenever key design decisions are changed later in the process.

Thus, when energy-focused decisions are made late in the design process, their focus is limited to MEP system efficiency. Given the practical limitation of construction budgets, the range of solutions is limited to a band of energy performance with cost close to the baseline (the dark blue band in Figure 7).

If energy-focused design decisions are made early in design development, effective investments in the building envelope can be selected. For example, insulation and glazing systems can be optimized for the building's climatic region. This investment in the building envelope allows the designer to reduce the MEP systems capacity, creating a range of solutions near the baseline building cost and significantly better energy performance (the cyan band in Figure 7).

When energy is a concern during project programming and early design, then building shape and orientation, as well as building systems (like night cooling and natural ventilation), can be included in the project design. In many cases, this allows the designer to eliminate a mechanical component (e.g., a chiller, the green band in Figure 7).

Further, to characterize the cost of renewable energy systems (the violet band in Figure 7), we must acknowledge several factors. First, the cost of renewable energy production varies widely from place to place, because sun angle, cloud cover, and wind vary. Second, specific

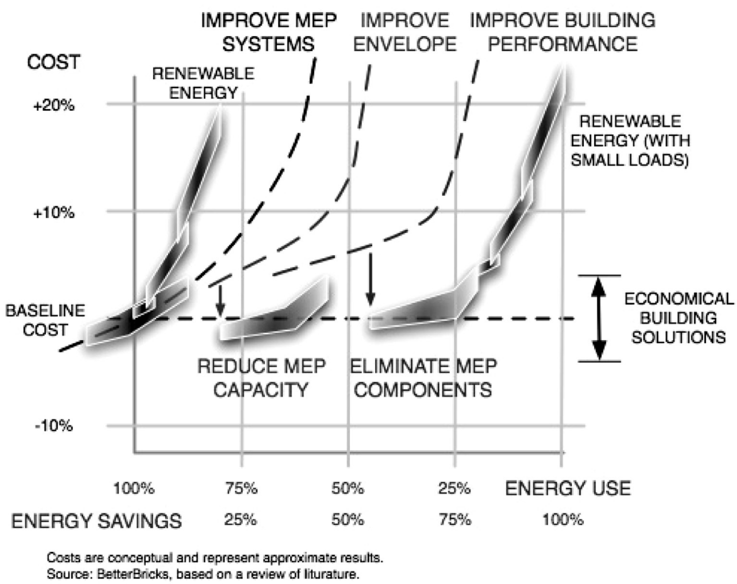

Figure 7. Construction Cost Impacts of Integrated Design. (© 2007 BetterBricks)

renewable systems have a limited range of capacity. For example, a hot water pre-heat solar collection system is only useful for water that will be used in the building. And a building-mounted photovoltaic system is limited by the area of the roof (or roof plus south facing walls) exposed to the sky. Thus, we indicate renewable systems as a series of individual systems, each with a limited capacity. Typically, site-mounted renewable sources are limited to 15-20 percent of the energy consumed by a code compliant commercial building.

Thus, we have demonstrated how difficult it is to reach zero. To create a building that exhibits carbon neutral operation is to design a building in the green band and provide renewable energy systems matched to the reduced building loads.

CHOOSING INTEGRATED DESIGN

An effective integrated design process is a disciplined, collaborative process where the types of decisions addressed during each cycle of design are planned and the value of these decisions is augmented by the actions of every team member as the design progresses.

By relying on success stories from recent integrated design projects, you can (carefully) select solutions to reasonably align a project with energy efficiency.

By relying on an integrated design process involving targeted experts, you are able to meet the needs of each design problem in a superior, integrated way that surpasses traditional methods.

The degree of collaboration we practice reflects our leadership position regarding energy. Anyone choosing to lead the way in the energy efficiency and sustainable design revolution will use an integrated design process to transcend the current catalog of solutions.