Building Envelope

The envelope is determined by the physical, thermal and moisture boundary in a building.

In commercial buildings under 50,000 square feet, space heating, cooling and ventilation account for 40 percent of the total electric and natural gas usage.[1] Energy efficiency and conservation measures which impact the largest end uses will have the greatest impact on overall energy consumption and utility expenses. Improving the performance of the building envelope/enclosure will improve energy efficiency, comfort, indoor air quality and durability.

The building envelope serves as the physical, thermal and moisture boundary between the conditioned and unconditioned space and manages the transmission of air, heat and moisture. It is comprised of exterior walls, floors, fenestration, ceilings, roof assemblies, ducts and foundation walls. Improvements such as consistent air sealing and thorough insulation can significantly reduce HVAC loads and costs.

Building efficiencies can be improved in an existing building envelope through low-cost improvements as well as capital improvements.

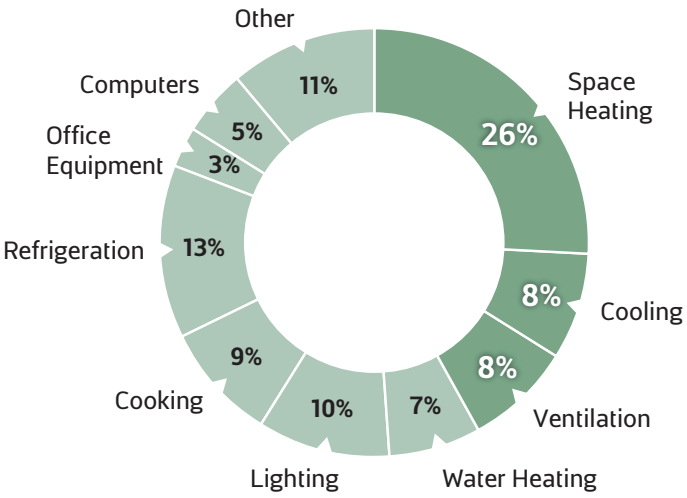


Figure 1: Small commercial energy consumption end use

Lower cost improvements

AIR SEALING

Leaked air flow between conditioned and unconditioned spaces can be a significant source of wasted energy. Sealing uncontrolled air pathways can prevent these losses in your building.

Seal Smaller Holes - Small holes and gaps can be easily sealed using caulk or 1-part spray foam.

- Wiring penetrations, including low voltage, cable TV and networking wires
- Lighting fixtures including recessed can lighting
- Plumbing penetrations such as water supply pipes, sprinkler pipes and waste lines
- Duct boot penetrations and exhaust ducts
- HVAC condensate lines
- Radon vent stacks
- Attic or basement access points such as pull-down stairs and knee wall doors can be sealed using weather stripping or prefabricated insulation tents or cover boxes
- Junctions between walls and ceilings and intersections of dissimilar or textured materials (e.g., corrugated roof decking)

Seal Larger Holes - Some holes are too large to be sufficiently sealed with caulk or 1-part spray foam. These larger pathways, often known as chases or bypasses, must be closed off using a sheet material such as plywood, gypsum board or sheet metal, together with caulk or spray foam:

- Chases containing ductwork such as dryer vents
- Chases around fireplace chimneys or combustion exhaust flues for water heaters and furnaces (use sheet metal and fire rated caulk)
- Chases containing plumbing
- Blocking at changes in ceiling height

SEALING AND INSULATING DUCTWORK

Leaks in ductwork, especially those located in unconditioned spaces, often cause the system to under-perform and the building pressure imbalances. Mastic may be used to seal leaky ducts and alleviate this problem. Additionally, make sure to insulate supply and return ducts to the R-value required by code to prevent energy losses throughout the ductwork.

SEALING WINDOWS AND DOORS

Leaky doors and windows separating conditioned space from outside can be a source of air infiltration and exfiltration. The following products help minimize air leakage and produce considerable energy savings:

- Replacement weather stripping, sealant compounds and low-expansion spray foam help ensure air barrier integrity around window panes and frames.
- Adhesive-backed foam strips, v-seals and gaskets reduce air flow around doors.

Higher cost improvements

RETROFIT ROOF INSULATION

Spray Foam Roofline

Attics can approach or exceed 130 degrees Fahrenheit on hot summer days, making them poor environments in which to house HVAC equipment and ductwork.[2] By insulating the roofline with continuous spray polyurethane foam (SPF), a building's attic and all of the ductwork and HVAC equipment contained within it is effectively brought inside the building thermal envelope where temperatures are much lower.[3] For attic spaces not containing ductwork or HVAC equipment, SPF application is not likely to be the most cost-effective strategy and the focus should be on air sealing and insulating the flat attic floor. SPF should only be applied if any combustion equipment in the attic space draws its combustion air from the outside.

Types of Spray Foam

- **Open-cell spray foam** is lower density foam and generally the most affordable spray foam option. Its structure is comprised mainly of air bubbles, making it light and airy. It is more vapor permeable than closed-cell, thus water from roof leaks can penetrate the insulation.
- **Closed-cell spray foam** is higher density foam and will be required in some northern climate zones due to its low vapor permeability. It is more expensive than open-cell foam due to its higher plastic-to-gas ratio which provides almost twice the insulating R-value per inch. An interesting benefit of closed-cell is that is adds structural strength to the assembly.

INSULATE ATTIC FLOORS

Insulating the attic floor reduces heat loss in the winter and heat gains in the summer while improving temperature evenness throughout the building. **Loose-fill insulation** provides very good floor coverage and may require special equipment or a professional to install. **Batt insulation** can be self installed and careful attention should be paid so that the floor space is continually insulated.

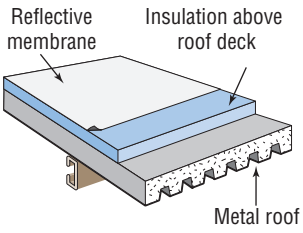
Preparing to Insulate

Before installing insulation be sure to make the following preparations:

- Air Sealing - Ensuring proper air sealing measures have been taken prior to installing insulation is critical. Refer to the *Air Sealing* section for details.
- Attic Venting - To maintain passive air flow through the attic space, soffit baffles and ridge, gable, or other high vents should be present to allow for the passage of air through the attic.
- Insulation Blocking - Installing insulation dams or blocking is necessary to prevent loose-fill insulation from spilling into attic ventilation pathways and ceilings with unconditioned spaces below (such as porches). Pathways between floors should also be blocked and air sealed. Blocking also helps to maintain uniformity of insulation depth.
- Consider an elevated catwalk/insulated raised pathway for future users to access areas of the attic. If no pathway exists, insulation coverage will likely be compromised.

Radiant Barriers for Added Efficiency

Radiant barriers are reflective, low-emitting materials that can be attached to the underside of roof rafters or decking to reduce the transmission of thermal radiation and help prevent excess heat gain in the attic space. Installing a radiant barrier in a vented attic can significantly reduce summer attic temperatures and could reduce your cooling costs, especially if you have mechanical equipment in your attic.



RE-ROOF COMPACT ROOF

If your building has a compact roof with an older membrane requiring replacement, adding additional layers of insulating board to the roof assembly and installing a white or reflective membrane will increase efficiency, comfort and durability.

RETROFIT EXTERIOR WALL INSULATION

Insulating exterior walls is important to maximizing HVAC efficiency and occupant comfort. It is important to thoroughly evaluate your building's current insulation level to see if the project will be worth the cost. It is often optimal to add insulation during a renovation or re-cladding project.

Insulating Wood-Framed Walls

If your commercial building has wooden studs inside the exterior walls, **dense-packed insulation** or **injection foam insulation** can be added to the existing cavities without complete removal of the drywall or cladding.

Insulating Metal-Framed Walls

Walls in commercial buildings are often framed with thermally conductive metal studs, which can transfer heat easily across the building envelope. This effect, known as *thermal bridging*, can significantly reduce effectiveness of cavity insulation.

Most building codes require continuous insulation for metal-framed buildings. However, if your building is over a certain age, continuous insulation may be missing. If this is the case, you may consider retrofitting with continuous thermal insulation. Although this option will be much more costly and challenging than installing cavity insulation, it will more effectively mitigate heat transfer in metal-framed buildings.

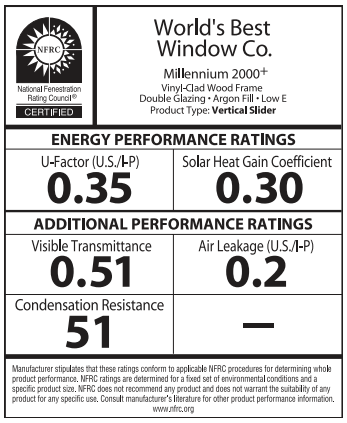
REPLACE WINDOWS

If your building has inefficient windows, especially metal-frame windows without a thermal break, replacement may be the most favorable option for improving energy efficiency. While this project has a longer payback period, high efficiency windows significantly lower the risk of condensation and improve comfort levels.

Selecting Windows

Several factors contribute to a window's level of performance. The National Fenestration Rating Council rates and labels windows for each of these properties using the following values:

- **U-Factor:** Indicates a window's resistance to heat flow from conduction. A lower U-factor translates to lower heat transfer and better insulation. The glass plus the frame assembly contribute to this performance. High efficiency, triple-paned windows can achieve a U-factor as low as 0.15.[4]
- **Solar Heat Gain Coefficient** (SHGC): Measures the amount of solar radiation transmitted through a window. SHGC is expressed as a number between 0 and 1 with lower numbers representing less transmittance of solar radiation.
- **Air Leakage** (AL): Measures the amount of air that passes through gaps in the window assembly. Low AL values represent tighter, more efficient windows.



Storm Windows

Attaching storm windows can considerably improve energy efficiency and comfort for about a quarter of the cost of a window replacement.[5]

Many storm windows are also coated with low-emissivity material to reduce radiative heating. Storm windows are a great option for historical renovations where existing windows cannot be replaced. Interior storms are an excellent option for historic buildings since they are nearly invisible once installed.

FOUNDATION INSULATION UPGRADES

The building foundation represents a possible opportunity for improving your building envelope. The appropriate strategy will depend on the type of foundation present. Consult with a building contractor to explore options available for your facility.

Crawlspace/Basement

Sealing and conditioning a building's crawlspace or basement effectively brings that space into the building envelope. This is advantageous when the current layout features plumbing or mechanical equipment present outside of the building envelope. Alternatively, the framed floor above the crawlspace or basement can be insulated with a continuous air and thermal barrier, but continuous insulation coverage and air barrier continuity are often problems with this approach.

REFERENCES AND RESOURCES:

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