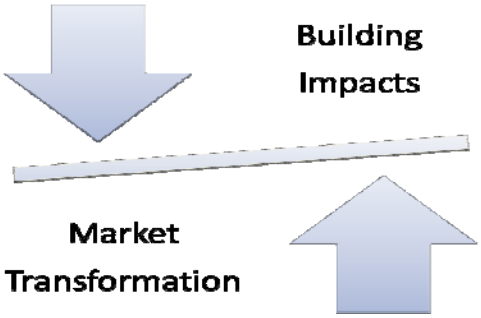
LEED 2009 Credit Weighting

May 1, 2008

Introduction

LEED is a building assessment and rating tool. In LEED version 2.2, credit weights reflected number of credits in different credit categories and a qualitative sense of the value of credits for LEED's market transformation mission. In other words, the number of credits associated with an issue implicitly increased it relative important and the points allocated to a credit reflects

The success of green building has created new expectations, including the notion that green building practices can contribute solutions to social, economic, and environmental problems. Such solutions typically mean reductions in negative impacts associated with buildings or, in some cases, positive change associated building design and operation (e.g., brownfield restoration).



Along with other factors, changes in market conditions and user requirements have encouraged the development of new credit weighting paradigm for LEED. This paradigm necessarily builds on LEED's foundation as a tool for market transformation by adding explicit consideration for the contribution of individual credits to building impacts. In this paradigm, credits are more valuable (i.e., worth more points) when they are associated with more important building impacts. The relative importance of impacts is evaluated with respect to specific impact categories.

This is fundamental change in how LEED credits are weighted. However, its consequences are incremental for the rating system as a whole. Existing credits are largely retained and assigned a substantial minimum weight, and the new, impact-driven paradigm is superimposed on the basic skeleton of the existing system. This means that new paradigm changes the relative emphasis of the system, but it does not constitute a wholesale reinvention of weightings.

Intent

The LEED 2009 weighting system intends to provide a transparent and reproducible approach to assign weights to credits. The system is a flexible, decision support environment that allows decision makers with explicit control over the integration of analytical results, policies, and values.

Weighting for each LEED 2009 system are documented with a self-contained Microsoft Excel workbook. Each workbook contains all calculations and rules used to assign weights to individual LEED credits. The workbook also serves as a decision support tool to evaluate the consequences of alternative scenarios on credits or the rating system as a whole. At this time, the workbooks are prototypes, and they are not designed or intended to

for independent use by project teams or the public (i.e., they are a tool for internal decision makers acting with assistance).

Summary of changes

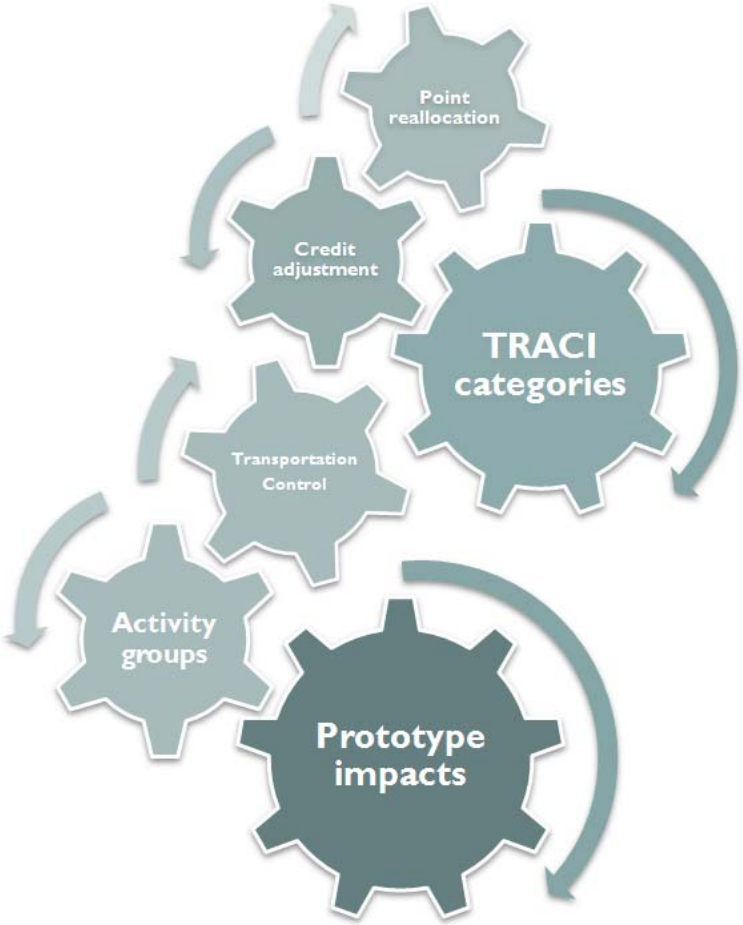
The weighting approach described here represents an incremental change to the LEED rating system. A number of key elements remain unchanged, including:

- Existing credits remain the same
- All credits receive a minimum score of 1
- Credits are positive, whole numbers – no fractional credits or negative values
- Credits have one set of "static weights" regardless of location or potential connections between credits

These elements were given design guidelines for the new weighting system. They limit the degree of change, and they impose significant constraints.

A number of important elements have changed, including:

- The total number of points – 100 points are now available excluding innovation and regional credits
- The relative allocation of points between credit categories – resulting in change in the relative emphasis of credit categories



Components

The LEED 2009 weighting approach explicitly integrates building impacts with the existing structure of LEED. Weighed is carried out through six interacting components including:

- A building prototype
- Impact assessment categories
- Credit groups ("activity groups")
- Transportation control
- Credit adjustments
- Point reallocation

These components work together to provide a representation of building impacts and use this information to assign points to individual credits. Each component provides an opportunity to change the ultimate weight of a credit. The most important single factor is the selection of a building prototype. This decision has the great potential influence and is subject to the great range of potential conditions (i.e., observed variance in key parameters). This is followed closely by the weights applied to impact assessment categories (i.e., TRACI weights). The last three components essentially provide opportunities for fine tuning.

Weighting process

LEED 2009 weighting can be described as a ten step process:

1. Building impacts are estimated based on a building prototype.
2. Impacts are described with respect to 13 TRACI impact categories
3. Impacts are associated with up to 6 groups of credits (activity groups) – this assigns some number of potential points to groups of credits.
4. Points are allocated proportionally to credits within an activity group – the default is that each credit in the group contributes equally to the impact associated with the category and consequently receives an equal score.
5. Some credit weights are adjusted to reflect the relative performance of individual credits – this changes the distribution of points *within* a category (points in other groups are not changed)
6. Impact scores for each activity group are adjusted based on individual and aggregate capabilities of existing credits (e.g., control over transportation) – this means "uncontrolled" points from transportation are distributed proportionally across the other groups.
7. Credit weights for the 13 TRACI impact categories are integrated by taking a weighted average across all impact categories based on weights from the TRACI/BEES exercise.
8. Combined credit weights are rounded to the nearest whole number and the "residual" created during the rounded is tallied.
9. Residual points (i.e., points created by rounding) are manually reallocated across the system based on specific rules – the LSC directed that points be allocated with priority for greenhouse gas emissions reduction potential.
10. Results are transferred back to the existing scorecard for each system.

Information sources

The LEED 2009 weightings workbook necessarily brings together a number of information sources. Models and statistical information is used to estimate building impacts and associate impacts with individual TRACI categories. Specific information sources used in individual calculations are documented throughout each LEED workbook. The association between impact categories and information sources is illustrated in the following table.

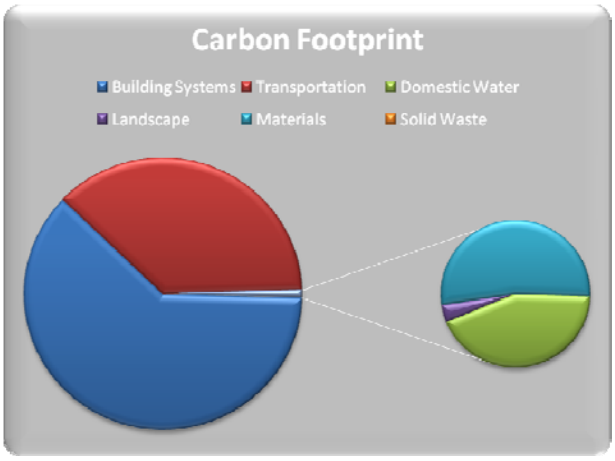
Table 1. Summary of information sources used for each impact category

TRACI category	BEES weights	Description of category	Information source
Greenhouse gas emissions	25	Operational greenhouse gas emissions (CO2e/year)	Empirical calculations based on CBECS, the Bureau of Transportation Statistics, and other national data sources
Fossil fuel depletion	9	Consumption of non-renewable, fossil fuels	SimaPro/USA Input Output 98 library
Water use	7	Consumption of water *throughout the life cycle of a building*	SimaPro/USA Input Output 98 library
Land use	5	Consumption of land *throughout the life cycle of a building*	SimaPro/USA Input Output 98 library
Acidification	3	Generation of "acid rain" emissions associated with acidification *throughout the life-cycle of a building*	SimaPro/USA Input Output 98 library/Ecocalculator
Eutrophication	5	Generation of nutrient pollution *throughout the life-cycle of a building*	SimaPro/USA Input Output 98 library/Ecocalculator
		Generation of nutrient pollution *at the site*	
Ozone depletion	2	Generation of ozone depleting emissions *throughout the life-cycle of a building*	SimaPro/USA Input Output 98 library/Ecocalculator
Smog formation	4	Generation of smog forming emissions *throughout the life-cycle of a building*	SimaPro/USA Input Output 98 library/Ecocalculator
Ecotoxicity	6	Generation of ecotoxic pollutants *throughout the life-cycle of a building*	SimaPro/USA Input Output 98 library/Ecocalculator
		Generation of ecotoxic pollutants *at the site*	
Particulates	8	Generation of particulate emissions *throughout the life-cycle of a building*	SimaPro/USA Input Output 98 library/Ecocalculator
Human health - cancer	7	Generation of cancer-causing compounds *throughout the life-cycle of a building*	SimaPro/USA Input Output 98 library
Human health – non-cancer	4	Generation of non-cancer-causing compounds *throughout the life-cycle of a building*	SimaPro/USA Input Output 98 library
Indoor environmental quality	15	Impacts on building occupants and the indoor environment	No model; association based on credit function

Application of weighting tool

The impact-driven weighting tool described above was applied to LEED-NC, LEED-EB, LEED-CI, and LEED-CS. All weightings share following characteristics. The impact prototype is a:

- 135,000 square foot office building
- Operated *9-to-5*, 5 days per week – a total of 250 days/year
- 540 full time employees
- Impacts associated with construction and materials are amortized over a 50 year performance period



The LEED Steering Committee and USGBC staff also provided specific requirements that guide the weighting system. The most important of these requirements include:

- Credits will have one static, independent values
- Credits will be positive integers with a minimum value of 1
- Credits total 100 possible points, excluding innovation and regional credits

Specific characteristics of each rating system (i.e., LEED-NC vs. LEED-EB) required modifications to the basic weighting system. These modifications are described in the following sections. There are four primary types of modifications:

1. Changes in the impact model
    - For example, building circumstances, such as location, landscape area, or parking area
2. Changes in percentage control over impacts
    - For example, transportation, stormwater, solid waste
3. Credit adjustments within activity groups
    - Fine tuning weights to address the relative effectiveness of credits
4. Point reallocation between credits and potentially across activity groups
    - Allocating points to satisfy requirements for minimum credit values and point totals

Table 2. Summary of building scenarios used for each rating system – the labels "Median", "Highest", etc. refer to specific choices in the LEED 2009 weighting tool workbook. These choices essentially combine to represent a statistically average US office building matching the specifications of the prototype.

System	Building systems	Transportation*	Water	Materials	Solid waste	Land use
NC	Median	Median (50%)	Median	Highest	n/a	Static
EB	Median	Median (40%)	Median	Highest	Median	Static
CI	Median	Median (40%)	Median	Highest	Median	Static
CS	Median	Median (?%)	Median	Highest	n/a	?

** Number indicates percentage control over transportation available through existing credits.*

Table 3. Description of the scenario used to drive weightings for all systems. This reflects the selected conditions indicated in Table 2. A wide range of alternative scenarios are available in the weightings tool workbook.

Component	Description
Building systems	Energy use for the 135,000-sf prototype in climate zone 3 (4,750 heating degree days, 1,800 cooling degree days); 80% building energy from electricity; Energy Star 50 rating; no on-site renewable energy; electricity carbon intensity equivalent to the national average
Transportation	5 day per week, 250 day per year work schedule, 20.5 mile average daily roundtrip commute; average fuel economy of 21 miles per gallon; 74% drive alone, 12% carpool, 4% rail, 3% bus, 1% rail, 1% bicycle, 1% walk; transient users and services are equal to 25% of commuters,
Water	Domestic water use: 50/50 male/female split; conventional toilets (1.6 GPF) and urinals (1 GPF), conventional facets (2.5 GPM) and showers (2.5 GPM) Landscape water use: 1 acre of landscaping; water use equivalent to trees, shrubs in climate zone 3, conventional sprinkler irrigation systems, irrigated with potable water, national average embodied energy, electricity carbon intensity equivalent to the national average
Materials	Two story steel construction, 109,950-sf surface parking lot,
Solid waste	Solid waste generation of 4.9 tons/1000-sf
Land use	Combination of building footprint (67,500-sf), surface parking lot, 1 acre landscaping,

Summary of credit adjustments

Credit adjustments alter the weight of individual credits *within activity groups.* Adjustments alter the relative allocation of credits across the activity group. These adjustments are typically based on an interpretation of how credits function (i.e., their relative value within an activity group). This weight is set based on a judgment about the function a credit in practice, rather than quantitative analysis. The default setting is 1 which indicates an association between a credit and an impact area.

Table 4. Summary of credit adjustments made to each system. These changes alter the relative importance of credits *within* activity groups. Values of other activity groups are not changed.

System	Description	Adjustment
NC	Change relative weight of energy credits	Remove EAc1.1; high (3) weight to EAc1.2, medium (2) weight to EAc2.1 and EAc5
	Change relative weight of transportation credits	High (3) weight to SSc2 and SSc4.1; medium (2) weight to SSc4.3, low (1) weight to SSc4.2 and SSc4.4
EB	Remove credits	0 weight for EAc1.1, EAc1.2, MRc1.1, MRc1.2, MRc4.2, MRc7.2
CI	Change relative weight of energy credits	Remove EAc1.1; high (3) weight to EAc1.2, medium (2) weight to EAc2.1 and EAc5
	Change relative weight of transportation credits	High (3) weight to SSc2 and SSc3.1; low (1) weight to SSc3.2 and SSc3.3
	Change relative weight of water credits	Medium (1.5) weight to WE1.1, low (1) weight to WEc1.2
	Change relative weight of materials and resources credits	Medium (2) weight to MRc1.2 and MRc2.2
CS	Same as NC	

Summary of point reallocations

Point reallocation is the final step in the weighting process. Points are made available for reallocation when fractional weights are rounded to the nearest whole number. Round-off points are manually reallocated – there is no constraint on their allocation within or between. Round-offs can result in either net surpluses or deficits of credits. The number of points available is a function of the impact scenario, TRACI weights, transportation reallocation, and credit adjustments. Changes in any of these factors will change the number of points available for reallocation.

The LSC directed that reallocation points be allocated based on the relatively value of credits for greenhouse gas emissions.

Table 5. Summary of point reallocations for each rating system. Points are made available by rounding to whole numbers. Points are reallocated manually based on guidance from the LSC.

System	Surplus/Deficit	Reallocation
NC	Rounded required *adding* 3 points	EAc1 +1, EAc2 +1 SSc4.2 +1
EB	Rounding required *adding* 14 points	EAc1.7 through EAc1.14+1 EAc2.1+1, EAc2.2+1 EAc4.2+1, EAc4.3+1 WEc2.2+1, WEc2.3+1 WEc3.2+1, WEc3.3+1
CI	Rounding required *removing* 12 points	WEc1.1-1 EAc1.1.1-1, EAc1.1.2-1, EAc1.1.4-1, EAc1.2-1 EAc1.3.B.1-1, EAc1.3.B.2-1, EAc1.4.1-1, EAc1.4.2-1 EAc2-1, EA3.B.1-1, EAc4-1
CS	Same as NC	

Uncertainty and limitations

The LEED 2009 weighting system is a decision support tool. It provides a framework for integrating the structure of the existing rating system with an impact-oriented weighting system. The system itself does not provide "answers" or weights as an output. Rather, it provides a framework for evaluating the interlocking set of issues that contribute to weights and, ultimately, changes in LEED scorecards.

The LEED 2009 system is driven by a building impacts model. The calculations used to estimate impacts are relatively simple scalars, such as energy use per square foot, emissions per gallon, therm, or kilowatt, etc. However, these simple calculations inherit the limitations of their data sources. In this case, one of the most important limitations is the degree to which the Department of Energy's Commercial Building Energy Consumption Survey (CBECS) represents the population of buildings LEED targets for market transportation. Errors or uncertainties in CBECS influence the degree to which the "median" prototype used here represents a national average condition.

More importantly, the choice of building scenario has a direct and profound impact on the LEED 2009 weighting system. Of course, this must be the case since the new system attempts to mesh the existing structure with explicit consideration for building impacts: when building impacts change, the importance of credits change and their relative weight within the system. The workbooks are designed to illustrate the consequences of the range of conditions found across the United States. However, the rating system ultimately requires selecting one prototypical condition and using it as the basis for weights.

Taking greenhouse gas emissions as an example, we see that total building-related greenhouse gas emissions vary by over a factor of 10 across the range of scenarios. More important for the current weightings framework, the fractions of impacts associated with different impact categories varies by nearly a factor of 2. For example, building systems may constitute 76% of emissions in one scenario, but only 47% in another. Alternatively, transportation may contribute 17% or 53%. These ranges are illustrative, but they do not bound the range of possible variation.

Table 6. Summary of greenhouse gas emissions scenarios available within the LEED 2009 weighting tool. Note that these scenarios illustrate plausible alternative conditions, and they do not fully bound the range of variation.

Scenario	Building Systems CO2e [met T]	[%]	Transportation CO2e [met T]	[%]	Water CO2e [met T]	[%]	Materials CO2e [met T]	[%]	Total CO2e [met T]
Highest	11137	76%	2418	17%	823	6%	218	1%	14595
Median	2832	62%	1711	37%	19	0%	15	0%	4577
Lowest	532	47%	604	53%	5	0%	2	0%	1143

Another important issue is the independent and context dependence of credit weights. It is clear that credits are not always independent, but they work together. For example, achieving higher levels of energy efficiency changes the relative value of different levels of green power purchasing. Of course, this is one of the central tenants of integrated design. The LEED 2009 weighting system does not yet internalize these considerations, because of the design requirement to provide static, independent weights.

The requirement for positive integers constrains the range of variation available within a 100 point system. This specification requires rounding fractional points and introduces a manual point reallocation step. This provides a potentially valuable tool for injecting policies or values into the weightings, but it is important to note that it is a specific consequence of a design constraint.

The requirement for positive integrates also makes it difficult to include credits that do more than simply reduce impacts. For example, some credits may create net positive benefits, rather than simply reducing impacts. These issues are recognized in the LEED 2009 credit weighting system but only partially addressed.

It is not possible to roll these issues up into some kind of composite measure of uncertainty associated with the weightings. The weightings are deterministically calculated within the limits of the system components. The impact model itself is subject uncertainty associated with the underlying data. Variation in outcomes associated with other components reflects policies and values – uncertainty in these outcomes can only be reduced through discussion, negotiation, and consensus. Fortunately, the LEED 2009 weighting system allows for explicit differentiation of the outcomes of analytical choices and rules, policies, and values.

These issues clearly indicate the potential value of a dynamic, context-sensitive weighting system. The LEED 2009 Weightings Tool provides a prototype for the capabilities needed for dynamic weighting in a future version of LEED. However, such a step would require substantial effort to move from the current prototype to an enterprise-level software system usable by project teams and capable of accommodating the breath of situations encountered in practice. Additionally, such a system would require substantial changes in LEED educational and certification processes.

Conclusions

The LEED 2009 weighting system represents an incremental attempt to integrate the existing structure of LEED with an analytical assessment of building impacts. The system represents a series of compromises to accommodate goals for market transportation, consideration for building impacts, operational constraints, and system design requirements. Consequently, it represents a complex mixture of quantitative analysis, rules, policies, and values. Fortunately, this process can be described in detail and is ultimately transparent with regard to its assumptions and outcomes. The LEED 2009 system provides a first step toward a dynamic, context-dependent weighting system.