Introduction to the LEED 2009 Credit Weighting Tool

Introduction

The LEED rating system provides a cross-cutting measure of building performance. Weighting is a central concern when combining performance across credits and credit categories. The current LEED system contains implicit weights – credits are weighted equally except when higher levels of performance receive one or more additional credits (e.g., EA Credit 1). This work is an effort to incrementally improve the weighting system.

Objectives

The *LEED 3.0 Credit Weighting Tool* was developed to provide a transparent and reproducible system for understanding building impacts and using this information to assign weights to individual LEED credits. The workbook is a decision support tool that is intended provide a framework for credit weighting – not definitive answers.

Weighting Approach

Changes to the LEED weighting system are based on the concept that the value of credits will be determined by a basic weighting equation (see below). This equation brings together information on building impacts, building functions (a.k.a., building "activity groups"), and the performance of individual credits. This approach is implemented in a Microsoft Excel-based workbook called the *LEED 3.0 Credit Weighting Tool.* The tool ultimately provides a new set of credit weightings such as those illustrated in the screen shot below.

Sample scorecard comparing credit weightings for LEED-NC v2.2 with LEED v3

					Existing Credit Point Allocation in LEED 2.2		Credit's Allocated Points Based on Environmental Impact	
					Points			
					LEED 2.2	LEED 2.2 (%)	LEED 3.0	LEED 3.0 (%)
0		0		**Transportation**	5	7%	8.3	8.3%
			Credit 2	**Development Density & Community Connectivity**	1	1.4%	1.66	1.7%
P			Credit 4.1	**Alternative Transportation,** Public Transportation Access	1	1.4%	1.66	1.7%
P			Credit 4.2	**Alternative Transportation,** Bicycle Storage & Changing Rooms	1	1.4%	1.66	1.7%
			Credit 4.3	**Alternative Transportation,** Low-Emitting and Fuel-Efficient Vehicles	1	1.4%	1.66	1.7%
P			Credit 4.4	**Alternative Transportation,** Parking Capacity	1	1.4%	1.66	1.7%
0		0		**Sustainable Sites**	9	13%	9.0	9.0%
Y			Prereq 1	**Construction Activity Pollution Prevention**	Required			
P			Credit 1	**Site Selection**	1	1.4%	1.74	1.7%
			Credit 3	**Brownfield Redevelopment**	1	1.4%	1.55	1.6%
			Credit 5.1	**Site Development,** Protect of Restore Habitat	1	1.4%	0.00	0.0%
			Credit 5.2	**Site Development,** Maximize Open Space	1	1.4%	0.00	0.0%

Basic weighting equation

Relative importance of each **impact category**

x

Relative contribution of a building **activity group** to building impacts

x

Association between individual credits and activity groups

=

Credit Weight

Definitions:

- **Impact category:** impacts of building on environment and occupants (e.g., TRACI categories)
- **Activity group:** a building-related function associated with a group of LEED credits (e.g., consumption of energy by building systems, transportation, water use)
- **Association** with activity group: a binary (yes/no) relationship indicating whether or not a credit contributes to reducing an impact

Approach Implementation

Impact Categories. Implementing this approach is based on impact categories and an evaluation of individual credits. Impact categories and their relative weights are based directly on the National Institute of Standards and Technology (NIST) weighting exercise using impact categories defined by EPA's TRACI project[1]. The categories and the weights assigned during the NIST process include:[2]

Greenhouse gas emissions (29%)	Eutrophication (6%)	Human health-cancer (8%)
Fossil fuel depletion (10%)	Ozone formation (2%)	Human health-non-cancer (5%)
Water use (8%)	Smog formation (4%)	Indoor air quality (3%)
Land use(6%)	Ecotoxicity (7%)	
Acidification (3%)	Particulates (9%)	

Weights for these categories were developed by NIST through an analytical hierarchy process (AHP) and sum to 100%. The use of AHP to derive category weights means these categories cannot be readily combined, divided, or supplemented. The weights are "locked" to the specific combination of choices available during the NIST process and the preferences of the participating individuals. However, the spreadsheet does provide the ability

[1] Bare et al. 2003. TRACI: The Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts. *Journal of Industrial Ecology* 6(3-4):49-78

[2] Note that the TRACI categories were originally designed to evaluate products. Consequently, they have focus on the impact of the "product" on the environment. They provide relatively limited information about the impact of the "product" (in this case a building) on its users/occupants. For example, there are no categories for indoor environmental quality or productivity.

to change weights. Note that the sum of all category weights must add to 100% (see the following section on *Using the workbook*).

Information sources and analytical approached vary by impact category:

- **Greenhouse gas emissions** were estimated using empirical engineering calculations for the range of conditions found across the United States. Building energy consumption was based on a combination of CBECS, Energy Star, and EPA eGRID data. Transportation emissions were estimated based on travel information from the Bureau of Transportation Statistics (BTS), vehicle fleet characteristics estimated by the California Air Resources Board, and emissions coefficients from the California Climate Action Registry General Reporting Protocol. Water-related emissions were based on empirical engineering calculations and a variety of peer-review publications evaluating water-energy relationships.

- **Indoor air quality** was not quantitatively evaluated and credits were simply logically associated with this impact category.

- **All other categories** were estimated using results from the SimaPro 7 Life Cycle Assessment (LCA) model and the USA 98 Input Output Model. SimaPro was used to estimate life-cycle impacts associated with each activity group for each of the TRACI impact categories. Additional information on the SimaPro modeling will be available in the final project report.

Activity Groups. All LEED credits were organized into **activity groups** that reflect core building functions. These activity groups can be associated with specific building impacts in each category. The categories include:

- Building systems (specifically fuel and electricity consumption)
- Transportation (commuting and services)
- Water consumption (domestic and landscaping-related)
- Materials (core, shell, and finishings)
- Indoor Environmental Quality

Each activity group represents a group of credits that are associated with the issue (e.g., "building systems" includes credits that relate to build energy use). A combination of empirical calculations and life cycle assessment (LCA) was used to assign percentages of total building-related impacts to each activity group. This step allows us to relate specific LEED credits to the impacts they affect. Credits in each activity group were given a binary association with each impact category: 0 = no association, 1 = association. The total weight assigned to each activity group is then proportionally allocated to each individual credit associated with each impact category.

Application of the Equation. The application of the basic weighting equation produces a matrix with impacts across the top and all LEED credits as the rows. Weights for each impact category (column) sum to 100% and have a range of values for each credit in that impact category (within a column). To obtain the final credit weight, the values for each credit for all impact categories are summed (row total). This is illustrated in the partial screen shot below. The image shows the part of the Building Systems activity group with existing LEED-NC v2.2 credits arranged in rows. It then illustrates the first three impact categories as columns with the relative weight of the impact categories indicated as a percentage.

				Impact Categories	Carbon Footprint		Fossil Fuel Depletion		Water Use	
				Impact Category Weighting Relative Importance [%]	50%		10%		8%	
Credit		Description	Impact		Credit Weight, 0 = Nothing, 10 = Maximal Impact	Relative Impact [%]	Credit Weight (0-10)	Relative Impact [%]	Credit Weight (0-10)	Relative Impact [%]
Building systems						63%		51%		0%
					Weights	63 Points	Weights	51 Points	Weights	0 Points
SS	7.1	Landscape and exterior design to reduce heat island, non-roof	Reduce EUI		1	3.2	1	2.6	0	0.0
SS	7.2	Landscape and exterior design to reduce heat island, roof	Reduce EUI		1	3.2	1	2.6	0	0.0
SS	8	Light pollution reduction	Reduce EUI		1	3.2	1	2.6	0	0.0
EA	1.1	Optimize Energy Performance 10.5%	Reduce EUI		1	3.2	1	2.6	0	0.0
EA	1.2	Optimize Energy Performance 14 %	Reduce EUI		1	3.2	1	2.6	0	0.0

Building Scenario. In the workbook, it is essential to note that the selection of a building scenario is central to determining credit weights. In other words, the description and circumstances of the building prototype alters the relative value of credits.

Analogy

This workbook is like a big game of **Sudoku**. In this case, the goal is to specify credit weights that sum to 100 points in each impact category and multiply across to a reasonable weight for individual credits. The workbook supports the calculations and provides quantitative information to bound the process (e.g., calculations for greenhouse gas emissions and SImaPro LCA results for a range of building scenarios). The user can change weights and associations between credits and impact categories.

This is illustrated in the example below. *Scenario #1* illustrates a situation for a relatively high-performance building with a low carbon grid in a transit-oriented location with minimal landscaping-related water consumption. *Scenario #2* illustrates an alternative case with the same building and grid, but an auto-dependent setting with relatively long commuting distances and a relatively large landscape irrigated with high-energy potable water. Notice that the weightings on the activity groups change dramatically between these circumstances. This implies that the relative importance of credits in each of these groups changes significantly between these scenarios. *The selection of a scenario and impact category weights is a policy call that must be made by the LSC, not individual projects.* The workbook provides the ability to consider the consequences of a wide variety of scenarios. Some of the scenarios are illustrated at the end of this document.

EXAMPLES	
Scenario #1: high performance, transit-oriented, low-water use building	Scenario #2: high performance, auto-dependent, high water use building
Total GHG emissions 1,845 metric ton/year Activity group weights: • Building systems: 66% • Transportation: 33% • Water 0.3%	Total GHG emissions: 4,476 metric ton/year Activity group weights: • Building systems: 27% • Transportation: 54% • Water 18.4%

• Materials: 1%	• Materials: 0%

Workbook organization

The *LEED 3.0 Credit Weighting Tool* is a Microsoft Excel 2007 workbook[3]. It includes three key components:

1. **Tab 1. Project Description.** A quantitative description of the building prototype used for the weighting calculation.
2. **Tab 2. Analysis Results.** A summary of building-related impacts and a set of controls for selecting building scenarios.
3. **Tab 3. Activity Group Weighting.** This is the "brains" of the workbook. It illustrates the organization of credits into activity groups which are weighted by both the percentages carried over from the building analyses (Tab 2) and the TRACI impact categories.
4. **Tab 4. Scorecard Development.** This tab provides a tool for performing point reallocations. It rounds the fractional values for Tab 3 and provides logical tests to ensure that reallocations meet the rules of the system.
5. **Tab 5. Scorecard Comparison.** This tab takes results from Tab 4 and presents them against a standard LEED-NC score card for comparison.

Review questions

In this framework, credit scores involve at least three key questions that can be informed but not made by quantitative analysis:

Review question #1: *Does the framework provide the necessary information and capabilities to design and evaluate credit weightings?*
Fundamentally, the *LEED v3 Credit Weighting Tool* provides a decision support framework. It is timely to ask if it contains the right information and the necessary controls to facilitate decision making

Review question #2: *Which building scenario should be the basis for the rating system?*
The value of credits varies based on the circumstances associated with the building prototype (e.g., building performance, carbon content of the grid, transportation impacts, and water consumption). The LSC needs select a building scenario as the basis for weighting.

Review question #3: *Can this combination of impact categories, activity groups, and credit associations provide acceptable credit weights?*
Ultimately, the key question is whether the combination of information and tools provided in the workbook address the right question and provide sufficiently informative answers. In other words, do the revised weights generated through this system qualitatively improve on existing LEED credit weightings?

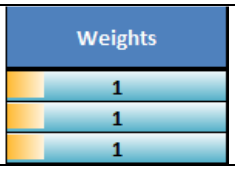
[3] The workbook was designed in Excel 2007 to take advantage of its superior graphics and conditional cell formatting. This version cannot be opened with earlier versions of Excel. A version saved in Excel 97 is substantially degraded and difficult to use and interpret.

Supporting information

The workbook also contains additional information on building scenarios and calculations in worksheets labeled A through K. These worksheets illustrate underlying calculations and assumptions for the individual scenarios that can be selected in Tab 2. The tabs also include some degree of documentation for methods.

Using the workbook

The workbook is designed to provide a framework for setting weights. It provides a number of opportunities to explore the implications of specific assumptions for the weighting of credits. **Points of control are indicated by large red arrows.** Each arrow points to a cell or group of cells that can be changed by the user, in this case the USGBC, not the project. Note that there is no mechanism for restoring "default" values to these cells. This is can be done by closing the workbook (without saving) and reopening it. Each arrow is numbered and the functions are described below:

	**Tab #2 |Change scenario** This arrow points to the cells used to select building scenarios. Each of the four cells in yellow has a drop down menu with three choices: lowest, median, highest. These terms refer to the level of impact (or emissions) for a given scenario. For example, building systems "highest" is the highest impact combination of building performance and electricity grid. Conversely, transportation "lowest" refers to the lowest level of transportation impacts, typically transit-oriented buildings with short commutes. These four pull downs act independently and provide a wide range of scenarios. Note that any changes in these cells are immediately reflected across the entire workbook (i.e., they change weights for credits).
	**Tab #3 |Change weights of impact categories** This arrow points to the cells used to describe the weight of TRACI impact categories. The default values reflect the NIST AHP process. Users can change any of the percentages and examine the consequences for individual credits. To work properly, percentages should sum to 100% in the "Result" field (column AF). However, the workbook will currently allow you to enter any number.
	**Tab #3 |Change control over transportation** This arrow allows a user to manipulate control over transportation impacts. This is important because it is difficult to quantify the value of existing LEED credits for transportation impacts. There is also quite a bit of scientific debate about the percentage of transportation emissions that can be addressed by the location and design of building projects. Despite the scientific uncertainty (or perhaps more accurately, the complexity of the relationships), transportation represents a very significant fraction of building-related impacts. This arrow allows the user to manipulate the level of control assigned to existing credits. This directly changes their weight in proportion to their contribution to building impacts under a given scenario. "Uncontrolled" transportation-related impacts go into a "residual". This value is passed down the worksheet and made available as a transportation-specific innovation credit (i.e., project teams would be encouraged to purpose innovation credits that could demonstrate reductions in transportation-related impacts by making more points available).
	**Tab #3 |Change association between credits, activity groups, and impacts** This function is not indicated by an arrow. Every "weights" cell in Tab 3 can be

	independently controlled by the user. Currently these cells define associations between credits, activity groups, and impact categories. When weights are set to "1", then the credit is associated with the category or group, and it receives a proportional share of the weighting. The cells can also accommodate values other than 0 or 1. For example, a value of 2 or 10 could be used to increase the relative importance of individual credits. However, weights other than 0 and 1 are very difficult to assign systematically.
	**Tab #4 |Reallocate points** This arrow indicates the column through which points are manually reallocated to make up for surpluses or deficits following rounding. The sheet has a number of logical controls. The values in column 6 appear black until point reallocation is complete. Only credits highlighted in green are available for reallocation – i.e., they have 2 or more points available (given the 1 point minimum).
	Tab #5 |Compare scorecards This tab provides a side-by-side comparison of the current and 2009 score cards. Since the total number of credits in each system are different, the most meaningful way to interpret changes in through consideration of percentages of total system value for credit categories and individual credits.