

C. ENERGY-EFFICIENT BUILDING SHELL

1. General

- a. Because the building shell is typically responsible for 10%—20% of the total energy consumed in a building, focusing on this area of design is an important component of energy-efficient design. Increased insulation in the walls and ceiling helps to reduce heat loss and improve comfort. Light-colored exterior walls and roofs help to reduce cooling loads. These factors also contribute to reducing the size and cost of the HVAC system required. The useful life of building materials, systems, and equipment incorporated in buildings can vary considerably, so the building shell decisions the designer makes will impact the first cost of the building as well as the long-term costs associated with operation, maintenance, and replacement.
- b. Wall insulation should be selected based on the likelihood that it will never be replaced. When selecting wall and roof systems, it is critical that the designer choose what is best for the entire life of the facility. Consider specifying interior and exterior finishes that are durable and as maintenance free as possible, and integrate insulation levels that are appropriate for the life of the facility. Also, incorporate durable strategies that prevent air infiltration.

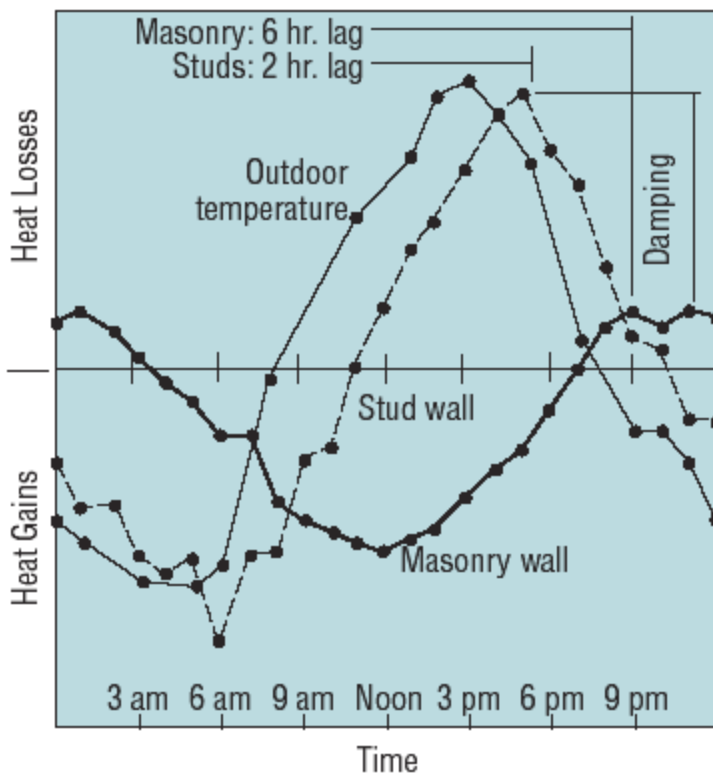
High-mass exterior walls, light colored roof finishes, and window treatments including lightshelves and low-glazing for view windows are among the energy-efficient building shell elements.



e

2. Massive Wall Construction

- a. High-mass construction techniques have been historically employed to moderate the heat gain experienced during the hot days, delaying the impact until nighttime when ventilation strategies can cool the interior spaces. If adequate mass is incorporated, these strategies are just as effective today, particularly since county facilities are typically not occupied during evening hours.
- b. Employing a high-mass wall construction technique, such as 16" brick-block and block-block cavity walls with rigid cavity insulation or adobe construction with insulation, thermal gains can be delayed by up to 12 hours.
- c. Newer wall systems using insulated concrete forms or tilt-up insulated concrete panels have also proven effective.



*Heat Gain Lags in High-Mass Walls
Using high-mass wall construction techniques can delay thermal gains by up to 12 hours.*

3. Moisture and Infiltration Strategies

- a. Controlling air flow and moisture penetration are critical elements in reducing energy consumption, maintaining structural integrity, and ensuring a healthy indoor environment.
- b. Air flow retarders should be installed on the exterior of the building, and building assemblies should protect the outside wall surface from getting wet. Any moisture should be allowed to drain away or dry towards the interior, using permeable interior wall finishes and avoiding wall coverings.
- c. Since air leakage can carry significant amounts of moisture into the building envelope, caulk and seal any building shell penetrations and tape the joints of insulating sheeting per the manufacturer's recommendation.

4. Insulation Strategies

- a. Evaluate the cost-effectiveness of varying insulation R-values to maximize long-term benefits.
- b. When selecting insulation levels, refer to ASHRAE Standard 90.1. R-values required by local building codes should be considered a minimum.
- c. When determining the choice of insulation, the designer should consider energy efficiency, initial cost, and long-term performance. Insulation products carefully considered for stability of R-value over time, and comparisons based on the average performance over the service life should be made.

5. Interior Finishes

- a. By properly selecting light-colored interior finishes, lighting energy demands can be reduced and visual comfort can be improved for no additional cost.
- b. Select light colors for interior walls and ceilings to increase light reflectance and reduce lighting and daylighting requirements.
- c. Consider the color and finish of interior finishes. Light colored, glossy finishes can create glare problems that negatively impact visual comfort.

Reflectance Table: Paints

Color	Reflectance
Gloss White	75%
Semi-gloss White	70%
Light Green*	53%
Kelly Green*	49%
Medium Blue*	49%
Medium Yellow*	47%
Medium Orange*	42%
Medium Green*	41%
Medium Red*	20%
Medium Brown*	16%
Dark Blue-Grey*	16%
Dark Brown*	12%

Reflectance Table: Woods

Type	Reflectance
Maple	54%
Poplar	52%
White Pine	51%
Red Pine	49%
Oregon Pine	38%
Birch	35%
Beech	26%
Oak	23%
Cherry	20%

* These values are estimated for flat paints. For gloss paints, add 5%–10%. Source: SBIC, Passive Solar Design Strategies
Careful consideration of interior finishes based on reflectance values can reduce lighting demands.

6. Stopping Radiant Heat Gains

- a. Creating a building shell that is massive and well insulated can effectively address conduction gains and losses, but it is critical to also consider radiant solar gains. In the warmer months, up to 90% of the cooling load coming from the roof area can be attributed to radiant heat gain. The designer should address this problem to decrease the cooling load significantly.
- b. Consider incorporating radiant barriers in the roof assemblies to reduce up to 95% of the radiant heat gain. When solar radiation strikes a roof, a certain percentage of radiation is reflected away and the balance is absorbed. When this occurs, it heats up that material and the material re-radiates downward. The low-emissivity properties of the aluminum in the radiant barrier stop this radiant process, allowing only 5% of the radiation to pass through. Radiant barriers that have coatings to protect against oxidation help ensure long-term performance. These types of radiant barriers are superior to reflective roofing strategies that tend to lose their reflective qualities over time. Dust accumulations on radiant barriers reduce their performance. When possible, they should be suspended from the joists or rafters to reduce dust accumulation.



Radiant Heat gain can be responsible for 90% of the heat entering through the roof. The use of a radiant barrier can block up to 95% of this gain.

- c. **To reflect solar gain away before it can create negative radiant impacts within the spaces below, incorporate highly reflective roofing systems. This strategy is important, particularly in areas where radiant barriers can not practically be installed.**
- d. **Consider selecting a light color for the exterior finish to reflect solar radiation.**
- e. **Consider shading exterior walls with architectural elements (or landscaping) to minimize the solar radiation that reaches the building shell.**

Reflectance Values for Exterior Surfaces

		% Reflected	% Absorbed
Roofing Material (1)			
Single-ply roof membrane	Black EPDM	6%	94%
	Gray EPDM	23%	77%
	White EPDM	69%	31%
Asphalt Shingles	Black	5%	95%
	Medium brown	12%	88%
	Green	19%	81%
	Grey	22%	78%
	White	25%	75%
Metal Roof	Aluminum	61%	39%
	Metal white	67%	33%
Exterior Wall Material (2)			
Brick	light buff	45%	55%
	dark buff	40%	60%
	dark red	30%	70%
Concrete	light	55%	45%
	medium	20%	80%
	dark	15%	85%

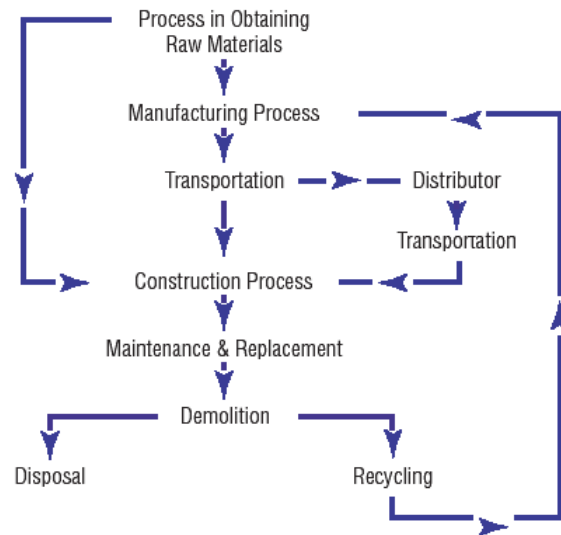
(1) Source: Berdahl 2000. "Cool Roofing Material Database," LBNL

(2) Source: 1981 IES Lighting Handbook

This chart indicates the reflectance of various typical roofing materials when first installed. Materials that maintain their reflective characteristics should be preferred.

7. Embodied Energy

a. When selecting building materials, consider that the amount of energy embodied in constructing the building typically exceeds two decades of energy consumption. To address the overall impacts of energy consumption, consider the energy involved in making each product, transporting the product to the site, and implementing the component into the building.



Total Embodied Energy Diagram
Products, materials, equipment, and processes incorporated into construction.

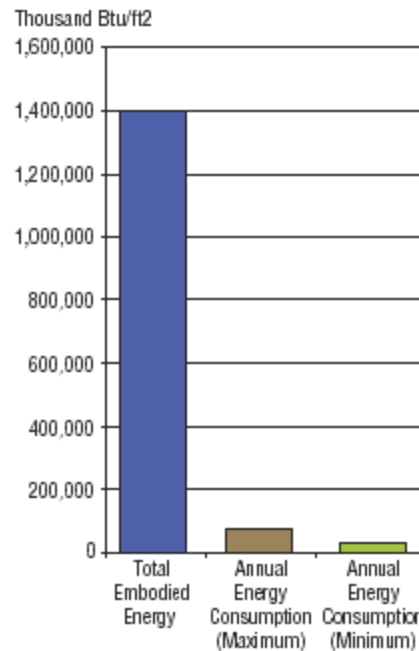
b. Because often half or more of the energy involved in constructing a building is related to transportation of materials, consider selecting locally made products and construction materials.

c. Consider the energy used in the manufacturing of materials and products incorporated in the building.

d. Consider the use of recycled products.

e. Evaluate the recyclability of construction materials once the building has passed its useful life.

f. If existing structures on the building site are to be demolished, consider how the typically wasted materials could be used in the new construction.



Total Embodied Energy per Square Foot for Educational Buildings

The embodied energy of a school building exceeds annual energy consumption of the school.