# DESIGN FROM THE OUTSIDE IN

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## INTRODUCTION

*As green building design matures, guiding principles can give form to the work. For example, over the past twenty years, the principle of "the building as a whole" has been developed in energy-systems design, emphasizing interactions among all aspects of a building, including envelope, lighting, heating and cooling, and renewable energy options. As another example, over the past ten years LEED has brought its own set of guiding principles that advocate balanced priorities in green design (site, water, energy, materials, and environmental quality); allowing the owner choice among these issues; and involving all stakeholders early in the process. Other guiding principles are proposed at the detailed design level: Consider daylighting, evaluate renewable energy, reduce water usage, and more.*

*This article explores a new principle to guide green building design, termed loosely "outside-in design." A variety of benefits arise from designing from the perimeter of a building site and proceeding inward toward the center of the building.*

*Outside-in design suggests minimizing exterior loads and impacts, such as temperature effects, energy usage, water usage, wind, and noise. This is most effectively done by starting farther from the building and working inward. It is in some ways equivalent to solving a problem at its source rather than trying to solve a symptom. It is also similar to solving health problems by making prevention the top priority. For example, it is preferable to reduce air conditioning energy usage by shading windows on the outside and preventing direct summer sun from reaching the windows, rather than by only increasing the efficiency of the air conditioning system. Such shading further allows more substantial savings if the air conditioning system efficiency is then also increased. As another example, a line of trees provides a first line of protection against wind, allowing building weatherstripping, caulking, and other air barriers to be more effective and to last longer, since they will not be subjected to the higher pressures of stronger wind.*

*With outside-in design, community issues relating to a building's design are considered first, then site issues such as landscaping and vegetation. This is followed by consideration of the building footprint and overall configuration (stories, building type), then near-building features (shading, awnings, renewable energy collectors, etc.), then the outer envelope design (outer walls, windows, roof, foundation, etc.), then unconditioned spaces (attics, basements, attached garages, and sheds), then the inner envelope between conditioned and unconditioned spaces, then internal loads (lighting and appliances), and finally the comfort system (heating and cooling).*

## ELEMENTS

Basic elements of outside-in design include:

1. First consider components farther from the core of the building. Give such "layers of shelter" priority in evaluating options for protecting the building core. Work from the outside layers (farthest from the building core) toward the inside.
2. Add multiple layers of shelter. This layering increases resistance to energy losses and to impacts of other external loads such as wind and rain.
3. Seek continuity for each layer of shelter. Avoid interruptions or penetrations that weaken each layer.
4. Minimize the surface area of walls, roofs, and floors between conditioned rooms and outside air, through buffering (placing unconditioned rooms or the ground between conditioned spaces and the outdoors), berming, using simple lines (avoid wall jogs, conditioned rooms overhanging outdoor air, etc.), and through the use of party walls.
5. Design undogmatically. Evaluate each component professionally and independently and avoid adding layers of shelter that do not make sense. Work in the best interests of the owner.

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## METHODOLOGY

Outside-in design views the building as the innermost component of a built environment. The core of the building is protected by layers of shelter (see Figure 1).

First is the broader community. Where will the building be sited in relation to workplaces, schools, and community centers? How will people be transported to and from the building? These questions are typically asked by urban planners but are equally valid questions for the building designer to pose to the prospective owner. Does the owner really want to be 15 miles from town? Is a downtown gut rehab an option, instead of building on an undeveloped rural or suburban site? Can adjacent buildings be used to protect the proposed building from wind and sun? Can the community footprint be minimized?

Next come site issues, such as landscaping, grading, and vegetation and site architectural features, such as retaining walls. These are often neglected from an energy perspective but can have a significant impact on energy use. An exposed building with no shielding by trees or adjacent buildings will use more energy than a well-shielded building (see Figure 2). Wind affects energy use in several different ways, including transporting heat away from a building's surface (forced convection). Wind also imposes added air pressure on a building's surface, which augments infiltration and can actually wear down weatherstripping and insulation. Site evaluation also presents an opportunity for an early examination of site equipment, such as air-conditioning condensers and cooling towers, electric transformers, and emergency generators. An air conditioning system will use less energy if kept clear of obstructions and sources of dirt and away from areas where air will recirculate.

Following the site, the building footprint is examined, including orientation and overall building configuration (number of stories, building type, etc.). While building orientation has long been a focus of schematic design interest, through solar exposure studies, and should continue to be so, outside-in design goes further by examining the surface-to-volume ratio of a building and its impact on energy use. A row house design of six townhouses will use less heating energy per unit of floor area than a single-family house or a duplex townhouse,



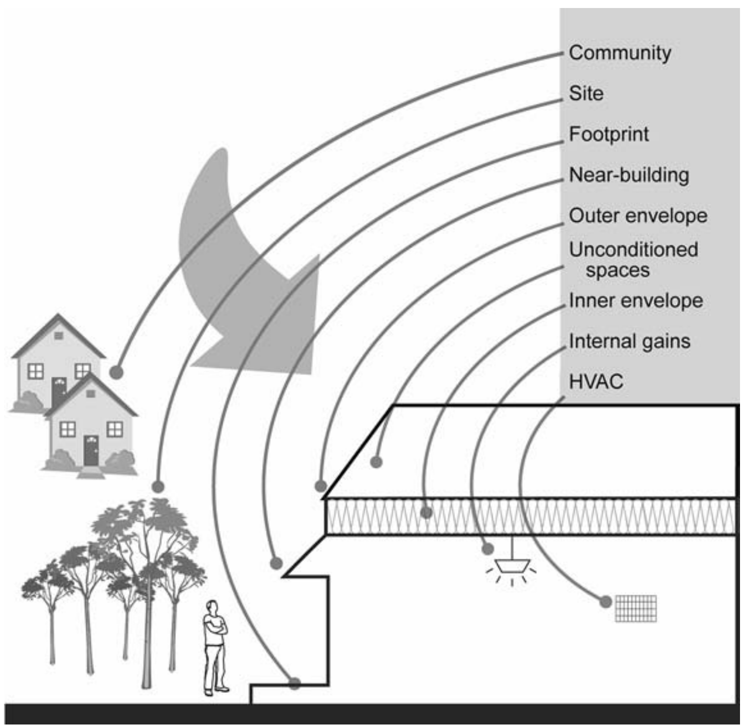
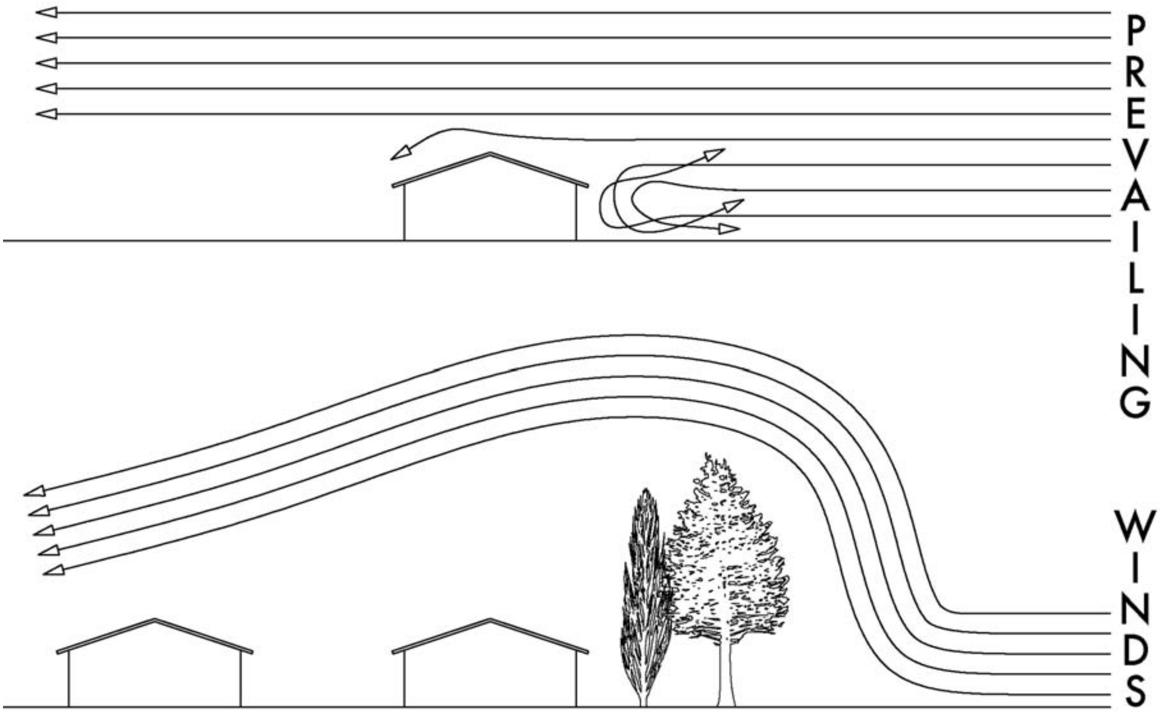



**FIGURE 1.** Designing From the Outside In: Layers of Shelter.

**FIGURE 2.** Protection from Wind.




on the basis of reduced exposure (ratio of exposed surface area to building volume). Vaulted ceilings are far more inefficient, energy-wise, in terms of exposed exterior surfaces relative to useful floor area. Important incremental gains can be made even by reducing the height of stories. Do bedrooms or basements really need to be 8 to 10 feet tall when historically they were as low as 7 feet 6 inches, and this complies with most code requirements? Complex building configurations with jogs and cantilevered overhangs add unnecessarily to surface-to-volume ratios and increase both energy inefficiency and construction cost. The character lost by removing these details can be made up by adding landscaping features, near-building features, and unconditioned-space additions, all of which reduce energy usage.

After looking at the building footprint, the designer evaluates near-outside features, such as shades, awnings, berming, and renewable energy devices such as solar collectors. Exterior shading is very effective in reducing solar load and air conditioning usage. Furthermore, by assessing near-outside features early in the process, dual functions can be sought, such as shading by solar collectors. Also, the chances of skipping locations for such features are reduced, if assessed early.

After the near-outside features, the critical exterior building is assessed: walls, windows, doors, roof, and foundation. Continuity and integrity of the building envelope is paramount. Holes and failures in the integrity of the envelope must be minimized. Continuous insulation, such as structural insulation panels (SIP) and insulated concrete forms (ICF), has been shown to be more effective than intermittent insulation, such as insulation between studs. Likewise, air and vapor retarders are more effective when continuous. Window design at this stage allows evaluation of daylighting. Hard questions should be posed regarding the need for windows in all spaces, recalling that even the best windows have thermal resistance that is four times less effective than a typical wall and allow an additional path for air leakage. Are windows really needed in stairwells, storage rooms, basements, and bathrooms? Can a large bow window be replaced by a more proportionate vision glazing? By how much does the glazed percentage of walls unnecessarily exceed the code minimum? Is the percentage of heating and cooling load disproportionately represented by windows? In energy efficient buildings, windows can amount to 50 percent or more of the heating load of a building; this can often be reduced substantially through a thoughtful evaluation of window size and placement.

Unconditioned spaces come next, such as attics, crawl spaces, basements, storage rooms, and other utility spaces. The issue here is to define a second building envelope, between unconditioned spaces and conditioned spaces. This second envelope must maintain its own continuity and integrity. A leaky attic hatch between a heated building and a vented attic is a shortcut for energy losses, even if the attic floor is well insulated. A major strategy can also be to move all unconditioned spaces outside the core conditioned space and to use them as buffers by locating them between the conditioned space and outdoor air. This adds a layer of shelter, adds to the effective thermal insulation of walls, reduces the area that needs to be conditioned, and reduces solar gains. Such unconditioned spaces could include tool sheds, woodsheds, workshops, attached garages, mud rooms, coat rooms, meter closets, dry storage, and children's non-winter play spaces. It is critical to maintain a strong and continuous thermal boundary between the conditioned and unconditioned spaces.

Next are the building's internal loads, such as lighting and appliances. Note how artificial lighting design follows sequentially after daylighting design, which happened at the envelope stage. Artificial lighting design should be computer assisted, to assure meeting but not exceeding required light levels, thereby assuring minimum construction cost. Minimized artificial lighting will in turn assist the subsequent design of the air conditioning system. Interior design should also encompass thermal mass. Thermal mass must connect with the building interior; thus it naturally follows the earlier design of the envelope and associated insulation design.

Last is the heating and cooling system. Having defined and minimized loads all the way from the outermost layer of shelter, the heating and cooling system can now be minimized in size and maximized in efficiency. In this way, the heating and cooling system follows the building design rather than leads it. Also, the heating and cooling system is intentionally and entirely located within the core of the conditioned space and not in more traditional locations such as unconditioned basements, attics, or mechanical rooms. Therefore, any losses from the plant and distribution system are useful in that they end up within the conditioned space.

A variety of these principles are illustrated in Figure 3.

## BENEFITS

A primary motivation for outside-in design is minimized energy usage. A variety of additional benefits, however, accrue from this approach.

Environmental degradation is prevented through the early, high-priority focus on the site. Added comfort derives from reduced drafts, which are the result of lower wind pressures. Solar glare is reduced or eliminated by the use of shading.

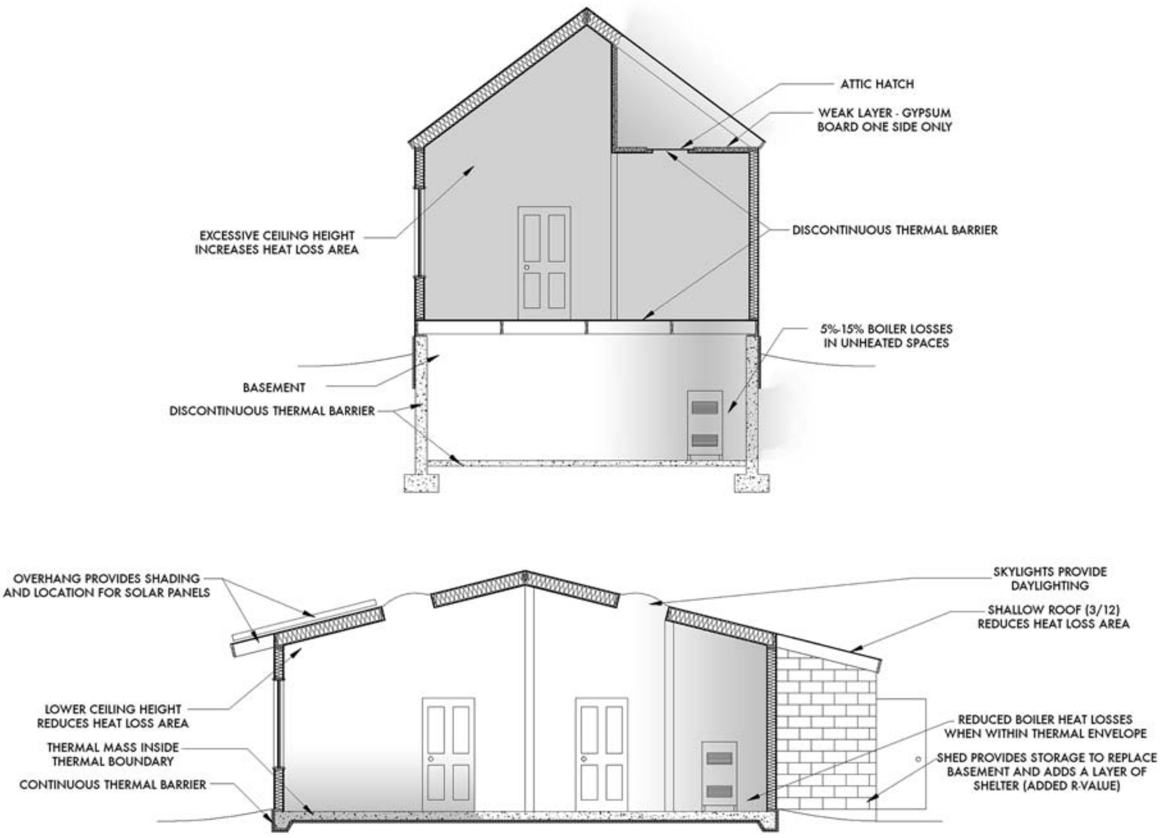
In many instances construction costs can be reduced by using outside-in design, because the outer layers of building protection (trees, overhangs, exterior shades) are more affordable than the incremental cost of a larger heating and cooling system. A higher volume-to-area ratio is more affordable than a building with extensive and complex exterior surfaces. A well-designed building will be sufficiently comfortable to allow elimination of perimeter heating systems, further reducing the construction cost of heating and cooling distribution. The right size and number of windows are inevitably smaller and fewer than what are often arbitrarily placed in a building. Optimal lighting design typically requires fewer fixtures than rule-of-thumb design.

Layers of shelter can work not only to shelter people, but also to protect animals and their impact. For example, shaded windows have been shown to be less likely to result in bird deaths from collisions caused by glare or reflection. Rodents and insects that have fewer paths in from the outdoors are less likely to cause problems indoors.

## NATURE

In considering outside-in design, it is informative to keep in mind the natural forces from which buildings provide shelter: sun; air (wind, air leakage, drafts); water (rain, surface water, subsurface water,

FIGURE 3. Various Aspects of Outside-In Design Illustrated (Near-Outside Features, Building Exterior, Unheated Spaces, Heating System). Top: Typical Design; Bottom: Outside-In Design.




humidity); animal life (insects, rodents, birds, and others); temperature; noise (wind, rain, hail, animal sounds, storms); and contaminants (dirt, dust, mud, airborne pollutants). The site and building design can work to not only enhance the layers of shelter, but also to offer ways in which building occupants can choose contact with the natural world. Perhaps the site can emphasize the sun with a sundial, water with a pond, or sounds with a stream. Rather than promoting artificial contact with nature through building failures (for example, large windows through which people simply look outdoors), the designer can seek deeper ways in which to promote these connections on the site: landscaping, gazebos, pergolas, benches, ponds, mazes, tree-houses, and the like. Similarly, these themes can be brought indoors with interior fountains or waterfalls, judicious use of natural light, and more.

## EXAMPLE

The most common construction for pitched-roof buildings is to insulate the attic floor and to vent the attic. This has resulted in one of the most widespread problems in design and construction. Somehow, likely because neither the pitched roof nor the attic floor has been regarded as the primary thermal surface, there has been failure in the continuity of both these surfaces of the thermal envelope. Heat from the building is transported to the attic through the very porous attic floor surface, through uncapped plumbing chases, recessed light fixtures, leaky attic hatches, and more. Heat continues to be transported out of the attic through vents in the ridge, soffits, or gables. The results are high energy losses and, in the north, widespread formation of ice dams as warm attics melt winter snow on the roof above.

Outside-in design would first examine the exterior envelope—the roofline. Perhaps insulation or a radiant barrier might be added at the roofline, either of which would provide added thermal protection. If the roof is insulated, perhaps venting can be eliminated, enhancing the continuity of the exterior envelope. Next, the unconditioned space of the attic is evaluated: What is its function? Is it "in" the thermal envelope or "out"? Does it need to be heated? Can its size be reduced? Can the pitch of the roof be reduced? Next, the interior envelope, at the attic floor, is examined. At a minimum, discontinuities here must be eliminated (uncapped chases, lighting penetrations). This surface should be air-sealed. The attic floor could also be insulated, adding a second layer of insulation protection. Continuous insulation is preferable to insulation broken by rafters.

The likely results are an attic that is warmer in winter and cooler in summer and that can be used constructively for storage or other functions. The space now has lower energy loss and increased comfort through fewer drafts and fewer summertime heat and humidity problems. Ice damming on the roof in winter is also eliminated.

## FLEXIBILITY

The outside-in green building design process must be flexible. Design is and should be an iterative process. The programming of an owner's requirements, much of which requires attention to the inside of a building, needs to happen early and cannot wait until site and envelope design has been finished. Heating and cooling engineers can provide valuable early insight into different building system features and tradeoffs. Their involvement should not be put off until the last stage of the outside-in process. On the other hand, under no circumstances should a heating and cooling system design be finalized until all outer aspects of design, from wind shielding to envelope to lighting design, are themselves final, in order to take advantage of correct-sizing the most appropriate heating and cooling system for the building. Outside-in design lends an inherent order to the process.

## SCHEDULE

Outside-in building design follows a typical design and construction schedule, with design proceeding in the natural sequence of typical construction, from site to envelope to interior. Decisions regarding landscaping can be made early, and shielding/shading trees planted early (or retained on the site), in time for greater maturity when construction is complete. The design generally follows approvals, from town and site planning approvals early on, to building permit, to specialty permits, to the final certificate of occupancy.

## CONCLUSION

A guiding approach to green building design is proposed, suggesting that methodically designing from the perimeter of a building site, inward toward the building core, offers a variety of benefits that minimize resource use and environmental impacts and that meet owner needs. Multiple layers of shelter reduce the risk or unwanted outdoor elements penetrating and reaching the building core. This outside-in approach minimizes building energy usage and delivers energy conservation improvements more cost-effectively. Shelter from elements, such as wind, drafts, glare, as well as from animals, is also enhanced. Furthermore, this approach promotes a conscious connection to and interaction with nature, rather than the superficial connection of simply looking through oversized windows. The outside-in approach can give context and direction to green building design.

## ACKNOWLEDGEMENTS

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