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ABSTRACT

The Leadership in Energy and Environmental Design (LEED) green building rating program developed by the U.S. Green Building Council (USGBC) is a globally used tool to help create better buildings that benefit people and the environment. LEED combines a small set of required elements with flexible credits that enable project teams to select strategies based on project priorities, geographical location and financial circumstances. In this paper, we consider the issue of durability with respect to strategies associated with the LEED for New Construction and Major Renovations (LEED-NC 2009) rating system. The paper includes a new framework to systematically understand and connect green building and durability considerations and credit-by-credit review of service life expectancy and other durability-dependent issues associated with common implementation strategies. This information provides the basis for the screening, classifying, and comparing of individual credits with respect to potential durability risks.

Key words: LEED, green building, durability, service life

1. INTRODUCTION

Durability is a multi-faceted issue for the green building community. Durability is seen as an essential strategy to reduce waste, ensure the efficient use of materials, and ultimately reduce environmental impacts. Yet, conversely, the durability of green building processes and technologies may be a source of concern or even dissatisfaction. The industry lacks a general, systematic framework to understand connections between green building strategies and durability-related risks and consequences.

Our investigation in this paper builds on a significant history of academic and professional research. Notable examples include:

- Studies of the life cycle financial performance of individual green technologies (Athena Sustainable Materials Institute & Morrison Hershfield Ltd., 2006).

- Studies of specific building components and assemblies, such as Kernan (2007)'s study of risks to long-term performance associated with residential building enclosures. This was followed by analogous work on commercial enclosures by Desmarais et al. (2010).

- Odom et al. (2008) provided a comprehensive analysis of so-called "hidden" risks associated with green strategies.

These studies address a wide range of issues, but, collectively, they describe the importance of the nexus between green building and the issues of service life, durability, and life cycle performance. Yet, they also illustrate the fragmented technical literature and suggest for an integrative, cross-cutting framework to understand connections between green building strategies and durability.

This paper attempts to provide one such framework tailored to the universe of green building strategies included in the LEED for New Construction (version 2009) family of green building rating systems. Our goals are to:

1. Describe a systematic framework for understanding connections between green building strategies and durability considerations.
2. Classify individual green building strategies based on durability.
3. Describe durability-related risks to individual green building strategies.

2. APPROACH

2.1. Scope of analysis

This study focuses on practices used to achieve prerequisites and credits in the LEED-NC 2009 green building rating system. Prerequisites and credits in LEED-NC 2009 are divided into five thematic categories including: Sustainable Sites (SS), Water Efficiency (WE), Energy & Atmosphere (EA), Materials & Resources (MR) and Indoor Environmental Quality (IEQ). The rating system also has categories for Innovation in Design (ID), which awards points for exemplary performance or new site-specific green measures, and Regional Priority (RP), which awards 'bonus points' for regionally important strategies. The ID and RP categories are out of the scope of this research.

To achieve a certain certification level, a project must satisfy all the prerequisites and earn points through the achievement of credits. The maximum achievable points of each credit correlate with the environmental benefit. A building has to earn at least 40 points from the achievable 110 to be awarded the lowest level of LEED certification (Certified). A project must earn a minimum of 50, 60 and 80 points to be awarded LEED Silver, Gold or Platinum respectively.

Each LEED prerequisite or credit can be achieved through a variety of individual strategies, typically applications of specific technologies, processes, or policies. It is not feasible to fully enumerate or describe the full range of strategies used across thousands of projects. Consequently, in this paper, we focus on common strategies associated with each credit.

2.2. Assumptions

The concept of durability refers to the extent to which values, characteristics, or performance are maintained over time. In practical terms, durability is intrinsically linked to expectations about the performance life, which vary for whole buildings, sub-systems, and components. For our purposes, the concept of performance life is synonymous with "economically reasonable working life" (European Commission, 2004).

For this study, we based our evaluation on a reference whole building service lifetime of 50 years with service lifetimes for sub-systems and components defined as fractions of this lifetime. This approach reflects criteria used in the development and weighting of LEED 2009 credits (USGBC 2009), technical literature (U.S. Department of Energy, 2012), and administrative rules (European Commission, 2004). We note that many building elements, such as inaccessible or structural components, may be expected to have significantly longer services lives (e.g., ISO 15686-1).

It is difficult to prescribe service life for more granular elements of buildings, such as products or processes associated with individual green building credits. For purposes of this analysis, performance expectations for strategies associated with prerequisites and credits are based on industry research and databases, including:

- ASHRAE: HVAC Service Life Database, 2013 (ASHRAE Research Project 1237-TRP)
- Canada Mortgage and Housing Corporation (CMHC), 2000: Service life of multi-unit residential building elements and equipment
- Chartered Institution of Building Services Engineers (CIBSE), 2008: Guide M
- Kompetenzzentrum der Initiative "Kostengünstig qualitätsbewusst Bauen", 2009 Lebensdauer von Bauteilen und Bauteilschichten: Info - Blatt Nr. 4.2.

3. SYSTEMATIC FRAMEWORK

The first objective of this paper is to articulate a systematic framework to understand and evaluate connections between green building strategies and durability. This requires establishing a set of new terms and hierarchical relationships.

For each element, we define the scope and structure of the element (rating system, category, credit, etc.). These elements are analyzed to provide information about durability characteristics.

I. LEED rating system

- *Scope and structure:*
  - Limited to new construction for the purposes of this study.
  - Typically approximately 50 LEED prerequisites and credits divided into 5 categories.
- *Durability characteristics (developed in this study):*
  - A *Rating System Service Life* (RSSL) – interval based on the Credit Service Lives (CSL) within the Rating System.
  - A *Minimum,* a *Maximum* and an *Average Rating System Service Life* ($RSSL_{min}$, $RSSL_{max}$, $RSSL_{ave}$).
  - A *Range of Rating System Service Life* (= $RRSL_{max}$ - $RRSL_{min}$).

II. LEED categories

- *Scope and structure:*
    - A combination of prerequisites (required) and credits (optional) elements.
- *Durability characteristics (developed in this study):*
    - *LEED Category Service Life* (LCSL) – interval based on the Credit Service Lives (CSL) within the LEED category.
    - A *Minimum,* a *Maximum* and an *Average LEED Category Service Life* ($LCSL_{min}$, $LCSL_{max}$, $LCSL_{ave}$).
    - *Range of LEED Category Service Life* (= $LCSL_{max}$ - $LCSL_{min}$).

III. LEED prerequisites and credits

- *Scope and structure:*
    - Each prerequisite or credit is composed of an intent, requirements, and one or more compliance options.
- *Durability characteristics (developed in this study):*
    - *Durability-dependent* | *durability-independent* based on the possible strategies serving the credit intent.
    - *Credit Service Life* (CSL) – interval based on the Strategy Service Lives (SSL) of typical strategies serving the credit/prerequisite intent.
    - A *Minimum,* a *Maximum* and an *Average Credit Service Life* (CSL_{min}, CSL_{max}, CSL_{ave}).
    - *Range of Credit Service Life* (= CSL_{max} - CSL_{min}).

IV. Green building strategies

- *Scope and structure:*
    - Each LEED prerequisite or credit is associated with one or more typical strategies.
- *Durability characteristics (developed in this study):*
    - *Durability-dependent* | *durability-independent*
    - *Strategy Service Life* (SSL) – interval based on the Predicted Service Lives (PSL) of typical building assemblies/components serving the strategy or the performance period of the strategy.
    - A *Minimum,* a *Maximum* and an *Average Strategy Service Life* (SSL_{min}, SSL_{max}, SSL_{ave}).
    - *Range of Strategy Service Life* (= SSL_{max} - SSL_{min}).

V. Building Assembly / Component

- *Scope and structure:*
  - Most of the strategies require certain building assemblies/components.
- *Durability characteristics (developed in this study):*
  - *Predicted Service Life* (PSL) – interval.
  - A *Minimum,* a *Maximum* and an *Average Predicted Service Life* (PSL_{min}, PSL_{max}, PSL_{ave}).
  - *Range of Predicted Service Life* (= PSL_{max} - PSL_{min}).

The green building strategies in this schema are defined as:

- *Durability-dependent:* strategies associated with building systems/assemblies that may degrade over time due to environmental and/or in-use impacts.

- *Durability-independent:* strategies that are not durability-dependent. *Durability-independent* strategies include practices linked to specific phases of the building lifecycle with intentionally limited performance periods (e.g., measures during construction), site characteristics, and occupant-dependent strategies)

If the credits/prerequisites are associated with durability-independent strategies only, we consider them durability-independent; otherwise they are durability-dependent.

The credits represent a specific intent that can often be achieved through a number of strategies or compliance paths. This means that most credits are associated with strategies that may vary with respect to their characteristics, including their expected service lifetime (a.k.a. *Strategy Service Life* - SSL). This creates the potential for ambiguity with respect to the specific strategies associated with an individual credit. Consequently, we introduce a new term to describe the durability of the bundle of strategies associated with an individual LEED credit:

Credit Service Life (CSL): the actual period of time during which the building system/assembly serving the credit strategy/strategies perform without unforeseen costs or disruption for maintenance and repair, and/or the required policy is expected to remain in place.

A LEED credit can reach the end of its service life if (Figure 1.)

a) The building assemblies influenced by the credit do not fulfill the basic functional requirements, OR
b) The building assemblies influenced by the credit do not fulfill the additional functional requirements, OR

c) The policy/measure required by the credit is expired. (Most policies cover a certain period of time of occupancy.)

Figure 1(a). Impact of LEED-NC credits on building assemblies

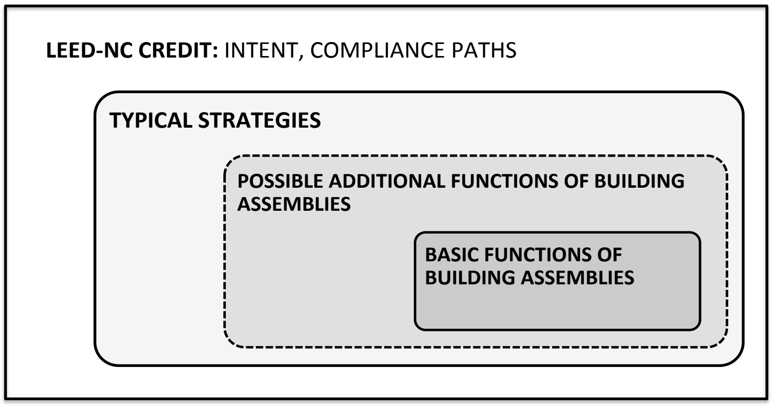
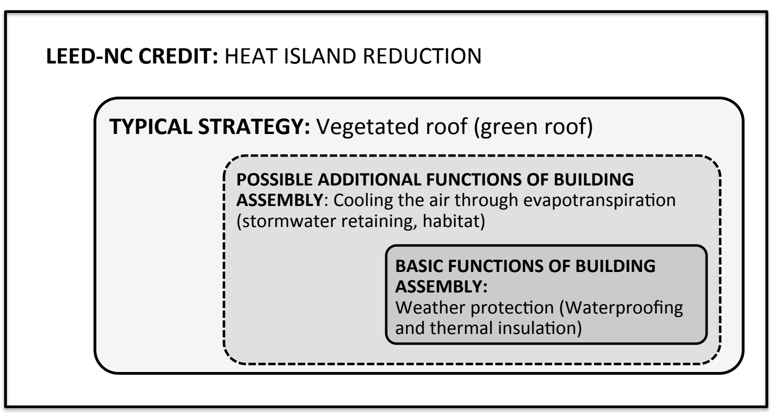


Figure 1(b). Example for Heat Island Effect – Roof. [Link]



In terms of policies and measures, the worst-case scenario is assumed, i.e. the strategies are not maintained after the mandatory period.

To describe the LEED categories and the overall rating system from durability perspective, we introduce the following terms:

- *LEED Category Service Life (LCSL):* Weighted average of the Credit Service Lives (CSL) within the LEED category based on their environmental benefit i.e. maximum number of achievable points.

- *Rating System Service Life (RSSL):* Weighted average of Credit Service Lives (CSL) within the LEED rating system based on their environmental benefit i.e. maximum number of achievable points.

Note that LEED prerequisites and credits with non-definable service lives (e.g. measures limited to the construction phase) are not considered in the LCSL and RSSL.

Since the Credit Service Life (CSL) is an interval, the LCSL and RSSL are also intervals, where the lowest value is the weighted average of the lowest possible CSLs, the highest value is the weighted average of highest possible CSLs.

4. ANALYSIS OF THE LEED-NC 2009 RATING SYSTEM

Durability considerations are relevant to most LEED-NC 2009 prerequisites and credits. We classified 72% as durability-dependent while fifteen criteria were classified as durability-independent (Figure 2). The durability-independent credits include measures limited to specific phases of the building lifecycle, occupant-dependent processes, and strategies that cover the entire lifetime of the building. The service life of many durability-dependent credits, due to multiple possible compliance paths, varies within a wide range.

The *Rating System Service Life* (RSSL) of LEED-NC Version 2009 varies from 13 to 34 years, with an average of 23 years (Figure 3). 44% of the credits have a Maximum Credit Service Life (CSL_{max}) of 50+ years. More than half of the credits (54%) can have a service life (CSL_{max}) above 30 years, and more than three quarters (78%) can reach 20 years. Only 4 credits (7%) have an anticipated performance lifetime (CSL_{max}) less than 10 years.

The Sustainable Sites (SS) and Materials & Resources (MR) LEED categories have the longest service lives ($LCSL_{max}$): 48 and 47 years (Figure 4). These categories are also associated with the widest *Range of LEED Category Service Lives*: 35 and 30 years.

Figure 2. Durability-dependency of the LEED NC - 2009 credits

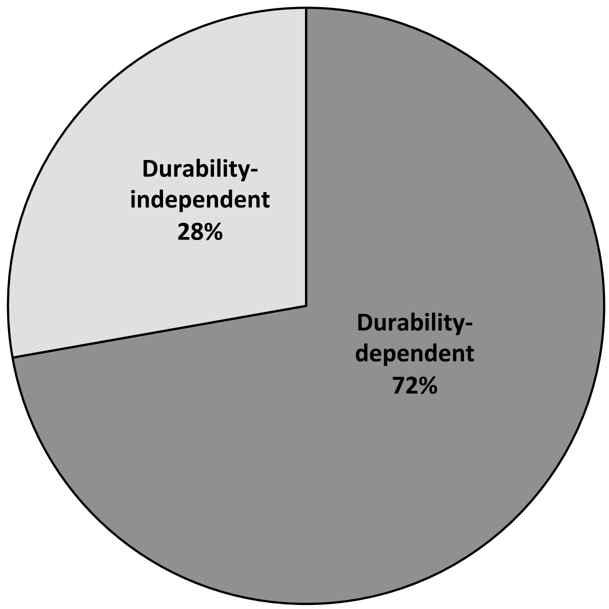


Figure 3. Credit Service Life (CSL) – LEED-NC 2009

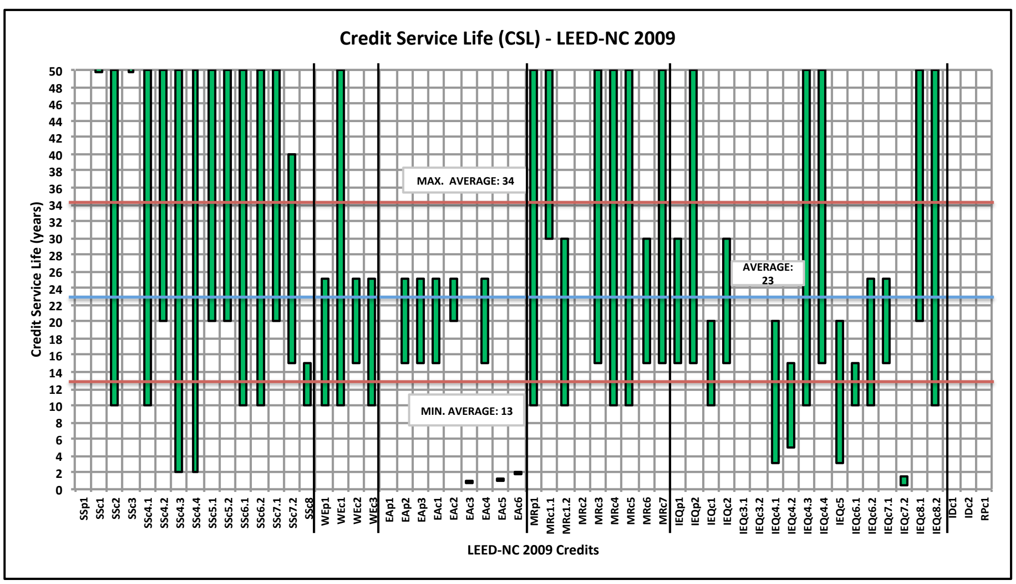
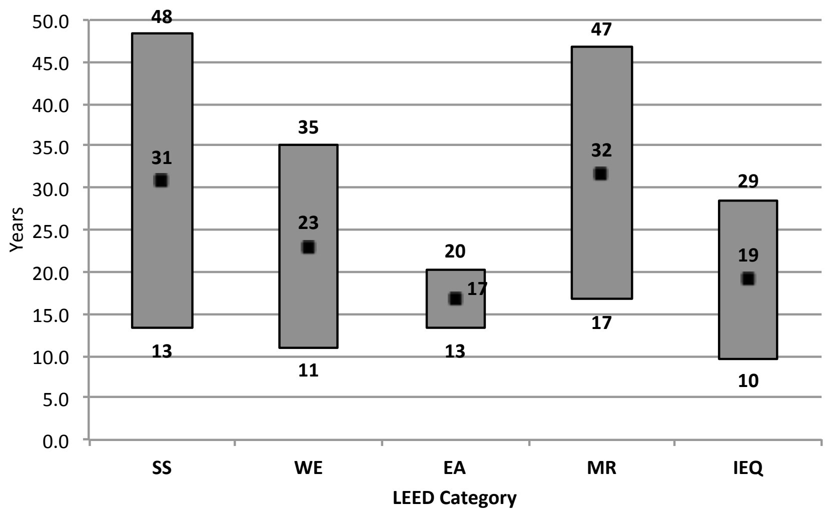


Figure 4. LEED Category Service Life (LCSL) – LEED-NC 2009



The Indoor Environmental Quality (IEQ) and Water Efficiency (WE) have the shortest *Minimum LEED Category Service Lives* ($LCSL_{min}$): 10 and 11 years.

The Site Selection (SSc1) and Brownfield Redevelopment (SSc3) credits have long-lasting implications, providing environmental benefit for the entire economic lifetime of the building. Conversely, credits such as Enhanced Commissioning (EAc3) are limited to short periods of time around the completion of the building. Short-term strategies include:

- *Enhanced Commissioning (EAc3):* review of energy related systems within 10 month after substantial completion.
- *Measurement and Verification (EAc5):* ongoing accountability of energy consumption for at least 1 year of postconstruction occupancy.
- *Green Power (EAc6):* 2-year renewable energy contract.
- *Thermal Comfort – Verification (IEQc7.2):* thermal comfort survey within 6 to 18 months after occupancy (along with permanent monitoring system).

5. DISCUSSION

Durability-related risks are found in many different interactions with widely varying consequences. Implications for intended outcomes and performance depend on a variety of factors, such as space type, the detectability of the failure, and the maintenance level.
Note that the risk of premature failures or underperformance may also depend on the climate conditions.

Sustainable Sites (SS)

From a durability perspective, Sustainable Sites (SS) is a very diverse category, including strategies serving throughout the entire expected economic lifetime of a whole building (e.g. Brownfield Redevelopment) and credits that can be achieved over short periods of time, such as a 2-year contract to promote Alternative transportation: Low-emitting and fuel-efficient vehicles (SSc4.3) or provide Parking capacity (SSc4.4)).

Three SS credits contain strategies with possible durability-related risk: Stormwater Design – Quantity Control (SSc6.1), Stormwater Design – Quality Control (SSc6.2) and Heat Island Effect – Roof (SSc7.2). All of these strategies are associated with potential moisture-related failures.

There are many ways to minimize stormwater runoff and remove sediment, including pervious paving materials, harvesting rainwater, designing infiltration swales and retention ponds, installing rain gardens, vegetated roofs or clustering development. The selection and implementation of specific strategies has significant implications for long-term performance. For example, Yong et al. (2008) found that some pervious paving systems start to pond during rain events after 10 years, while an apparent substitute, porous concrete, can remain pervious for 50 years (https://www.greenspec.co.uk). Either of these could contribute to the achievement of a LEED credit, yielding significantly different performance over time.

We can find analogous situations for rain harvesting. For example, an above ground rain barrel may have a 20-30 year expected service life while a much more capital-intensive underground cistern could perform predictably for 50 years or more. However, the pumps and electronic controls needed to operate a large-scale below grade cistern may have a 10-15 year lifespan (https://www.greenspec.co.uk). Again, either strategy might contribute to a green building credit with significant differences over time.

We can also find trade-offs in the selection of roofing materials. For example, there are two options for reducing the heat island effect on roofs (SSc7.2): vegetation (green roof) or roofing material with high solar reflectance index (cool roof). Vegetated roofs have a greater risk of water intrusion due to a clogged drainage system and/or the constantly wet growing media. If, however, the green roof performs adequately, it protects the waterproofing layer from UV-radiation and mechanical damage as well as decreasing the diurnal thermal expansion of roof assemblies. The expected service life of a vegetated roof is considered 20-40 years (Blatt Nr. 4.2, 2009).

A high albedo (e.g. white PVC), straight-order roof has a shorter, 15-30 year service life (Blatt Nr. 4.2, 2009); however, the reduced surface temperature increases the membrane's lifespan according to the Arrhenius-equation (Lstiburek, 2006).

Comparing the two options, in most climates cool roofs are considered less risky, but in cold climate the high albedo surface can contribute moisture accumulation in a self-drying construction (Bladau, Zirkelbach, Kunzel, 2008).

Water Efficiency (WE)

According to a survey (Kernan, 2007) occupants of some green buildings have experienced issues with high-efficiency/dual flush toilets and waterless urinals. However, proper maintenance (e.g. cartridge replacement) can reduce the occurrence of such problems.

Energy & Atmosphere (EA)

The passive strategies for energy efficiency optimization generally have a longer lifespan than active solutions. Passive strategies include building orientation, passive solar design, and increased thermal insulation. Although the active components - heating/cooling and ventilation (15-25 years), service water heating (15-25 years), lighting fixtures (10-20 years) - have a shorter service life, they often cannot be substituted completely for passive strategies. For example, so-called "passive houses" typically use active high-efficiency heat recovery ventilation systems.

Durability-related risks in this category are associated with choices regarding the building envelope and HVAC system design and operation. These are complex systems with significant levels of physical interaction. Unanticipated or unplanned changes in operations or external conditions can alter long-term performance. For example, increased thermal insulation may change the dew-point location within the wall and potentially promote damaging condensation (Odom, Scott, DuBose, 2008). Similarly, an unconventional HVAC system may be difficult to maintain and operate and, consequently, create the risk for occupant comfort problems (Kernan, 2007).

Materials & Resources (MR)

Durability-related risks associated with MR credits relate to the possibility of reusing contaminated building components with reduced lifespan or applying new/recycled materials with less known hygrothermal properties (Odom, Scott, DuBose, 2008). However, in practice, recycled components are rarely used in the enclosure (e.g. thermal insulation), but conventional building materials – e.g. steel frame, gypsum board – often contribute to this credit (Kernan, 2007). The lifetime of locally produced or recycled building materials can vary from 10 years (e.g. a carpet) to 50+ years (a structural element). Reused materials are usually limited to salvaged brick, structural timber, stone, and pavers; but, for example, a remanufactured wood door as a built-in countertop is also eligible. The potential risk of new materials can be reduced significantly by accelerated aging and other laboratory tests.

Retaining an existing building envelope – as part of the MRc1.1 credit – may contribute to durability-related risk. The addition of a non-permeable waterproofing membrane to an existing built-up roof has the potential to trap moisture underneath leading to membrane blisters. This could contribute to premature failure through puncture and leakage (Bailey, Bradford, 2005). Thoughtful construction techniques including thorough inspection, the application of waterproofing membrane with higher vapor-permeability and/or the installation of breather vents can decrease this risk significantly (Dudás, Farkas, 2013). (The non-structural roofing materials are excluded from the calculation of this credit. The replacement of such materials, and the installation of a vapor barrier eliminates this risk completely.)

Indoor Environmental Quality (IEQ)

The ventilation-related strategies create potential durability risks for many structures. These are not unique or specific to green buildings, but green building goals may increase the potential for unintended outcomes. The service life of typical mechanical ventilation systems is about 15-25 years (ASHRAE: HVAC Service Life Database, 2013); while, the natural ventilation strategies, based on operable windows, façade in- and outlets are usually more durable: 20-30 years. Sensors and automatic overrides, if implemented, have a durability constraint of about 15 years. Although, natural ventilation can initially be 10-15% less expensive to implement than a comparable mechanical system (CIBSE: Good Practice Guide 237, 1998), greater effort is necessary in the design phase to ensure satisfactory operation. Natural ventilation should be considered as an alternative especially in colder climates.

In terms of thermal comfort controllability (IEQc6.2), operable windows without sensors may be more durable than individual diffusers, radiant panels (10 years). However, windows left unintentionally open can let rainwater and/or humid air into the building, causing moisture-related problems.

The building flush-out path within the Construction Indoor Air Quality Management Plan–Before Occupancy credit (IEQc3.2) uses the HVAC system to evacuate contaminants after construction. The process is supplying a total air volume of 14,000 cubic feet per square foot outdoor air. This credit requires maintaining a relative humidity of no higher than 60% and an internal temperature at a minimum of 60°F. Attention to these requirements is necessary to reduce the risk of introducing humid air into the building (Odom, Scott, DuBose, 2008). Therefore, in hot and humid climates the Air Testing compliance path is recommended, or the flush-out process should be accompanied with stringent moisture control.

In hot and humid climates, the Indoor Chemical and Pollutant Source Control credit (IEQc5) may also be associated with durability-related risk, since the higher exhaust rate can lead to local depressurization potentially pulling the humid outside air into the building (Odom, Scott, DuBose, 2008).

The Daylight and Views – Daylight (IEQc8.1) credit might also have an effect on durability. The shadings' structural supports may create thermal bridges, resulting in potential condensation in the wall structure. However, a large glazing without adequate shading can contribute to excessive heat gain (Kernan, 2007).

The selection of materials also has the potential to introduce risks or uncertainty. For example, the specification of low emitting adhesives and sealants (IEQc4.1) without formaldehyde may be perceived or realized to have lower adherence performance than conventional products (Desmarais, Trempe, Gonçalves, 2010). This could result in perceived or actual underperformance. However, the "green" attributes of such products may or may not be responsible for any changes in long-term performance. In practice, this is difficult to evaluate systematically.

6. CONCLUSIONS

This paper establishes a systematic framework to evaluate connections between green building strategies and durability considerations. The framework to evaluate elements of the LEED for New Construction and Major Renovations (2009) Rating System, describes the expected service life of key elements, LEED credits and categories, and assesses the durability-related risks to individual green building strategies.

The main results:

- The service life of LEED-NC rating system components varies from 13 to 34 years, with an average of 23 years;
- 44% of LEED-NC credits are expected to perform throughout the full lifetime of the building (50+ years);
- More than half of the credits (54%) are expected to have a service life of more than 30 years;
- 72% of credits are expected to perform for 25 years or more.
- More than three quarters of the credits (78%) are expected to perform for at least 20 years;
- Only 4 credits (7%) are expected to perform for less than 10 years. These include contract-based policies, such as green power purchasing, or commissioning after occupancy.

Overall, these statistics suggest that LEED intends to promote long-lasting, durable solutions. The degree of durability varies significantly among credits as a function of typical implementation strategies. This reflects the degree to which durability is not a separable concept within green building practice, rather it is integral to almost every dimension of green building. This means that green building practitioners are faced with opportunities and trade-offs that can increase or decrease potential durability. The challenge is to find the optimal trade-off that balances first costs, risks, and project goals.

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Appendix 1

	Credit code	Points	Credit name (LEED - NC 2009)	Durability-dependent	Durability-independent	CSLmin (yr)	CSLmax (yr)
Sustainable Sites	SSp1	Pr	Construction activity pollution prevention		✓	-	-
	SSc1	1	Site selection		✓	**50**	**50**
	SSc2	5	Development density and community connectivity		✓	**10**	**50**
	SSc3	1	Brownfield redevelopment		✓	**50**	**50**
	SSc4.1	6	Alternative transportation - public transportation access		✓	**10**	**50**
	SSc4.2	1	Alternative transportation - bicycle storage and changing rooms	✓		**20**	**50**
	SSc4.3	3	Alternative transportation - low-emitting and fuel-efficient vehicles	✓		**2**	**50**
	SSc4.4	2	Alternative transportation - parking capacity	✓		**2**	**50**
	SSc5.1	1	Site development - protect or restore habitat	✓		**20**	**50**
	SSc5.2	1	Site development - maximize open space	✓		**20**	**50**
	SSc6.1	1	Stormwater design - quantity control	✓		**10**	**50**
	SSc6.2	1	Stormwater design - quality control	✓		**10**	**50**
	SSc7.1	1	Heat island effect - nonroof	✓		**20**	**50**
	SSc7.2	1	Heat island effect - roof	✓		**15**	**40**
	SSc8	1	Light pollution reduction	✓		**10**	**15**
Water Efficiency	WEp1	Pr	Water use reduction	✓		**10**	**25**
	WEc1	4	Water efficient landscaping	✓		**10**	**50**
	WEc2	2	Innovative wastewater technologies	✓		**15**	**25**
	WEc3	4	Water use reduction	✓		**10**	**25**
Energy & Atmosphere	EAp1	Pr	Fundamental commissioning of building energy systems		✓	-	-
	EAp2	Pr	Minimum energy performance	✓		**15**	**25**
	EAp3	Pr	Fundamental refrigerant management	✓		**15**	**25**
	EAc1	19	Optimize energy performance	✓		**15**	**25**
	EAc2	7	On-site renewable energy	✓		**20**	**25**
	EAc3	2	Enhanced commissioning		✓	**0.83**	**0.83**
	EAc4	2	Enhanced refrigerant management	✓		**15**	**25**
	EAc5	3	Measurement and verification		✓	**1**	**1**
	EAc6	2	Green power		✓	**2**	**2**
Materials & Resources	MRp1	Pr	Storage and collection of recyclables	✓		**10**	**50**
	MRc1.1	3	Building reuse - maintain existing walls, floors and roof	✓		**30**	**50**
	MRc1.2	1	Building reuse - maintain interior nonstructural elements	✓		**10**	**30**
	MRc2	2	Construction waste management		✓	-	-
	MRc3	2	Materials reuse	✓		**15**	**50**
	MRc4	2	Recycled content	✓		**10**	**50**
	MRc5	2	Regional materials	✓		**10**	**50**
	MRc6	1	Rapidly renewable materials	✓		**15**	**30**
	MRc7	1	Certified wood	✓		**15**	**50**
Indoor Environmental Quality	IEQp1	Pr	Minimum indoor air quality performance	✓		**15**	**30**
	IEQp2	Pr	Environmental Tobacco Smoke (ETS) control	✓		**15**	**50**
	IEQc1	1	Outdoor air delivery monitoring	✓		**10**	**20**
	IEQc2	1	Increased ventilation	✓		**15**	**30**
	IEQc3.1	1	Construction IAQ management plan - during construction		✓	-	-
	IEQc3.2	1	Construction IAQ management plan - before occupancy		✓	-	-
	IEQc4.1	1	Low-emitting materials - adhesives and sealants	✓		**3**	**20**
	IEQc4.2	1	Low-emitting materials - paints and coatings	✓		**5**	**15**
	IEQc4.3	1	Low-emitting materials - flooring systems	✓		**10**	**50**
	IEQc4.4	1	Low-emitting materials - composite wood and agrifiber products	✓		**15**	**50**
	IEQc5	1	Indoor chemical and pollutant source control	✓		**3**	**20**
	IEQc6.1	1	Controllability of systems - lighting	✓		**10**	**15**
	IEQc6.2	1	Controllability of systems - thermal comfort	✓		**10**	**25**
	IEQc7.1	1	Thermal comfort - design	✓		**15**	**25**
	IEQc7.2	1	Thermal comfort - verification		✓	**0.5**	**1.5**
	IEQc8.1	1	Daylight and views - daylight		✓	**20**	**50**
	IEQc8.2	1	Daylight and views - views		✓	**10**	**50**
ID	IDc1	5	Innovation in design				
	IDc2	1	LEED Accredited Professional				
RP	RPc1	4	Regional priority				
	∑ (except: ID, RP)	100	∑	**39**	**15**		
				54			