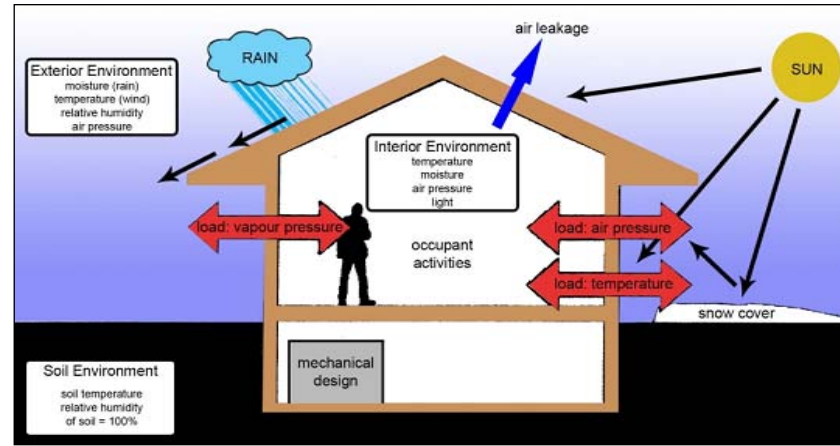
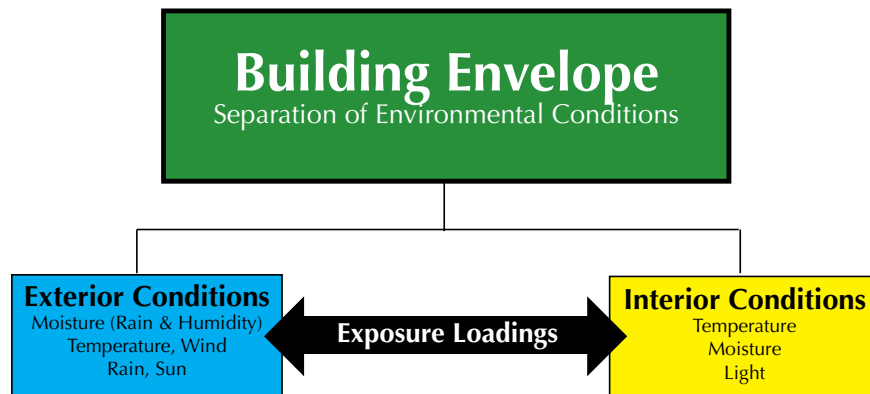


Environmental Separation



Residential High-Rise Envelope Failure – Steel Stud Corrosion



14.0 Building Envelope Design Principles

The primary role of the building envelope is to separate different environments, typically the interior from exterior, by managing the flow of air, moisture, and heat between them. The envelope must also consider the impact of architectural orientation and styles, as well as heating and venting strategies, owner's expectations, and future requirements. Successful envelope design harmonizes all of these needs, while looking for synergies in design.

In terms of sustainable or green design the envelope must perform its functions for the life of the building without excessive maintenance or renewals. In addition, the materials should be locally extracted or manufactured, resistant to degradation, recyclable/reusable, and balance lifecycle cost and embodied energy. Together these characteristics define Envelope Durability.

The goal outlined for SEFC project is a minimum 100-year building service life. Typically, residential buildings are designed for 50+ years in Vancouver. To design for a 100-year building, the envelope will need to meet both today's and tomorrow's performance and energy demands. The envelope will require future-proofing. This means current residential design practices may not be appropriate. Building materials should be chosen for their initial and future performance, ease of disassembly, low maintenance and eventual reuse or recycling. Insulation should be appropriately placed for highest effective values (i.e., minimized thermal bridges), and allow increases in thickness or easy removal and replacement, as material's R-values improve.

The building envelope failures that have plagued Vancouver's condominium market since the early 1990's illustrate the importance of proper building envelope design and commissioning. The cost for repetitive maintenance, repairs, premature replacement, health effects and occupant disruption has escalated to multibillion-dollar levels. The repairs result in increased embodied energy, which over the expected lifetime of the building will far outweigh that of the originally constructed building. The envelope has obvious impacts on the sustainability of buildings.

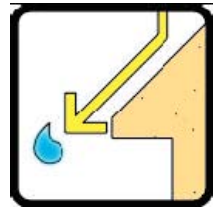
This section outlines the principles of envelope design for the SEFC project.

14.1 Moisture Control Mechanisms

In Vancouver, rain penetration control is the most critical moisture management function. It is being addressed as a priority for all buildings. Other moisture control functions such as control of condensation, vapour flow (humidity), air flow and heat transfer also need to be addressed. A balance between wetting and drying mechanisms is required. Walls get wet and need to drain or dry.

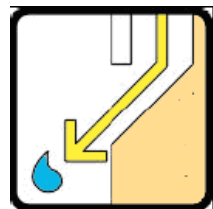
The principles of moisture management are commonly defined as the 4 D's of cladding design.

These include:



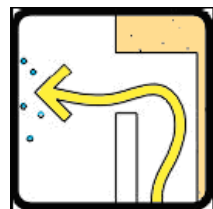
1. Deflection: Rain should be deflected or shed such that wall wetting is minimized. There are several design synergies that can be achieved with;

- Architectural design – orientating buildings and varying heights to limit exposure.
- Mechanical strategies - limiting solar gain through glazing assemblies.
- Landscaping shading design - protecting the envelope from wind blown rain, solar gain and thermal fluctuations (including green roof and green walls).

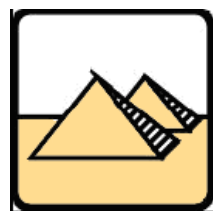


2. Drainage: All walls should incorporate a drained cavity behind the cladding. Where water penetrates past the cladding it can be drained to the exterior via flashings or similar means.

Water storage and reuse synergies are available to capture and reuse draining water for landscaping and toilet flushing..



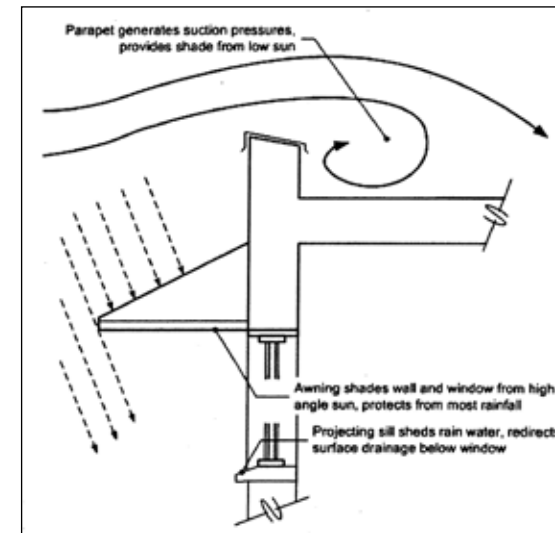
3. Drying: Where moisture is absorbed into the wall it must be safely stored until it can dry to the exterior. The drying time should be as short as possible and must not exceed the safe storage time. Design and materials must facilitate diffusion and evaporation of moisture out of an assembly. The cavity incorporated for drainage and drying can also provide a method for pressure equalization across the cladding, further reducing moisture ingress potential.



4. Durability: Initially the durability of the material must meet their safe storage requirements. Additionally, the assembly or components must perform its intended function(s) in its service environment over a period of time without excessive maintenance, repair or renewal. Materials and assemblies need to be selected based on; building's moisture management system, service life, lifecycle cost, availability, trade experience, and embodied energy.out maintenance, repair or renewal.

Protection from Rain (Deflection)

There are many current design methodologies employed in Vancouver's residential market to provide rain protection from the building envelope, these include:



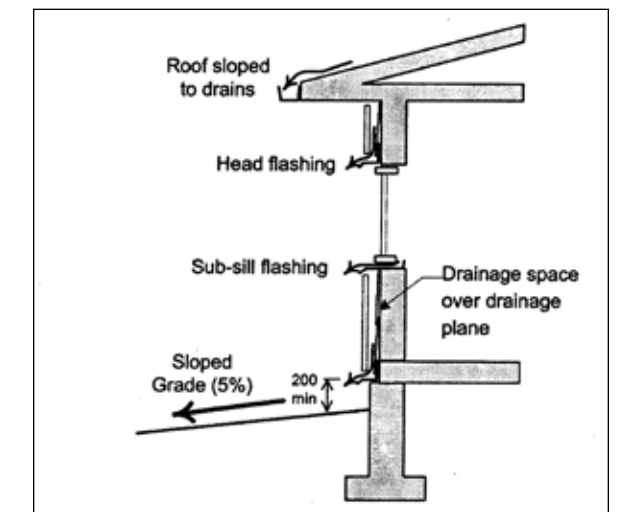
Roof Overhangs and Canopies



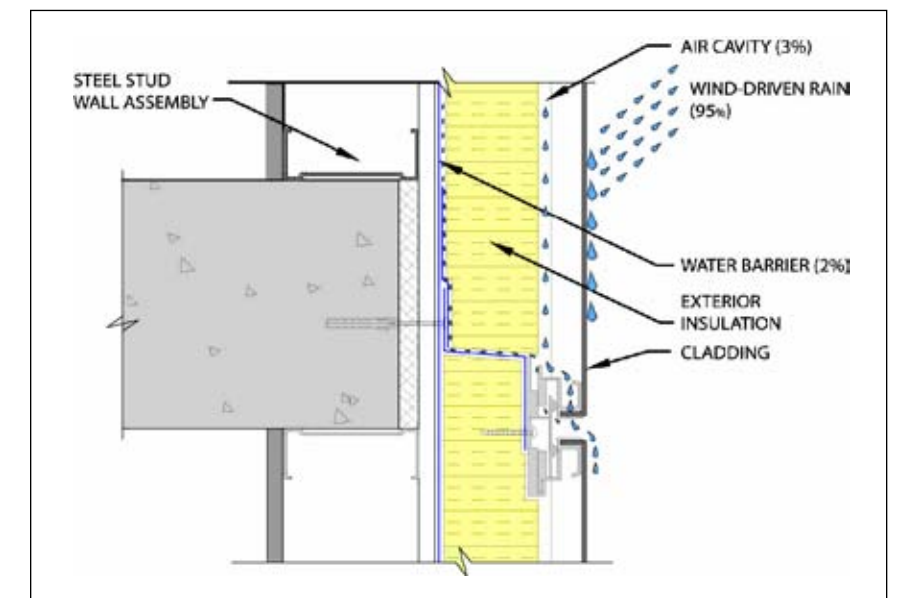
Slab Projections, Eyebrows and Balconies

Drainage and Drying (Rainscreen Principles)

Wall and window assemblies that utilize rainscreen principles, generally incorporate two lines of defense against moisture penetration. Rainscreen is a design strategy whereby a secondary drainage plane is created immediately inboard of the exterior cladding material and outboard of the moisture barrier. The cavity must be of sufficient size, in width, to break the surface tension of water, and allow incidental water entering the cavity to drain by gravity, and exit with the aid of flashings. This type of construction is required in Vancouver Building By-Law. The following illustrates examples of building and wall rainscreen principles.



Typical Rain screen Wall

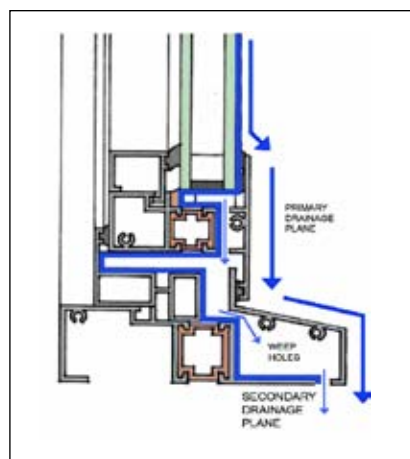


Typical Exterior Insulated Rainscreen Wall Assembly

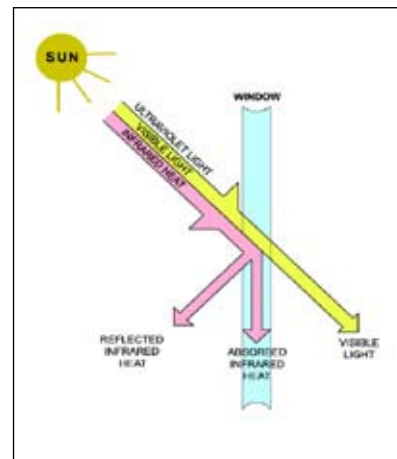
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Windows are typically the weakest link in a wall assembly, but essential for sales, views, connection to the exterior and mechanical strategies. Windows must be carefully selected, sized and designed to meet the project needs, performance objectives and durability requirements. The materials and components need to resist the environmental agents, such as rain, wind and sun, while maintaining aesthetic appearances and allowing future replacement. The following outlines some of the performance criteria used to select windows for the SEFC project.



Typical Rainscreen Window Assembly



Energy Flow Through a Window

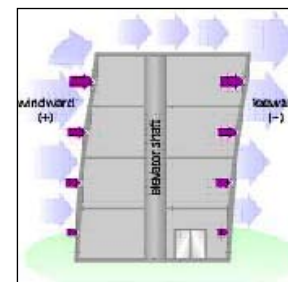
14.2 Air Leakage Control

Air leakage control is critical to thermal comfort, condensation resistance and heat loss. It requires a continuous and supported plane in the exterior wall assemblies, which integrates the air barriers in other assemblies, such as windows, doors, roof assemblies, and foundation walls.

When designing an effective air barrier the following elements need to be considered:

- Continuity
- Structural support (both sides)
- Impermeability to air flow
- Durability
- Constructability / Quality assurance

Air pressure differentials can be applied to a building by wind, mechanical pressurization, or stack effect (commonly called “chimney effect”). The ventilation strategies, especially natural ventilation, needs to consider the type and properties of the air barrier.



14.3 Thermal Loss Control

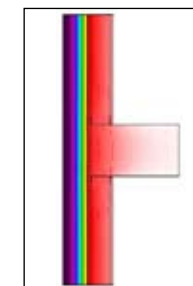
Thermal performance is typically evaluated by determining the U-values for wall, roof, windows, etc. U-values are commonly determined by the thickness and effectiveness of the insulation. Insulation resists the passage of heat by trapping air molecules within the material. Unfortunately, not all insulation is created equal. Manufacturers will provide theoretical values, but they can be greatly reduced by installation methods.

From a mechanical perspective, the primary purpose of insulation is to provide interior thermal comfort by reducing heat loss from the building and minimize energy consumption. From a building science perspective, the placement and secondary properties (air or vapour barrier) of the insulation within the wall assembly plays an important role in controlling moisture problems. Insulation must be placed such that it minimizes potential condensation planes within a wall, roof or foundation assembly. Computer models, such as THERM, can be used to evaluate potential condensation planes by determining dew point temperatures within the assemblies (refer to adjacent illustrations, showing temperature changes through a window or wall – refer specifically to the blue line). The models can also be used to determine potential thermal bridge locations. Thermal bridging is caused by a conductive material bypassing the insulation plane. Thermal bridging can cause thermal loss, condensation and material degradation.

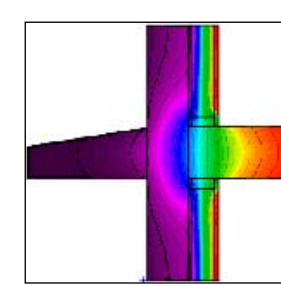
Wall Assembly Selection Considerations

Wall assemblies are typically chosen on the type of cladding material and back-up wall (combustible / non-combustible and structural / non-structural in-fill). In some cases, the cladding is the structural element (e.g., cast in-place concrete and mass masonry), simplifying some aspects, but adding others (thermal bridges, no drainage cavity). The cladding material type will dictate the attachment method, and play a role in back-up wall selection, due to requirements for transferring structural and wind loads. Once the structural elements are considered, the air, vapour, moisture and thermal barriers need to be positioned. The positioning of the air, vapour, moisture and thermal barriers is critical, to ensure proper performance of the wall assembly. Although each element needs to be considered separately, many materials can perform one or all of the requirements (e.g., Polyurethane spray foam). The material selection for each element also requires consideration to fastening methods, thermal bridges, moisture tolerance, sequencing and cladding attachment. In an integrated design process, all the above is conducted with the various parties involved to build on synergies and minimize contradicting elements.

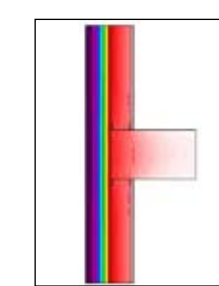
For non-combustible wall assemblies, steel or concrete structures, thermal bridges are a huge issue for energy loss. To address thermal bridging, best practice envelope design promotes placing all of the assembly’s insulation outboard of the structure or back-up wall. This provides the least risk for condensation and best effective thermal performance; but there is typically an increase in the initial assembly cost, compared to conventional assemblies. To offset the additional wall thickness, the City of Vancouver’s Floor Space Ratio exclusion bulletin can be used to exclude an additional 150mm for increased durability. Exterior insulating will also be required for future-proofing and complying with the LEED Canada EA prerequisite 2, a 25% energy reduction relative to the MNECB.



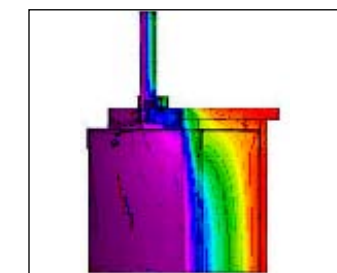
Interior Insulated Wall



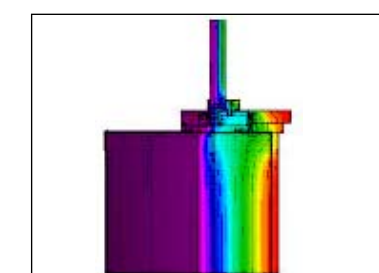
Interior Insulated Wall with Slab Projection



Exterior Insulated Wall



Window Exterior of Insulation



Window aligned with Insulation

14.4 Building and Material Durability

To properly assess building durability, a combined evaluation of the building assemblies on the macro (e.g., windows, cladding, roofing, mechanical equipment, plumbing, etc.) and micro (e.g., fasteners, caulking, flashing, fire separations, etc.) level is required. This is commonly done during the design phase by evaluating the building function and design service life, building exposure, and the service life of each component within an assembly. The CSA Standard S478-95 (R2001) Guideline on Durability in Buildings is the recommended tool for LEED Canada, Material and Resources, Credit 8. Lifecycle assessment, although not covered in LEED or similar green building tools, can provide valuable information for decision-making. Tools, such as BEES and Athena, can be used to assess embodied energy and other environmental indicators.

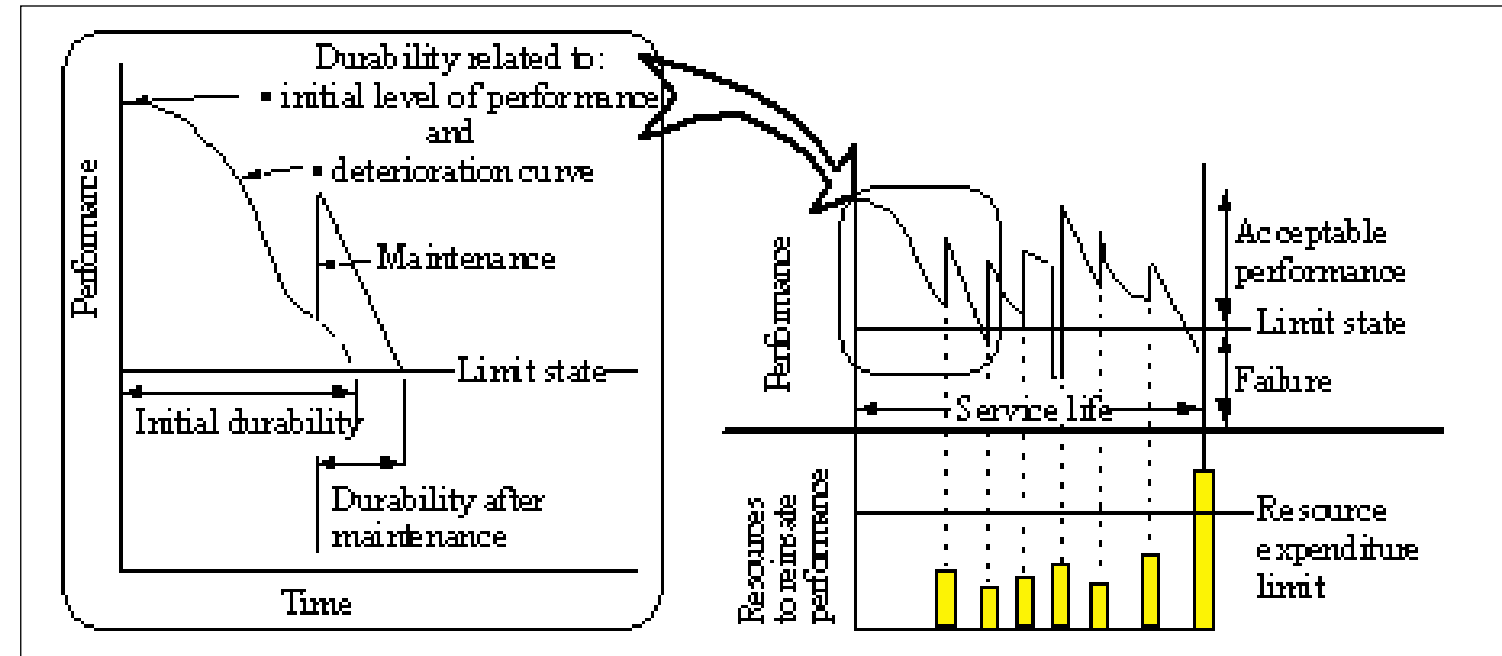
Although there are many ways to evaluate building durability, it is most often evaluated on the material level by comparing initial cost versus reoccurring maintenance and renewal costs – commonly called Lifecycle Cost analysis. As illustrated by the following chart, an increase in initial performance or durability can result in long-term cost savings on maintenance and renewals

Building commissioning is another key area of building durability. A building cannot be considered durable based on material selection and design alone. Proper field review, mock-ups and performance testing is required to ensure materials serve their intended functions.

Material Selection and Sustainability

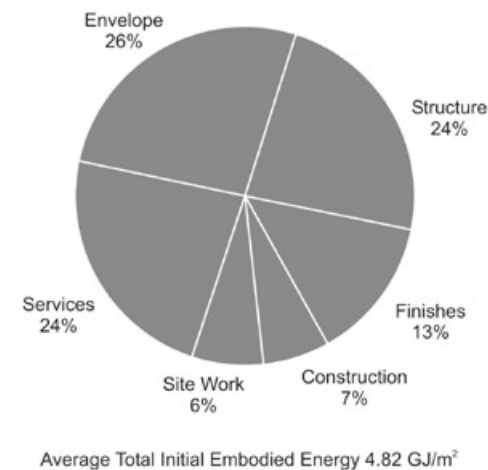
In terms of sustainability, materials need to be carefully selected to minimize the impact on the environment today and in the future. However, the materials need to meet the durability requirements above all. Considerations need to be given to the following:

- Travel Method and Distance – The distance materials must travel from excavation, manufacturing, assembly and final installation can cause significant impact to the environment. The method of travel is also significant, and LEED Canada differentiates the impact of travel by ship, rail and truck. Ideally, the majority of the materials used for this project will be sourced within the Lower Mainland of British Columbia.
- Reuse Materials - Reusing existing materials and designing for future re-use of material will decrease resource depletion.
- Recycled versus Virgin – Materials should be selected on their percentage of recycled material (post-consumer/post-industrial) to minimize the use of solely virgin materials.



Loss of Performance (Deterioration) Over Time – Effects of Maintenance and Renewals

- Adaptability, flexibility and ease of disassembly – Materials need to be adaptable and flexible for future occupant uses, and easy to dismantle for reuse.
- Embodied Energy – This commonly referred to as the amount of energy consumed in the extraction, manufacture, transport, construction and assembly on site of building materials, including the energy costs of disposal of waste or surplus materials. As illustrated below in the pie chart, envelope materials can be the majority of the initial building embodied energy. The adjacent table outlines the embodied energy of some typical construction materials. Embodied Energy is an excellent indicator for material selection.



MATERIAL	EMBODIED ENERGY	
	MJ/kg	MJ/m ³
Aggregate	0.10	150
Straw bale	0.24	31
Soil-cement	0.42	819
Stone (local)	0.79	2030
Concrete block	0.94	2350
Concrete (30 Mpa)	1.3	3180
Concrete precast	2.0	2780
Lumber	2.5	1380
Brick	2.5	5170
Cellulose insulation	3.3	112
Gypsum wallboard	6.1	5890
Particle board	8.0	4400
Aluminum (recycled)	8.1	21870
Steel (recycled)	8.9	37210
Shingles (asphalt)	9.0	4930
Plywood	10.4	5720
Mineral wool insulation	14.6	139
Glass	15.9	37550
Fiberglass insulation	30.3	970
Steel	32.0	251200
Zinc	51.0	371280
Brass	62.0	519560
PVC	70.0	93620
Copper	70.6	631164
Paint	93.3	117500
Linoleum	116	150930
Polystyrene Insulation	117	3770
Carpet (synthetic)	148	84900
Aluminum	227	515700

NOTE: Embodied energy values based on several international sources - local values may vary.