SEDAC ENERGY SMART TIPS

New Construction: Building Envelope

New Construction EST Series 2 of 4

Owner's Guide

Envelope

HVAC

Lighting

One of the most important things for a building owner to know when designing a new structure is that a high-performance envelope (exterior shell) is only achievable in a cost-effective way during the original design and construction process.

What's an ENVELOPE?

The building envelope, or enclosure, is the physical separation between inside and outside, made up of:

1. Foundations
2. Walls
3. Windows, Doors, and Skylights
4. Roofs and Attics

It is possible to upgrade windows, seal leaks, and add insulation later, but after-the-fact envelope fixes are far more expensive and difficult than doing it right from the start. Some decisions, like the direction the building faces and the wall type, are for the life of the building.

The financial rewards for careful design and construction are long-lasting. An efficient envelope design can cut the average cost of operating a building in half. Designing for efficiency also saves money up front, because it reduces heating and cooling loads and allows smaller HVAC equipment to be installed.

Interestingly, efficiency has a positive impact on the bottom line - much greater than the energy cost savings alone - even when those cost savings are significant.

How is this possible? Employee salaries are the greatest outlay a business owner makes. Studies show that employee sick days, absenteeism and healthcare costs are all reduced in high quality, energy efficient buildings.[1] In other words, people in these buildings are healthier, happier, and more productive - qualities all business owners want to see in their employees.

This brochure provides an overview of the most important factors to be aware of when working with an architect on a building envelope. Brochures on *HVAC* and *Lighting* are also available in this series of Energy Smart Tips, as well as a general *Owner's Guide*.

Goals for a good building

ENVELOPE

1. Design for high performance
2. Reduce loads and save energy $$$
3. Create comfortable, inviting space

At SEDAC, we provide personalized advice to new construction clients on how to improve their building envelope designs and save energy dollars. We also identify incentive funding to reduce the up-front costs of building a better envelope. Apply at SEDAC.org.

[1] www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/us_re_Dollars_Sense_Retrofits_190608_.pdf

The Smart Energy Design Assistance Center performs energy assessments on various building types. Each building type has different energy requirements. SEDAC's Energy Smart Tips help building operators identify energy cost reduction measures.

SMART ENERGY DESIGN ASSISTANCE CENTER

PROVIDING EFFECTIVE ENERGY STRATEGIES FOR PUBLIC AND PRIVATE BUILDINGS IN ILLINOIS

HOW DO YOU GET A BETTER BUILDING ENVELOPE?

DESIGN FOR HIGH PERFORMANCE

WHY DESIGN AN EFFICIENT ENVELOPE?

1. Save money up front and long term:
   - Lower first costs for HVAC equipment
   - Lower operating costs for heating & cooling
2. Happy, healthy, productive occupants:
   - Fewer drafts, cold spots, and hot spots
   - Even daylighting that enhances visual quality
   - Cleaner air
   - Less noise
3. Improved image and marketability:
   - Show corporate environmental commitment
   - Attract quality tenants and employees

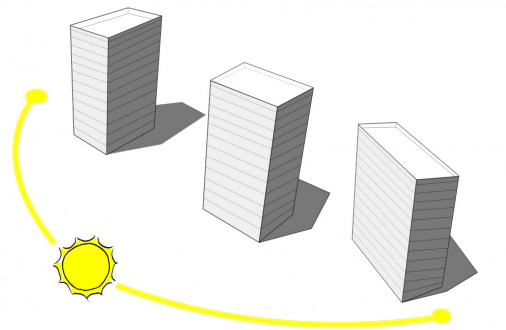
WHAT ABOUT NET ZERO?

Want your building to be on the leading edge? The Architecture 2030 challenge will lead to designing all our new buildings to net zero energy status by 2030 - but we have the technology and the knowledge to do it now.

If you want a net zero building, first make it your goal. Then, during envelope design, extra attention to orientation, windows, and insulation is necessary. You may have heard the term "super-insulated" - the addition of extra insulation to further slow heat loss in winter and heat gain in summer. Even if not going for net zero, super insulation is still a great idea for adding comfort and saving energy costs.

SITING, ORIENTATION, & MASSING

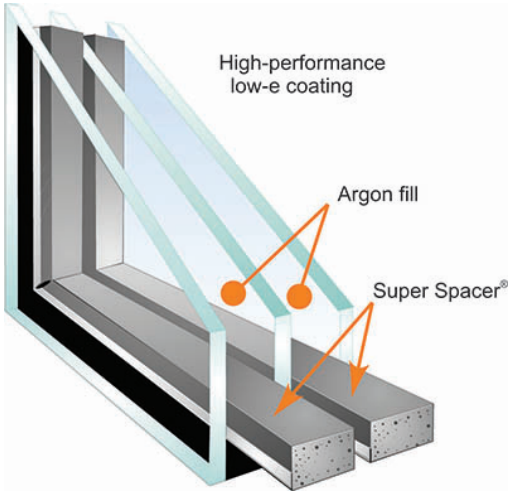
Siting, orientation, and massing are the first steps of building design. ***Siting*** is where a building is placed. ***Orientation*** is the direction a building faces. ***Massing*** is the general shape of a building. High-performance buildings must be designed with respect to the sun, because solar exposure is the greatest variable affecting heating and cooling requirements that designers can control. Where possible, face the broad side of the building to the south. It is easiest to control glare and overheating on the south side because horizontal shading devices are most effective at keeping out direct sun on south-facing windows. Controlling the size of east- and west-facing walls and glazing helps avoid excessive heat from the sun in the morning and afternoon.



WINDOWS & GLAZING

Windows are largely responsible for a building's look and feel, as well as its energy efficiency. Wise choices on window size, location, and type make the difference between a comfortable building with excellent quality of light, and a building with glare problems and the tendency to overheat in the summer and feel drafty in the winter. Consider these three points:

1. The **amount of window surface area on each building facade**: More is not necessarily better. Large glass walls without exterior shading let in excess heat in summer and lose heat in winter. They require energy-intensive perimeter heating and cooling systems to make the space inside comfortable. Windows should be sized to provide daylighting without glare. SEDAC recommends limiting total glazing area to no more than 30% of the overall wall area.
2. The **placement of the windows with respect to the sun**. It is difficult to control glare and heat gain on the east and west, so limit glazing on those faces and use vertical shading on those windows. South-facing glazing with horizontal shading is great for passive solar heating, and for daylighting when light-shelves are used. North-facing glazing is perfect for daylighting, but must have increased insulation values to slow heat loss in winter.
3. The **technical qualities of the window** glass and frame. A good window has a low U-factor, is double- or triple-pane with thermally broken frames, and has coatings (like low-e) appropriate to the direction the window faces. Windows with argon fill have better thermal resistance.



Be careful with value engineering! Shading devices may be designed to compensate for the heat gain from large banks of windows, but later eliminated to cut up-front costs. If the windows themselves are not re-designed, the result is visual discomfort from glare and higher energy costs.

Many buildings have the problem of morning and afternoon glare; people must draw the blinds to see their work. When this happens, the benefits of the windows are lost: the view is gone and daylight is not available. Blinds don't stop heat from entering the building, however, so cooling costs remain.

When it comes to windows, a daylighting analysis and an energy analysis of the building envelope are highly worthwhile.

ENVELOPE COMMISSIONING

SEDAC strongly recommends ***commissioning*** your building's envelope. Envelope commissioning includes a detailed design document review. Thorough visual inspection is also necessary to check if the air barrier is properly installed and the right sealants and gaskets are provided in all locations. ***Air tightness testing*** is also recommended (using thermal imaging, isolated infiltration testing, and/or blower door testing) to identify areas of infiltration and confirm fixes after sealing work is completed.

Remember, uncontrolled air leakage adds dramatically to heating and cooling costs - up to 40%.[2] Assign a budget early in the design process for commissioning. It will pay off.

[2] Pollock. 2001. BETEC/DOE/ORNL Spring Symposium: Air Barrier Solutions.

FOUNDATIONS

The design of building foundations can be a source of hidden energy losses that are highly impractical, if not impossible, to fix after the building is built. The continuous line of insulation that extends into the wall system of your building should begin below ground. Make sure your architect minimizes thermal bridging at the intersection between the foundation and the walls.

WALLS

An air barrier, vapor barrier, and insulation must all be present in the right location and quantity regardless of the wall system chosen. Thermal bridging (see box at right) should be considered and avoided by careful detailing. It is commonly found where different construction materials intersect: around windows and doors and where the walls meet foundation and roof. Consider adding thermal mass to stabilize internal temperatures.

ROOFS

Roof assemblies are responsible for a large percentage of heat loss and gain in low-rise buildings. Roof design is improved by insulating above code-minimum levels and using a cool roof color. A typical dark-colored roof absorbs heat from the sun and drives air conditioning bills up. White or light roof colors are similar in cost and help keep your building and neighborhood cooler.

INSULATION

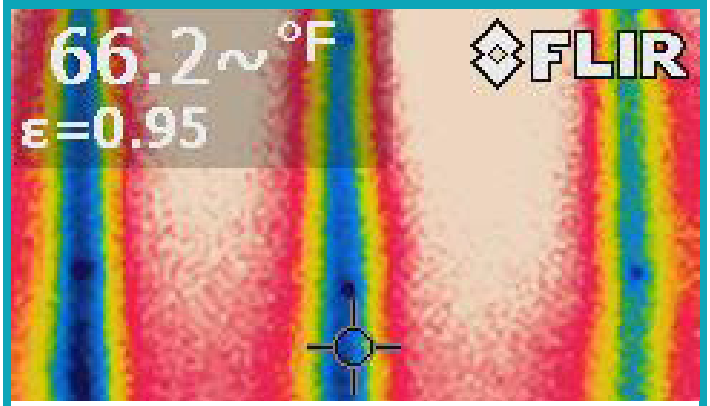
Energy codes require minimum levels of insulation. Exceeding code minimums makes buildings more efficient and comfortable. Continuous insulation (a layer of insulation unbroken by structural framing) is now required for walls and roofs and is a major improvement. A designer should be able to draw an unbroken line of insulation around the entire building envelope, leaving no hidden gaps to leak energy dollars.

AIR SEALING

Gaps around windows and doors, junctions between building materials, and utility and mechanical penetrations are areas where air can leak in and out of a building. Air leakage (known as ***air infiltration***) causes drafts and is a major source of discomfort. Infiltration can cause an uncontrolled ***stack effect***, which wastes large volumes of heated air in the winter. Attention to air barriers in design and air sealing during construction are simple but effective ways to stop infiltration. The newest version of the energy code (ASHRAE 90.1 - 2013) requires a continuous air barrier. Careful implementation during construction is a must!

DON'T LET THIS HAPPEN TO YOUR BUILDING:

THERMAL BRIDGING



Thermal bridging occurs when insulation is interrupted, and highly conductive materials like metal studs or concrete allow heat to move freely from one side of the wall to the other. This thermal image shows a common construction method of metal studs (blue) with insulation between studs (red), but with no continuous insulation. The result is thermal bridging every 16 inches, which results in heat loss and can contribute to moisture problems. Continuous insulation is the solution.

DON'T LET THIS HAPPEN TO YOUR BUILDING:

HIGH AIR INFILTRATION

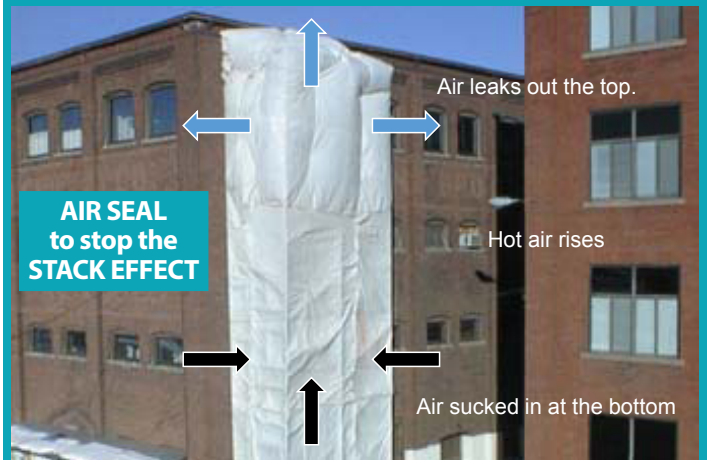


photo: David Keefe, Vermont Energy Investment Corporation

CHECKLIST FOR BUILDING OWNERS

Here are some basic points to talk about with your architects and contractors. Check on these items in design and ensure implementation in construction to decrease future maintenance and lower future energy costs in your building.

- ✓ **Siting, orientation, and massing** for good solar exposure
- ✓ **Glazing under 30%** of wall area - more on S side, less on E, W, & N
- ✓ **High quality windows** with thermally broken frames
- ✓ **Exceeding code minimum insulation requirements**
- ✓ **Continuous insulation** to stop thermal bridging
- ✓ **Air sealing** to stop air infiltration
- ✓ **Envelope commissioning** during design and construction

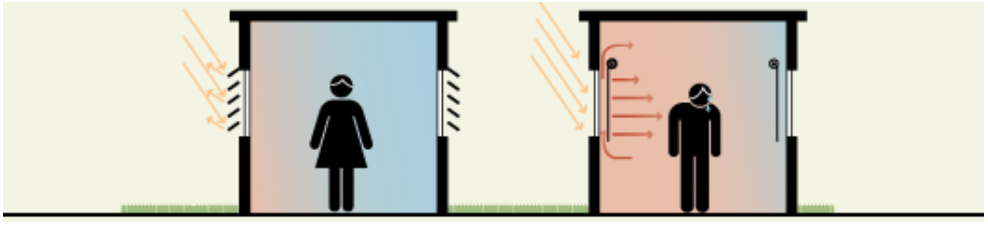
AVOID THESE COMMON PITFALLS

When designing a new building envelope, some common practices can undermine the energy efficiency of the final structure. Be aware of these pitfalls and make sure your architect and contractors take care to avoid them.

Lighting and HVAC consultants brought in too late in the design process
Design Development is *too late* for consultants to give valuable input to reduce the energy use of the building. Bring these consultants in during schematic design! Making an efficient building requires teamwork between all consultants early in the design process, with an explicit goal of energy efficiency.

Thermal bridging in design details
Thermal bridging is the hidden enemy of energy efficiency, and happens all the time in standard building design. An architect should be able to draw an unbroken line of insulation all the way around the building, with extra care taken at the junctions of different building materials.

Too much unshaded glass
The visual appeal of large glass walls from the outside is obvious, but the energy and comfort costs are steep. Glare, excessive heat gain in summer, and excessive heat loss in winter makes the spaces inside these unshaded glass walls very uncomfortable, and wasteful to heat and cool. Exterior shades are far more effective than interior blinds.



ENERGY SMART RESOURCES FOR NEW CONSTRUCTION

Visit the SEDAC New Construction Program website at NC.sedac.org

And for more resources and reading go to NCtips.sedac.org

SEDAC

WHO WE ARE

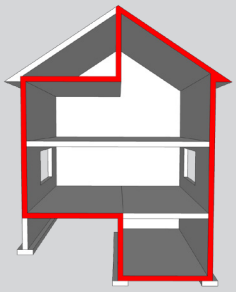
SEDAC is sponsored by the Illinois Department of Commerce and Economic Opportunity in partnership with investor-owned utilities to achieve energy efficiency savings in buildings throughout the State of Illinois.

SEDAC is an applied research program at the University of Illinois at Urbana-Champaign.

SEDAC works in collaboration with the 360 Energy Group.

SEDAC PROGRAMS

- Energy Assessment
- Public Sector Retro-Commissioning
- New Construction Design Assistance
- Public Sector New Construction Incentive Review
- Public Housing Efficient Living
- Training and Outreach
- Energy Incentive Guidance



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