

BEYOND

SMART CITIES

MATERIALS & RESOURCES - GREEN BUILDING

TECHNOLOGY TRAINING PROGRAM

FOR GREEN BUILDING AND SUSTAINABILITY SPECIALISTS

KRISHNAJI PAWAR, LEED AP BD+C, GSAS CGP, ISO 14001:2015, GCP

GREEN BUILDING SPECIALIST CURRICULUM

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BUILDING LIFE-CYCLE IMPACT REDUCTION - CREDIT

FOR GREEN BUILDING AND SUSTAINABILITY SPECIALIST

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LEARNING OBJECTIVES



Intent of Building Life-Cycle Impact Reduction - Credit

Behind the Intent

Step by Step Guidance

Requirements

Required Documentation

Connection to Ongoing Performance

Terms and Definitions

MR- CR(5) - CONSTRUCTION

INTENT

To encourage adaptive reuse and optimize the environmental performance of products and materials.

POTENTIAL TECHNOLOGIES & STRATEGIES

Over their lifetimes, buildings have local, regional, and global environmental effects. Some occur during the harvest, extraction, manufacture, and transportation of materials; others involve construction and operations; and others take place at demolition and disposal. A life-cycle assessment (LCA) examines as many of these environmental effects as possible. This credit identifies several strategies for reducing harm done to the environment over a building's entire life cycle: restoring existing buildings, reusing building components, and reducing a building's environmental footprint through LCA.

BUILDING LIFE-CYCLE IMPACT REDUCTION

REQUIREMENTS

Demonstrate reduced environmental effects during initial project decision-making by reusing existing building resources or demonstrating a reduction in materials use through life-cycle assessment. Achieve one of the following options.
Option 1. Building and Material Reuse (1-5 points BD+C, 2-6 points Core and Shell)
Option 2. Whole-Building Life-Cycle Assessment (1-4 points)

IMPLEMENTATION

REQUIRED DOCUMENTATION

Requirement	Option 1	Option 2	Option 3	Option 4
Documentation of historic designation status	X			
Historic building designation (if any)	X			
Documentation of new addition and alterations (if any) that have been approved	X			
Historic building designation or registration	X			
Reused elements from existing buildings	X	X		
Documentation of LCA quantifying costs and environmental impacts from cradle-to-grave and end-of-life				X
LCA credit must document primary energy usage, greenhouse gas emissions, and other environmental impacts from cradle-to-grave and end-of-life				X

BEHIND THE INTENT

Over their lifetimes, buildings have local, regional, and global environmental effects. Some occur during the harvest, extraction, manufacture, and transportation of materials; others involve construction and operations; still others take place at demolition and disposal. A life-cycle assessment (LCA) examines as many of these environmental effects as possible. This credit identifies several strategies for reducing harm done to the environment over a building's entire life cycle: restoring existing buildings, reusing building components, and reducing a building's environmental footprint through LCA.

Restoring existing buildings, preserving historic structures, and rehabilitating blighted buildings reduce the energy use and waste associated with demolition and construction. A report by the National Trust for Historic Preservation, titled *The Greenest Building: Quantifying the Environmental Value of Building Reuse*, found that building reuse almost always offers environmental savings over demolition and new construction. A new, energy-efficient building will not compensate for the climate change effects of its construction for at best 10 years and perhaps 50 years. Restoring existing buildings preserves a site's historical, cultural, and aesthetic values, and reusing or repurposing wood, brick, steel, stone, or other materials from off site can be a cost-effective and sustainable strategy.

For new construction projects, a cradle-to-grave LCA enables building professionals to understand the cumulative energy use and other environmental consequences resulting from all phases of the building's life. A comprehensive, quantitative analysis helps determine which materials best fit the project's needs throughout the building's lifetime. Employed as a design tool, LCA may reduce the amount of materials used ("dematerialization"), which in turn reduces environmental harm and saves money. And LCA also allows the design team to understand the trade-offs of material selection and energy performance and find an appropriate balance between the two. For example, high thermal mass can reduce a building's peak energy demands; an LCA can quantify the environmental damage associated with the additional materials used so that the team can compare these effects with the benefits for energy performance and then make more informed design decisions. By looking at how materials interact within the whole structure and enclosure rather than merely individually, it is possible to gain a larger perspective and reduce overall environmental effects over the long term.

The whole-building LCA option takes into account a wide range of such effects. These include global warming potential, atmospheric ozone depletion, acidification of land and water sources, eutrophication, formation of tropospheric ozone, and depletion of nonrenewable energy sources. These are only some of the most common, measurable, and well-understood environmental impacts that LCA tools evaluate. Current LCA tools cannot accurately measure human health, ecological, and land-use issues; however, these effects are also important to a life-cycle approach to materials and are addressed under other Materials and Resources credits.

STEP-BY-STEP GUIDANCE

Select the appropriate option for the project (see *Further Explanation, Project Type Variations*). ➡

- Options 1, 2, and 3 are for projects that will reuse all or part of an existing building.
- Option 4 is for entirely new buildings but can also be used by projects that are new additions to existing buildings; it involves conducting a life-cycle assessment for the whole building.

Option 1. Historic Building Reuse

STEP 1. DETERMINE WHETHER BUILDING HAS OR IS ELIGIBLE FOR HISTORIC DESIGNATION

Search national, state, and local historic registers to determine whether the existing building has historic designation or is within a historic district.

STEP-BY-STEP GUIDANCE +

- If the building does not have historic designation, it may be considered eligible if it meets one of the four National Register criteria or meets state or local historic criteria. The U.S. National Register of Historic Places defines a building as historic if it meets at least one of the following criteria:
 - It is associated with events that have made a significant contribution to the broad patterns of our history.
 - It is associated with the lives of significant persons in the past.
 - It embodies the distinctive characteristics of a type, period, or method of construction; represents the work of a master; possesses high artistic value; or represents a significant and distinguishable entity whose components may lack individual distinction.
 - It has yielded, or may be likely to yield, information important in history or prehistory.
- Projects outside the U.S. should consult the historic preservation guidelines set both in the local or national register of historic places (see Further Explanation, Measurement Two).

STEP 2. REUSE HISTORIC BUILDING

- If the building has or is eligible for historic status, confirm the specific requirements for maintaining that designation during design and construction. Confirm what parts of the building can and cannot be altered to maintain its historic status and ensure that the design and construction uphold these requirements.
- This option does not have a threshold for credit compliance. There is no minimum area of the building that must be reused to meet the requirement. However, if its historic designation or eligibility is revoked because of demolition or alteration, the project is no longer eligible for this option.
 - Demolition of any part of the historic structure must be reviewed by the appropriate review board or commission to local standards for rehabilitation (U.S. projects must adhere to the secretary of the interior's Standards for the Treatment of Historic Properties).
 - If historic designation is required, project teams may pursue Option 3 Building and Material Reuse for the partial reuse of buildings.
 - If there is no local review board in place, include on the project team a qualified professional to guide historically sensitive design and construction decisions.

Option 2. Renovation of Abandoned or Blighted Building

STEP 1. DETERMINE WHETHER BUILDING IS ABANDONED OR BLIGHTED

Determine whether the jurisdiction in which the project is located has a program or designation for abandoned or blighted buildings and whether the building meets this definition. If no such program or definition exists, use the LEED definition for abandoned or blighted property to determine whether the project is eligible for this option.

STEP 2. DETERMINE REUSABLE AREA

Identify and quantify the surface areas of the structure and building enclosure that can and cannot be retained. Areas of the structure and building enclosure that are structurally unsound and must be demolished, as determined by a structural engineer, can be excluded from the calculation in Step 3.

STEP 3. CALCULATE PERCENTAGE OF REUSED AREA

- If more than 20% of the building's surface area is considered unsound and must be demolished, the project is ineligible for this option but may pursue Option 3 Building and Material Reuse.
- Calculate the percentage of the total surface area that will be reused (see Further Explanation, Calculations, and Table 2).
- Ensure that the reusable areas are clearly defined and incorporated into the design and construction of the project.

STEP-BY-STEP GUIDANCE +

TABLE 2. Calculating reuse for abandoned or blighted buildings

Structure or enclosure element	Existing area (sq')	Reused area (sq')	Percentage reused
On-grade floor assembly			
Foundation, slab or grade	200	200	100%
Curbside	3000	2000	66.7%
Impervious flooring	3000	1000	33.3%
2nd-floor assembly			
Structure area	200	1000	50%
Impervious flooring	3000	2000	66.7%
Ceiling line	200	1000	50%
Roof area			
Reclaimed area	165	165	100%
Roof deck (structurally unsound and removed)	80	-	-
Asbestos ceiling tile (chemically altered and removed)	165	-	-
Top-floor wall assemblies (including windows)			
Brick enclosure	100	100	100%
Aluminum	100	100	100%
Concrete	100	0	0%
2nd-floor wall assemblies (including windows)			
Brick enclosure	100	100	100%
Aluminum	100	100	100%
Concrete	100	0	0%
TOTAL	20,000	18,100	90.5%

Option 3. Building and Material Reuse

STEP 1. CALCULATE EXISTING BUILDING SURFACE AREA AND REUSE EXISTING BUILDING

- Identify and quantify the surface areas of the structure, building enclosure, and interior elements (e.g., walls, doors, floor coverings, and ceiling systems) that can and cannot be retained.
- Exclude from the calculation any hazardous materials that are remediated as part of the project.
 - Once the scope of reuse is determined, ensure that the areas intended for reuse are well defined and incorporated into the design and construction.

STEP-BY-STEP GUIDANCE +

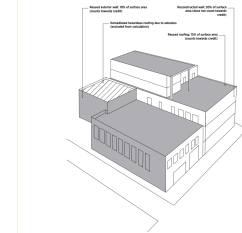


Figure 1. Existing building footprint and new building footprint

STEP 2. REUSE OFF-SITE MATERIALS

Off-site products and materials used in the project may be included in the credit calculations but may not be double-counted for MR Credit Building Product Disclosure and Optimization—Sourcing of Raw Materials, Option 2.

- Any reused product or material may be included in either this credit or MR Credit Building Product Disclosure and Optimization—Sourcing of Raw Materials, Option 2.
- Teams pursuing both credits may count their materials in either credit, whichever is more appropriate for their projects.
- For this credit, building and material reuse is measured in surface area. In MR Credit Building Product Disclosure and Optimization—Sourcing of Raw Materials reuse is measured by cost or replacement value.

STEP 3. CALCULATE REUSE

Calculate the percentage of total area that will be reused (see Further Explanation, Calculations, and Table 2).

STEP-BY-STEP GUIDANCE +

TABLE 3. Calculating reuse for existing buildings and materials			
Structure, enclosure, or material element	Building area (m ²)	Reused area (m ²)	Percentage reused
On-grade floor assembly			
Foundation, slab on grade	18,220	18,220	100.0%
Subfloor	17,000	9,000	53.1%
Carpet	16,000	0	0.0%
2nd-floor assembly			
Structural deck	18,220	18,220	100.0%
Insulated flooring	18,000	2,950	16.4%
Concrete reinforcing form work	2,000	1,000	50.0%
Celling tiles	14,100	1,000	7.1%
Roof assembly			
Roof deck	8,000	1,620	20.3%
Asph/Flt shingles (the "heaviest material removed")	-	-	-
3rd-floor wall assembly (including window)			
Brick enclosure	9,400	9,400	100.0%
Shelving	9,000	8,400	93.3%
Insulation	1700	0	0.0%
Window doors (from old site)	700	68	9.7%
2nd-floor wall assembly (including window)			
Brick enclosure	9,400	8,000	85.1%
Steel structure	9,400	9,400	100.0%
Insulation	1,300	0	0.0%
TOTAL	201,440	142,915	70.9%

Option 4. Whole-Building Life-Cycle Assessment

This option has only one threshold. To achieve this option the proposed building must demonstrate at least a 10% reduction in global warming potential and a 10% reduction of two of the other impact measures (detailed below) when compared to a baseline building, without increasing any other impact by more than 5%.

STEP 1. CALCULATE EXISTING BUILDING SURFACE AREA AND REUSE EXISTING BUILDING

Recognize that the scope of the analysis is a make-or-buy assessment, which includes environmental impacts associated with all the life-cycle stages for the building structure and enclosure resources: extraction or harvest, building product manufacture, on-site construction, product maintenance and replacement (where warranted), and deconstruction or demolition and disposal over the assumed 60-year service life. The LCA must address the following:

Products. The LCA must cover the complete building envelope and structural elements, including the material components of footings and foundations, structural wall assembly (from ceiling to interior finish), structural floors and ceilings (not including finishes), and roof assemblies.

STEP-BY-STEP GUIDANCE +

- Exclude electrical and mechanical equipment and controls, plumbing fixtures, fire detection and alarm system fixtures, elevators, and conveying systems.
- Exclude elevators and other site developments.
- Include parking structures, exclude parking lots.
- Additional building elements, such as interior structural walls or finishes, may be included at the discretion of the project team but were not additional credit.

Functional equivalence. The proposed and baseline buildings have to serve the same function and must have the same gross floor area, orientation, and operational energy usage.

Service life. For LEED, the project team must take into account the entire building structure and enclosure from design to demolition for an assumed 60-year service life. The assumed service life must be the same for the baseline and proposed buildings and must be at least 60 years to properly account for material maintenance and replacement (see Further Explanation, Product Replacement).

System boundary. The system boundary of the analysis must be defined to account for credit to green environmental impacts associated with all the life-cycle stages for the building structure and enclosure as defined in ISO 25900 sections A1 thru A4, B1 thru B7 and C1 thru C4.

Any parameters not defined above may change across the baseline and proposed buildings to achieve design intent and performance goals.

STEP 2. SELECT APPROPRIATE TOOLS AND DATA SETS FOR LCA ASSESSMENT

Review existing LCA tools and data sets and select the most suitable for the project (see Further Explanation, LCA Tools Selection). The choice of tool will determine whether an LCA specialist is required.

The same LCA software or tool and ISO 16044-compliant data sets must be used to study both the baseline building and the proposed building. Data set selection may be determined by the tool being used and the relevant data sets for the project location (see Further Explanation, LCA Input Measures or Indicators).

Ensure that the selected tool can be applied at the whole-building level and produce results for the relevant indicators.

STEP 3. CREATE AND MODEL BASELINE BUILDING

Create the baseline building with which the team will compare alternatives early in the design process, once programmatic and size needs have been determined. Input the baseline building into the selected LCA tool (see Further Explanation, Creating the Baseline Building).

STEP 4. SELECT RELEVANT IMPACT MEASUREMENT SYSTEMS

Select the appropriate output units for each LCA impact indicator shown in Table 4 (see Further Explanation, Life Cycle Impact Measures Or Indicators).

TABLE 4. LCA Impact Indicator units			
LCA Impact Indicators	TRACI 2.1	CML 2002	ReCiPe
Global warming potential	CO ₂ e	CO ₂ e	CO ₂ e
Ozone depletion potential	CFC-R eq	CFC-R eq	CFC-R eq
Acidification potential (acid)	SO ₂ e	SO ₂ e	SO ₂ e
Ecological potential (fresh water)	R ₂ O ₇ /e	R ₂ O ₇ /e	P _{eq}
Formation of tropospheric ozone photochemical oxidant equivalent	C ₂ H ₄ /e	C ₂ H ₄ /e	kg NMOC
Depletion of nonrenewable energy resources	HV	Weight or volume of raw material	kg of oil

STEP 5. USE LCA TO MAKE DESIGN DECISIONS THAT REDUCE ENVIRONMENTAL IMPACTS

Use the proposed LCA model to conduct "what if" scenario analyses and support design decisions to evaluate and select environmentally preferable assemblies and materials. Examples of alternatives analyses could include the following:

- Comparing the environmental consequences of building footprint and shape
- Evaluating different structural system types, such as load-bearing walls versus columns
- Defining the selection of building products and assemblies
- Optimizing structural system design (e.g., column spacing, slab depth)

If the design team wants to use a material, product, or assembly that is not in the selected LCA tool's data set, the results of a critically reviewed LCA or a verified environmental product declaration (EPD) can be used, provided the results cover the required full set of impact indicators for that component. The material, product, or assembly in the model must then be removed and the impact measures for the replacement added as a side calculation, taking account of all related ancillary product use. Any such additions must be documented and the documentation included in the submittal; include the rationale for the change and the source of the replacement impact measures.

STEP 6. INCORPORATE FINAL LCA RESULTS

Review the results, incorporate decisions in design documents, and prepare a narrative that describes the LCA assumptions, scope, and baseline and proposed buildings (see Further Explanation, Developing an LCA Narrative).

REQUIREMENTS

Demonstrate reduced environmental effects during initial project decision-making by reusing existing building resources or demonstrating a reduction in materials use through life-cycle assessment. Achieve one of the following options.

Option 1: Building and Material Reuse (1-5 points BD+C, 2-6 points Core & Shell)

Maintain the existing building structure, envelope, and interior nonstructural elements. Reused or salvaged materials from off-site that are incorporated into the building can also contribute to the credit calculations. However, reuse materials contributing toward this credit may not contribute toward MR Credit Material Disclosure and Optimization - Sourcing of Raw Materials.

Historic, abandoned, or blighted buildings: Portions of buildings deemed structurally unsound or hazardous can be excluded from the credit calculations.

Path 1 and 2 reward projects that reuse structural and/or nonstructural elements based on the project area. Path 1 and 2 can be combined for points.

Path 1: Maintain Existing Structural Elements: Walls, Floors, Roofs, and Envelope (1-5 points BD+C, 2-6 points Core & Shell):

Maintain the existing building structure (including floor and roof decking) and envelope (the exterior skin and framing, excluding window assemblies and nonstructural roofing materials). Calculate reuse of the existing project area according to Table 1.

Table 1. Path 1 Points for reuse of existing building structural elements

Percent of existing walls, floors and roof reuse by project area	Points BD+C	Points - Core & Shell
100%	5	6
75%	4	5
50%	3	4
25%	2	3

REQUIREMENTS

MR	1	2
100%	5	6
75%	4	5
50%	3	4
25%	2	3

OR

Path 2: Maintain Interior Nonstructural Elements (2 points)

Use existing interior nonstructural elements (e.g., interior walls, doors, floor coverings and ceiling systems) for at least 50% of the area considered building, including underground.

OR

Option 3: Whole-Building Life-Cycle Assessment (3 points)

For new construction (buildings or portions of buildings), conduct a study to assess the life-cycle potential of the project. Life-cycle assessment and analysis shall be based on the following paths below to earn up to 3 points.

Path 1: Conduct a life-cycle assessment of the project structure and envelope (2 points).
Path 2: Conduct a life-cycle assessment of the project's structure and envelope that demonstrates a minimum of 10% reduction, compared with a baseline building, in at least three of the six impact categories listed below, one of which must be global warming potential (2 points).

Path 3: Conduct a life-cycle assessment of the project structure and envelope that demonstrates a minimum of 10% reduction, compared with a baseline building, in at least three of the six impact categories listed below, one of which must be global warming potential (2 points).
Path 4: Meet requirements of Path 1 and incorporate reuse and/or salvaged materials into the project to earn up to 1 point. For this category, design, construction, operation, and maintenance shall be considered. The project shall demonstrate a minimum of 10% reduction in at least two of the six impact categories listed below (4 points).

For Path 3, 4, and 5, a life-cycle assessment shall be conducted and a report shall be submitted. The life-cycle assessment shall be conducted and a report shall be submitted. The life-cycle assessment shall be conducted and a report shall be submitted. The life-cycle assessment shall be conducted and a report shall be submitted.

The baseline and assessed buildings must be of comparable size, function, construction, and operating energy performance as defined in the International Performance Design Requirements. The project shall be assessed and certified through the LEED v4.1 rating system. The project shall be assessed and certified through the LEED v4.1 rating system. The project shall be assessed and certified through the LEED v4.1 rating system.

Global warming potential (greenhouse gases) in kg CO₂e.

CONNECTION TO ONGOING PERFORMANCE

LEED O+M MR prerequisite Waste Performance : The concept above is a collection of strategies that can help achieve MR prerequisite Waste Performance in the O+M v4.1 rating system.

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2	Option 3	Option 4
Documentation of historic designation status	X			
Narrative describing demolition (if any)	X			
Documentation of how additions and alterations (if any) meet local review board requirements	X			
Narrative describing abandoned or blighted status		X		
Reused elements table and calculations		X	X	
Description of LCA assumptions, scope, and analysis process for baseline building and proposed building				X
Life-cycle impact assessment summary showing outputs of proposed building with percentage change from baseline building for all impact indicators				X



REFERENCED STANDARDS

ISO 14044: [iso.org/](https://www.iso.org/)

National Register of Historic Places: nhrp.focus.nps.gov/

Secretary of Interior's Standards for the Treatment of Historic Properties: nps.gov/ and nps.gov/hps/tps/standguide/



EXEMPLARY PERFORMANCE

Option 1 : Path1: Reuse 90% of the building

Option 2 : Achieve Path4 and show 40% reduction in CWP



TERMS AND DEFINITIONS

Hazardous material is any item or agent (biological, chemical, or physical) that has the potential to cause harm to humans, animals, or the environment, either by itself or through interaction with other factors.

Historic building: a building or structure with historic, architectural, engineering, archeological, or cultural significance that is listed or determined to be eligible as a historic structure or building, or as a contributing building or structure in a designated historic district. The historic designation must be made by a local historic preservation review board or similar body, and the structure must be listed in a state register of historic places, be listed in the National Register of Historic Places (or a local equivalent outside the U.S.), or have been determined eligible for listing.

A historic district is a group of buildings, structures, objects, and sites that have been designated as historically, architecturally, or culturally significant and categorized as either contributing or noncontributing.

Life-cycle assessment is an evaluation of the environmental effects of a product from cradle to grave, as defined by ISO 14040-2006 and ISO 14044-2006.



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