SESCI 2004 Conference
University of Waterloo
Waterloo, Ontario, Canada
August 21st-25th, 2004

LEED™: Evaluating the Impact Potential on Passive/Active Solar Buildings and Renewable Energy

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ABSTRACT

Ever since the building design industry first became conscious of the need for energy conservation and environmentally motivated design 3 to 4 decades ago, reward incentives for high performance buildings have been less than enthusiastically accepted by the building industry.

The idea of energy and environmentally *improved* design has recently gained momentum. The **L**eadership in **E**nergy and **E**nvironmental **D**esign (LEED™) Green Building Rating System is an assessment tool that is currently being promoted throughout North America for the evaluation and promotion of sustainable design. The goal of LEED™ is to initiate and promote practices, which limit the negative impact of buildings on the environment and occupants. The design guideline is intended to prevent exaggerated or false claims of sustainability and to provide a standard of measurement of and between buildings. In addition to creating a working definition of "green building", LEED promotes integrated, whole-building integrated design practices (IDP).

LEED is beginning to function as a "motivational" tool to those in the building industry, because of its "medal" oriented rating system. Buildings are awarded Platinum, Gold, Silver or Certified status based on a system of reward points. The structure of the LEED rating system is segmented into sections, credits and points. The five key sections (initiatives) are identified as sustainable sites, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality. In addition to these five initiatives, a sixth section is reserved for design process and innovation. This framework definition of sustainable design extends former ideas of energy efficient design to include aspects that encompass the whole building, all of its systems, and all questions related to site development.

The energy crisis of the mid 1970s, resulted in modifications to building design, envelope design, insulation levels and airtightness that were specifically focused on increasing *energy conservation* through building envelope performance. This area of interest only accounts for 25% of the current list of requirements for sustainable design under the LEED umbrella.

The paper will fully explain the workings of the LEED Rating System, with a focus on issues that would be most relevant to members of SESCI. Included in this exploration will be a LEED chart based analysis of the 69 points, highlighting and explaining which of the areas can be directly impacted by SESCI areas of focus: passive solar, active solar, daylighting, wind, solar water, etc. An additional "motivational/marketing" purpose of this chart will be to illustrate the importance of these issues in gaining LEED accreditation for buildings. Conversely, I will also explore the reverse scenario – can a designer achieve LEED certification while ignoring significant SESCI topic areas.

INTRODUCTION

Background

Ever since the building design industry first became conscious of the need for energy conservation and environmentally motivated design 3 to 4 decades ago, reward incentives for high performance buildings have been less than enthusiastically accepted by the building industry.

The idea of energy and environmentally *improved* design has recently gained momentum. The **L**eadership in **E**nergy and **E**nvironmental **D**esign (LEED™) Green Building Rating System is an assessment tool that is currently being promoted throughout North America for the evaluation and promotion of sustainable design. The goal of LEED™ is to initiate and promote practices, which limit the negative impact of buildings on the environment and occupants. The design guideline is intended to prevent exaggerated or false claims of sustainability and to provide a standard of measurement of and between buildings. In addition to creating a working definition of "green building", LEED promotes integrated, whole-building integrated design practices (IDP).

LEED is beginning to function as a "motivational" tool to those in the building industry, because of its "medal" oriented rating system. Buildings are awarded Platinum (52-69 points), Gold (39-51 points), Silver (33-38 points) or Certified (26-32 points) status based on a system of reward points. The structure of the LEED rating system is segmented into sections, credits and points. The five key sections (initiatives) are identified as sustainable sites, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality. In addition to these five initiatives, a sixth section is reserved for design process and innovation. This framework definition of sustainable design extends former ideas of energy efficient design to include aspects that encompass the whole building, all of its systems, and all questions related to site development. Most sections include one or more basic *prerequisite* items. These must be fulfilled or the balance of the points in the category will not be counted.

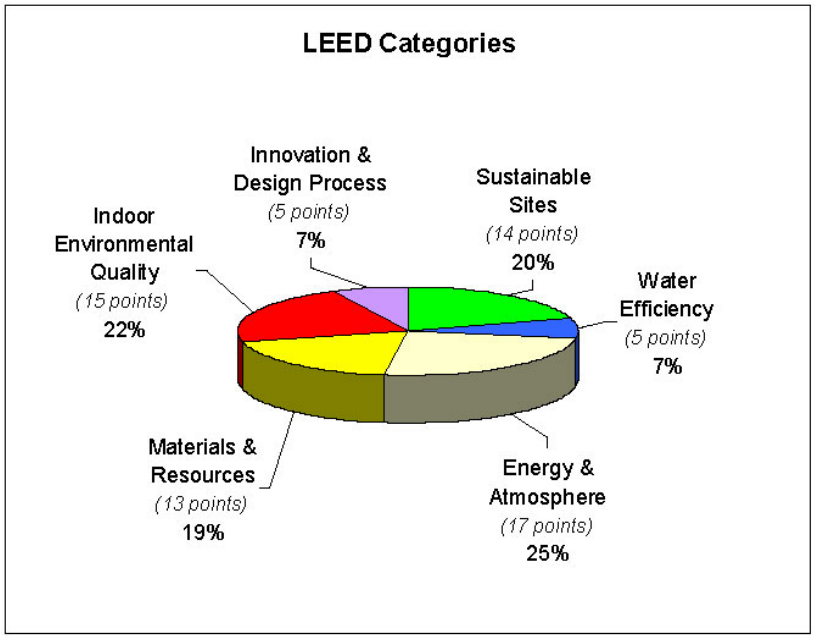


Figure 1: The LEED Pie

The energy crisis of the mid 1970s began to promote passive and active solar systems as a means to reduce dependence on fossil fuels for heating and cooling buildings. This motivation also resulted in modifications to building design, envelope design, insulation levels and airtightness that were specifically focused on increasing *energy conservation* through building envelope performance. This area of interest

only accounts for 25% of the current list of requirements for sustainable design under the LEED umbrella. Both passive and active solar systems played key contributing roles in answering the basic question of fossil fuel dependency reduction as an answer to energy conservation issues. In order to take full advantage of the LEED credit system, it is imperative to understand how passive and active solar as well as renewables figure into the LEED credit system. Interestingly, the importance of these systems pervades well beyond the issue of energy conservation, which would be included only in the Category of "Energy and Atmosphere".

This paper will delve into the relationship between "SESCI Interests" and LEED on 3 levels. First, a general look at the LEED Categories and the areas of passive, active and renewables will address a visualization of the categories. Secondly, via a LEED credit spreadsheet that itemizes the points and identifies more specific areas of correlation. And lastly, via a table that describes, credit by credit, more precisely, the actual passive, active and renewable strategies that apply to each credit.

THE LEED CATEGORIES: RELATIONSHIP TO PASSIVE/ACTIVE/RENEWABLES

A. General Relationship:

How do SESCI interests relate to LEED "in general"? What do the LEED credits *look like* in buildings? I ask the second question as from an architectural perspective, historic energy efficient approaches to design are perceived to have produced some distinctly awkward buildings. The built examples contained within this paper have been chosen to illustrate that many of the approaches have become more acceptably mainstream.

Sustainable sites deals primarily with issues of site selection, site access and site design (materials, density, drainage). The prerequisite concerns erosion and sedimentation control on site. There are eight credits offering a total of 14 potential points. The development of sustainable site design is seen as a critical starting point for an attitude towards the entire building design in the IDP. Solar access can play a key role in the success of some aspects of site development. Although urban/brownfield sites, being denser, are highly preferred over rural or green field sites, items such as green roofs do raise solar issues for their success. Stormwater management issues on site can promote the use of cooling ponds, which can be used in more energy efficient cooling systems for the building.

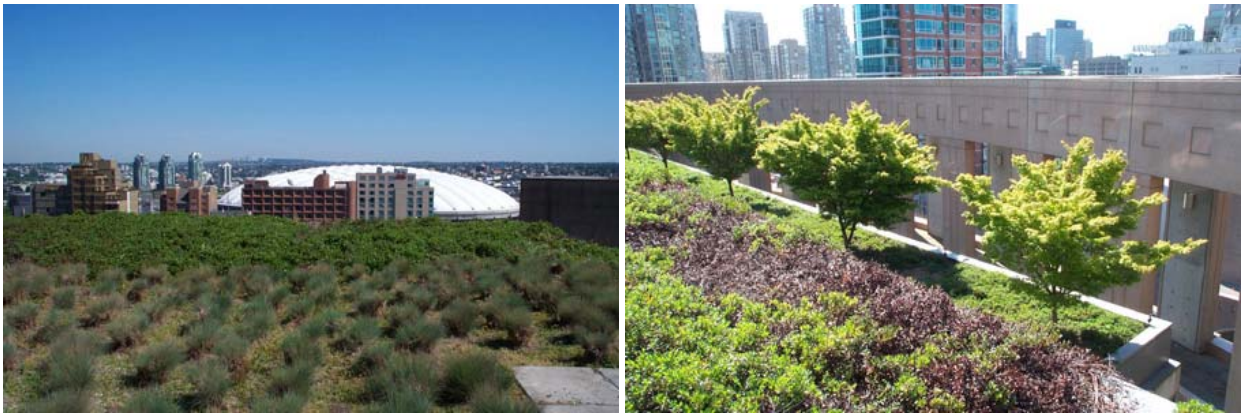


Figure 2: Vancouver Public Library. Moshe Safdie and Associates with Downs Archambault and Partners. *Sustainable Sites:* Credit 7.2 Landscape & Exterior Design to Reduce Heat Islands (roof)

Water efficiency is the smallest section comprising only three credits, worth 5 points. This section deals with landscaping, wastewater treatment and water use reduction. Items such as Living Machines™, use of the Waterloo Biofilter™, waterless urinals and composting toilets can be rewarded with points in this category. Although water efficiency may not present an obvious connection to passive or active solar interests, the proper functioning of water related systems such as Living Machines is

greatly reliant of adequate daylighting of containment spaces, as well as direct solar access to the spaces containing the plants.

Figure 3: YMCA Environmental Learning Centre, Charles Simon Architect
Water Efficiency: Credit 2 Innovative Wastewater Technologies: Living Machine™

Living Machines, Living/Breathing Walls and composting toilets have worked there way into an increasing number of projects. The 3 storey C.K. Choi Building at UBC has successfully used composting toilets since its construction in the mid 1990s. The new campus at the Ontario Technical University in Oshawa has proposed to include a Breathing Wall in its atrium space.

Energy and atmosphere, includes three prerequisites – fundamental building systems commissioning, *minimum energy performance*, and CFC reduction in HVAC&R equipment. The prerequisites are followed by six credits for energy performance, renewable energy and additional building monitoring, with a potential value of eight points. Prior to the adoption of LEED, energy efficiency might have been the only motivation to improving design strategies. Within the holistic sustainable design framework provided by LEED, the relative importance of these issues has been revised to represent only 25% of the potential credits. This is likely the area where interests of passive and active systems as well as renewable energy sources have historically been seen as most important. This continues to be the case with LEED where these systems can answer well to the need for energy reduction in overall performance of the building through credits related to energy optimization, use of renewables and green power.

Figure 4: BC Gas (Terasan Gas) Musson, Cattell Mackey Partnership
Energy Efficiency: Prereq 2: Minimum Energy Performance: Solar shading to reduce energy consumption.

Materials and resources, with 13 points generated in seven credits, this section has only one prerequisite: storage and collection of recyclables. The credits focus on building reuse; waste management; reused, recycled or certified materials; as well as local or regional materials. This portion of the LEED requirements has very little direct relationship to the employment of either passive or active systems or the use of renewables. It is necessary, however, to be cogniscent of the relationship between the specified passive components (i.e. Glazing, windows and shading devices), active components (ie. PV systems and wind turbines) as the shipping distance is critical to obtaining a credit for the supply of materials within a distance that does not increase embodied energy due to transportation related issues. (Credit 5.1: 20% of materials manufactured locally). The limiting distance is within a 500-mile radius and refers to the location of final assembly of the materials into the manufactured product – the materials themselves may come from further afield.

Figure 5: Liu Centre for Asian Studies, UBC, Architectura
Materials and Resources: Credit 4 Recycled Content

Figure 6: C.K. Choi Institute for Asian Studies, UBC, Matsuaki Wright Architects
Materials and Resources: Credit 4 Recycled Content (both the timber frame and brick)

Indoor environment quality is the largest category with two prerequisites, IAQ performance and environmental tobacco smoke control, eight credits and a total of 15 points. The credits in the indoor environment quality cover many issues of air quality, including ventilation and carbon dioxide monitoring, low-emitting materials, construction IAQ, controllability of systems, thermal comfort and daylight access. This category places high emphasis on occupant comfort and well-being – issues that are not addressed in other mandatory code requirements – this category falling outside issues of life safety, structural integrity and minimum energy requirements.

Maintaining a high ventilation rate, combined with reduced toxicity as a result of specified components or processes within the building, is the primary goal. Secondly, in the interest of occupant

comfort and satisfaction, the section promotes *perimeter control* of "systems" by the occupant. This would include level of heating, cooling, direct sunlight or daylight. There is considerable room in the category for the incorporation of passive interests that will include passive cooling/ventilation and daylighting. As passive and active solar buildings have historically relied on occupant involvement to open and close windows and shades as a means to regulate the interior environment, this credit tends to work with pre-existing passive and active systems.

Issues of consistency in levels of thermal comfort may pose some issues for traditional passive systems whose success often relies on an expanded acceptable "comfort zone" due to outdoor temperature fluctuations that may not always be immediately compensated for by natural systems. This will often necessitate hybrid systems that require passive components *and* mechanical/electrical supply *and* sensors to provide automated switching between the two systems.

Figure 7: Mountain Equipment Coop, Toronto, Stone Kohn and Vogt Architects
Indoor Environmental Quality: Credit 8 Daylighting

Figure 8: C.K. Choi Institute for Asian Studies, UBC, Matsuaki Wright Architects
Indoor Environmental Quality: Ventilation Effectiveness + Control of Perimeter systems

Post occupancy assessment of systems is always important. The operable windows on the C.K. Choi Building may provide user control and ventilation, but feedback indicated that the style of window and its method of opening were uncomfortable for the users. The extreme height and inward tilt was found to feel "threatening", and the upward flow of air was not immediately felt.

Innovation and design process allows a building to obtain as many as four design innovation points, as well as one additional point for including a LEED accredited professional in the design process. The design innovation points may be awarded for achievements such as lifecycle analysis, community development or education of occupants. Substantially exceeding one of the earlier credits, may also merit an innovation point. So for example if adequate passive and active systems were incorporated into the design as to allow the building to function independent of the grid, this would qualify for an innovation point. A point is also given for the involvement of a LEED Accredited Professional, which may be somewhat self-serving to the system, but does encourage a higher level of sustainable design education of the profession to pass through the accreditation exam process.

Figure 9: *Innovation and Design Process:* CMHC Healthy House, Martin Leifhebber Architect, Toronto, Ontario
Potentially off grid house in urban setting.

Increased interest in innovative sustainable design construction methods that have more recently been imported from European models, such as double skin wall façade systems, can also qualify for an innovation point. These buildings are normally more sustainable motivated, and the double skin wall system will also impact issues of perimeter control, access to natural ventilation, indoor air quality, thermal quality, envelope performance as well as protection of shading devices in harsh climates. Such systems can now be seen in the Telus/William Farrell Building designed by Busby and Associates in Vancouver, the Caisse de Depots et Placement, in Montreal and currently under construction, the Centre for Cellular and Biomolecular Research at the University of Toronto, by Benisch, Benisch with Architects Alliance.

Figure 10: *Innovation and Design Process:* Caisse de Depots et Placements, Montreal
Double skin wall construction.

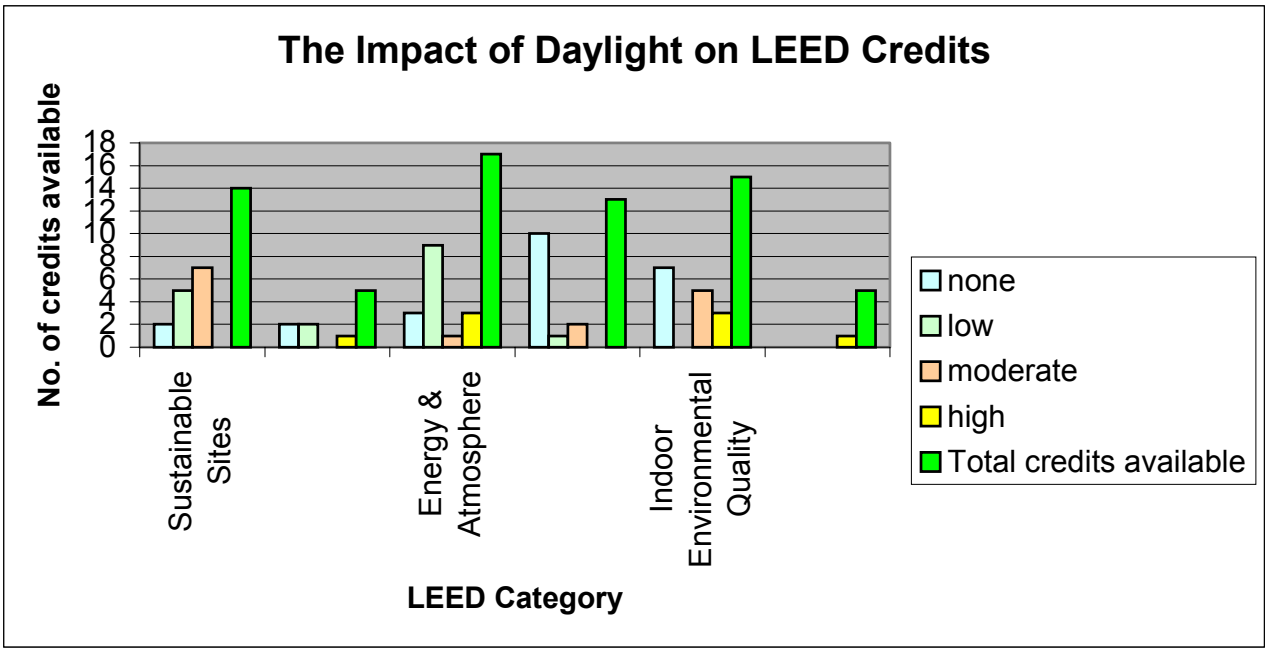
B. The LEED Spreadsheet: Visual Diagramming of the Relationship between the LEED and SESCI

Within this study interest areas of the SESCI Group were identified. These would include:
Active Systems: Solar Collectors, Space Heating, Domestic Hot Water
Passive Systems: Passive Solar Heating, Passive Cooling/Ventilation, Daylighting
Renewables: Photovoltaics, Wind, Biomass, Geothermal
Miscellaneous: Wetlands, Living Machines™ or similar non-proprietary systems, Aquaculture, Biofilter™ or other non-proprietary systems, Green Roofs.

The charts that follow were created by examining the LEED criteria point by point, and identifying the ones that would see the above systems effect a positive outcome. This does not necessarily mean that the positive outcome is invariably linked to the passive/active/renewable, only that inclusion of this system is likely to produce a better outcome. Also, one of the limitations of the LEED system is its usual award of one point per credit. Hence daylighting, for example, only has two directly linked credits that require a specified level of daylighting. Daylighting can and will have an impact on other credits. This linkage is illustrated in Table 2a and Table 2b, and verbally expanded in Table 3.

A detailed expansion of the relationship between LEED and Daylighting was carried out by Caroline Prochazka in her work entitled: "Emergent Threshold: Daylight Modeling and Sustainable Design." The linkage between daylighting as a single factor was examined throughout all of the LEED Credits and rated as "none, low, moderate or high". The following table illustrates the outcome of this study.

Table 1: Relationship Between LEED Criteria and Daylighting



Visually it is easy to see the relationship between the interest areas and the specific points. The relationship to Sustainable Sites is less direct. The impact on Water Efficiency has largely to do with innovative water systems, rather than solar interests. The impact on Energy and Atmosphere is very high – higher even than the numbers might indicate. Credit 1: Optimize Energy Performance can assign a range of points varying from 1 to 10. Only 1 point has been credited on this table for any of the solar interest areas (totaling 6 across the table). This may vary by project as a function of the number and intensity of systems employed in the design.

Table 2a: Detailed Breakout of Relationship between LEED Categories ***Sustainable Sites, Water Efficiency, Energy and Atmosphere*** and SESCI Interests

LEED Rating System Version 2.1		Active			Passive			Renewables				Miscellaneous					
This chart creates a pictoral summary of the relationship between solar areas of interests and LEED credits. Each incidence is recorded as a value of "1" for the purpose of chart addition. Totals and values are meant to infer areas of importance and do not necessarily directly relate to the actual number of potential LEED credits.		Solar Collectors (SC)	Space Heating (SH)	Domestic Hot Water (HW)	Passive Heating (PS)	Passive Cooling (PC)	Daylighting (D)	Photovoltaics (PV)	Wind (W)	Biomass (B)	Geothermal (G)	Wetlands (WL)	Living Machine (LM)	Aquaculture (A)	Biofilter (BF)	Green Roof (GR)	Relative Impact on Credit
	---Sustainable Sites---																
Prereq 1	Erosion & Sedimentation Control										1	1					**2**
Credit 1	Site Selection																0
Credit 2	Development Density				1	1	1										**3**
Credit 3	Brownfield Redevelopment																0
Credit 4.1	Alternative Transportation, Pub. Trans. Access																0
Credit 4.2	Alternative Transportation, Bike Stor. & Changerooms																0
Credit 4.3	Alternative Transportation, Alt. Fuel Vehicles							1									**1**
Credit 4.4	Alternative Transportation, Parking Capacity																0
Credit 5.1	Reduced Site Disturbance,Open Space				1	1	1	1	1								**5**
Credit 5.2	Reduced Site Disturbance,Footprint				1	1	1										**3**
Credit 6.1	Stormwater Management, Rate and Quantity											1					**1**
Credit 6.2	Stormwater Management, Treatment											1	1	1			**3**
Credit 7.1	Landscape: Reduce Non-roof Heat Islands					1											**1**
Credit 7.2	Landscape: Reduce Roof Heat Islands							1								1	**2**
Credit 8	Light Pollution Reduction																0
	Sustainable Sites Sub Total	0	0	0	**3**	**4**	**3**	**3**	**1**	0	0	**2**	**1**	**1**	0	**1**	**19**
	---Water Efficiency---																
Credit 1.1	Water Efficient Landscaping, Reduce by 50%											1		1			**2**
Credit 1.2	Water Efficient Landscaping, No Potable/No Irrigation											1					**1**
Credit 2	Innovative Wastewater Technologies						1						1		1		**3**
Credit 3.1	Water Use Reduction, 20% Reduction												1		1		**2**
Credit 3.2	Water Use Reduction, 30% Reduction												1		1		**2**
	Water Efficiency Sub Total	0	0	0	0	0	**1**	0	0	0	0	**2**	**3**	**1**	**3**	0	**10**
	---Energy & Atmosphere---																
Prereq 1	Fundamental Building Systems Commissioning	1			1	1	1	1									**5**
Prereq 2	Minimum Energy Performance	1			1	1	1	1									**5**
Prereq 3	CFC Reduction in HVAC&R Equipment										1						**1**
Credit 1	**Optimize Energy Performance (1-10 pts)**	**1**		**1**	**1**	**1**	**1**	**1**									**6**
Credit 2.1	Renewable Energy, 5%	1	1	1	1	1	1	1	1	1	1						**10**
Credit 2.2	Renewable Energy, 10%	1	1	1	1	1	1	1	1	1	1						**10**
Credit 2.3	Renewable Energy, 20%	1	1	1	1	1	1	1	1	1	1						**10**
Credit 3	Additional Commissioning																0
Credit 4	Ozone Depletion																0
Credit 5	Measurement & Verification				1	1	1										**3**
Credit 6	Green Power							1	1	1							**3**
	Energy and Atmosphere Sub Total	**6**	**3**	**4**	**7**	**7**	**7**	**7**	**4**	**4**	**4**	0	0	0	0	0	**53**

Table 2b: Detailed Breakout of Relationship between LEED Categories ***Materials and Resources, Energy and Atmosphere and Innovative Design Process*** and SESCI Interests

LEED Rating System Version 2.1		**Active**			**Passive**			**Renewables**				**Miscellaneous**					
This chart creates a pictoral summary of the relationship between solar areas of interests and LEED credits. Each incidence is recorded as a value of "1" for the purpose of chart addition. Totals and values are meant to infer areas of importance and do not necessarily directly relate to the actual number of potential LEED credits.		Solar Collectors (SC)	Space Heating (SH)	Domestic Hot Water (HW)	Passive Heating (PS)	Passive Cooling (PC)	Daylighting (D)	Photovoltaics (PV)	Wind (W)	Biomass (B)	Geothermal (G)	Wetlands (WL)	Living Machine (LM)	Aquaculture (A)	Biofilter (BF)	Green Roof (GR)	Relative Impact on Credit
	---Materials & Resources---																
Prereq 1	Storage & Collection of Recyclables																0
Credit 1.1	Building Reuse, Maintain 75% of Existing Shell																0
Credit 1.2	Building Reuse, Maintain 100% of Shell																0
Credit 1.3	Building Reuse, Keep 100% of Shell/50% Non-Shell																0
Credit 2.1	Construction Waste Management, Divert 50%																0
Credit 2.2	Construction Waste Management, Divert 75%																0
Credit 3.1	Resource Reuse, Specify 5%																0
Credit 3.2	Resource Reuse, Specify 10%																0
Credit 4.1	Recycled Content, 5% p.c. or 10% (p.c. + p.i.)																0
Credit 4.2	Recycled Content, 10% p.c. or 20% (p.c. + p.i.)																0
Credit 5.1	**Local/Regional Materials, 20% Manufactured Locally**																**0**
Credit 5.2	Local/Regional Materials, 50% Harvested Locally																0
Credit 6	Rapidly Renewable Materials																0
Credit 7	Certified Wood																0
	Materials and Resources Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	---Indoor Environment Quality---																
Prereq 1	Minimum IAQ Performance				1	1	1										**3**
Prereq 2	Environmental Tobacco Smoke (ETS) Control																0
Credit 1	Carbon Dioxide (CO2) Monitoring					1											**1**
Credit 2	Increase Ventilation Effectiveness				1	1	1										**3**
Credit 3.1	Construction IAQ Management Plan, During Constr.																0
Credit 3.2	Construction IAQ Management Plan, Pre-Occup.																0
Credit 4.1	Low-Emitting Materials, Adhesives & Sealants																0
Credit 4.2	Low-Emitting Materials, Paints																0
Credit 4.3	Low-Emitting Materials, Carpet																0
Credit 4.4	Low-Emitting Materials, Composite Wood																0
Credit 5	Indoor Chemical & Pollutant Source Control																0
Credit 6.1	Controllability of Systems, Perimeter				1	1	1										**3**
Credit 6.2	Controllability of Systems, Non-Perimeter		1		1	1	1										**4**
Credit 7.1	Thermal Comfort, Comply with ASHRAE 55-1992				1	1	1										**3**
Credit 7.2	Thermal Comfort, Permanent Monitoring System				1	1	1										**3**
Credit 8.1	Daylight & Views, Daylight 75% of Spaces				1	1	1										**3**
Credit 8.2	Daylight & Views, Views for 90% of Spaces				1	1	1										**3**
	Indoor Environmental Quality Sub Total	0	**1**	0	**8**	**9**	**8**	0	0	0	0	0	0	0	0	0	**26**
	---Innovation & Design Process---																
Credit 1.1	Innovation in design	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	**15**
Credit 1.2	Innovation in design																
Credit 1.3	Innovation in design																
Credit 1.4	Innovation in design																
Credit 2	LEEDTM Accredited Professional																
	Innovation and Design Process Sub Total	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	**15**
Total Pts		**5**	**5**	**5**	**16**	**18**	**17**	**9**	**6**	**5**	**4**	**5**	**5**	**3**	**4**	**2**	**109**

Table 3: LEED: Areas of Development for the Interests of the Canadian Solar Energy Society:

CATEGORY				
Active Solar	Solar collectors (SC)	Space heating (SH)	Domestic hot water (HW)	
Passive Solar	Passive solar heating (PS)	Passive cooling (PC)	Daylighting (D)	
Renewable Energy	Photovoltaics (PV)	Wind (W)	Biomass (B)	Geothermal (G)
Other/miscellaneous	Wetlands (WL)	Living Machines (LM)	Aquaculture (A)	Biofilter (BF)
	Green Roof (GR)			

Credit	**Points**	**Name and Description**	**Impact on Passive/ Active**	**Strategies with Potential Impact Positive / negative**	**Role of Passive/Active/Renewables**
		Sustainable Sites			
Prereq		**Erosion and Sedimentation Control**: reduce negative impacts on water and air quality	low	G, WL	Can impact the use of ponds for cooling, rainwater collection, drainage issues..
1	1	Site Selection: do not develop on land which is prime farmland, habitat for any threatened or endangered species, within 100 of water ways or wetlands, lower than 5 feet above the 100 year flood or public parkland	moderate	SC, PS, PC, D, PV, W	While urban sites pose challenges with over-shadowing from nearby neighbouring buildings, rural sites provide freedom for solar design. Some of those sites that are ideal for solar design, and that would accommodate wind, wetlands, etc., may not be permitted by this credit.
2	1	Development Density: utilize sites within a density zone of 60000 s.f./acre (2-storey downtown development density)	moderate	PS, PC, D, W	Increased site density may require deeper floor-plates and more urban siting (less daylight access and less potential for passive heating and cooling). Designs may need to include atrium spaces to promote daylighting.
3	1	Brownfield Redevelopment: remediate contaminated site for building use	none		For brownfield sites in urban settings, there *may* be solar access issues to consider.
4.1	1	Alternative Transportation: locate project near commuter rail, subway or bus lines	none		Commuter systems are often only available in built-up areas, which *may* impact solar access.
4.2	1	Alternative Transportation: include secure bicycle storage, showers and changerooms	none		Bicycle storage is often only useful on sites near urban centres. This *may* pose solar access problems.

Credit	Points	Name and Description	Impact	Positive / negative	Role of Passive/Active/Renewables
		Sustainable Sites cont'd			
4.3	1	Alternative Transportation: provide alternative-fuel vehicles or alternative-fuel refuelling stations.	low	PV	May promote use of PV to charge cars.
4.4	1	Alternative Transportation: encourage car-pools/van-pools and limit new parking	none		Likely only practical where commuter systems are available in urban settings (potential solar access concerns).
5.1	1	Reduced Site Disturbance: limit site disturbance to conserve and restore habitats and biodiversity	moderate	PS, PC, PV, W, D	Promotes greater care for the unbuilt, exterior part of a site. This may encourage design for solar access. In remote areas where grid access is limited, the use of PV and wind power can be seen as viable energy sources.
5.2	1	Reduced Site Disturbance: reduce the development footprint to exceed local zoning requirements for open space	low	PS, PC, D	Dense buildings may be easier to passively light, heat and cool as this point implies a shallow floor plate.
6.1	1	Stormwater Management: limit the rate and quantity of stormwater run-off	none	WL	Promotes on site water management, cooling ponds, wetlands.
6.2	1	Stormwater Management: Include a stormwater treatment system on site to eliminate contaminants and increase infiltration.	moderate	WL, LM, A	Potentially may encourage creation of constructed wetlands, living machines, aquaculture ponds.
7.1	1	Heat-Island Effect: provide shade within 5 years or place parking underground or use open grid paving	moderate	PC, D	Careful selection of trees may provide seasonal shading of glazed areas. This will net a positive impact on passive cooling and negative on daylighting.
7.2	1	Heat-Island Effect: use high-albedo roofing or a green roof	moderate	GR, PV	Green roof requires some solar access. Choice of materials may affect reflectivity of roof, hence solar gain or daylighting impacted. BIPV roofing may be acceptable as most are mounted on white coloured membranes.
8	1	Light Pollution Reduction: reduce the impact of building and site lighting on nocturnal habitats and night-sky access	low	D	Select interior lighting scheme to reduce light leakage to exterior. This may impact window layout as well. Large areas for solar gain may need nighttime shading to prevent light leakage.

Credit	Points	Name and Description	Impact	Positive / negative	Role of Passive/Active/Renewables
		Water Efficiency			
1.1	1	Water Efficient Landscaping: reduce use of potable water for irrigation by 50%	low	PS, D, WL, A	Bright daylit sites that promote passive solar and daylighting will tend dry out faster. Using drought resistant plants and careful soil composition will reduce the need for irrigation on sunny sites.
1.2	1	Water Efficient Landscaping: use no potable water for irrigation or do not install a permanent irrigation system	low	WL	Can promote rainwater collection, use of wetland.
2	1	Innovative Wastewater Technologies: reduce building sewage by 50% or treat 100% of waste water on site	high	D, LM, BF	Daylight is required for proper growth and functioning of biofiltration system. UV has role in killing bacteria.
3.1	1	Water Use Reduction: reduce building water consumption by 20% over the calculated baseline	low	LM, BF	Promotes use of efficient fixtures, Living Machines and Biofilters.
3.2	1	Water Use Reduction: reduce building water consumption by 30% over the calculated baseline	low	LM, BF	Promotes use of efficient fixtures, Living Machines and Biofilters.

		Energy & Atmosphere			
Prereq		**Fundamental Building Systems Commissioning:** verify design, installation and calibration of the fundamental building systems	high	PS, SC, PC, PV, D	Photosensors and dimmable fixtures must be adjusted to the comfort of occupants but also to perform as originally specified for energy savings. Requires post occupancy analysis to ensure that passive systems and controls are working properly for occupant comfort.
Prereq		**Minimum Energy Performance:** ensure a minimum energy efficiency to comply with ASHRAE 90.1-1999	high	PS, SC, PC, PV, D	Careful design for and accounting of daylighting will permit energy savings through reduced artificial lighting. Promotes passive solar heating, passive cooling.
Prereq		**CFC Reduction in HVAC&R Equipment**: base building HVAC&R equipment is to use no CFC-based refrigerants	low	G	Passively heated and cooled buildings tend to be less reliant on a variety of HVAC&R systems that could lose this point/category.
1	1 - 10	Optimize Energy Performance: exceed the ASHRAE 90.1-1999 energy performance standard for regulated systems	high	PS, SC, DH, PC, PV, D	Significant savings are possible through efficient use of daylighting and reduced use of artificial lights, passive heating, passive cooling, PV.

Credit	Points	Name and Description	Impact	Positive / negative	Role of Passive/Active/Renewables
		Energy & Atmosphere cont'd			
2.1	1	Renewable Energy: include on-site renewable energy systems to provide at least 5% of the total energy use of the building	high	PS, SC, PC, PV, D, G, B, HW, SH, W	Photovoltaic systems work in tandem with daylighting. Building integrated photovoltaics can be mounted to shading devices. Thin-film photovoltaics can be mounted directly on glazed surfaces. Both daylighting and photovoltaics require good solar access. Also promotes passive solar heating, passive cooling, solar collectors, domestic water heating, wind, space heating, biomass, wind, geothermal systems.
2.2	1	Renewable Energy: include on-site renewable energy systems to provide at least 10% of the total energy use of the building	high	PS, SC, PC, PV, D, G, B, HW, SH, W	
2.3	1	Renewable Energy: include on-site renewable energy systems to provide at least 20% of the total energy use of the building	high	PS, SC, PC, PV, D, G, B, HW, SH, W	
3	1	Additional Commissioning: complete additional verification of systems design, construction and calibration	low	PS, PC, D	Post occupancy evaluations more often required for passive buildings to ensure that occupants have been properly educated to prevent improper functioning of building.
4	1	Ozone Protection: ensure that base building HVAC&R and fire suppression systems do not use HCFCs or Halons	none		No significant impact.
5	1	Measurement and Verification: install metering equipment for key efficiency issues including lighting systems, motor loads, chiller efficiency, cooling load, and several others	high	PS, PC, D	Install photosensors and dimmable ballast to make proper use of available daylight. Thermal sensors required to control active supplements of heating and cooling for passive buildings and to give indication to occupants involved in operating supplemental systems.
6	1	Green Power: engage in a minimum two-year contract for renewable energy to supply at least 50% of the building's electricity	high	B, W, PV	Promotes biomass, wind, PV.
		Materials & Resources			
Prereq		**Storage and Collection of Recyclables:** provide facilities for storage and separation.	none		No significant impact.
1.1	1	Building Reuse: retain 75% of walls, floors and roof of existing building on site	low	PS	No significant link to CSECI interests, although solar orientation may be pre-determined where foundations or shell/structure are being re-used. Existing window openings, affecting potential.

Credit	Points	Name and Description	Impact	Positive / negative	Role of Passive/Active/Renewables
		Materials & Resources cont'd			
1.2	1	Building Reuse: retain 100% of walls, floors and roof of existing building on site	moderate	PS	
1.3	1	Building Reuse: retain 100% of shell/structure and 50% of non-shell/non-structure portions of existing building on site	moderate	PS	
2.1	1	Construction Waste Management: recycle and/or salvage 50% of site waste (construction, demolition and land clearing) to limit material going to landfill	none		No significant link SESCI interests on the project site.
2.2	1	Construction Waste Management: recycle and/or salvage 75% of site waste (construction, demolition and land clearing) to limit material going to landfill	none		
3.1	1	Resource Reuse: source 5% of building materials as salvaged, refurbished or reused	none		No significant link SESCI interests on the project site..
3.2	1	Resource Reuse: source 10% of building materials as salvaged, refurbished or reused	none		
4.1	1	Recycled Content: source 5% of building materials as post-consumer product or 10% of building materials as post-consumer and post-industrial	none		No significant link SESCI interests on the project site.
4.2	1	Recycled Content: source 10% of building materials as post-consumer product or 20% of building materials as post-consumer and post-industrial	none		
5.1	1	Regional Materials: ensure that at least 20% of building materials and products are manufactured within a 500mi radius of the site	low		Specify glazing, shading, PV and wind systems, etc. from suppliers within the 500 mile limit.
5.2	1	Regional Materials: ensure that at least 50% of the building materials and products are harvested, extracted or recovered within a 500mi radius of the site	none		No significant link SESCI interests on the project site.

Credit	Points	Name and Description	Impact	Positive / negative	Role of Passive/Active/Renewables
		Materials & Resources cont'd			
6	1	Rapidly Renewable Materials: ensure that at least 5% of the building materials are made from plants harvested within a ten-year cycle)	none		No significant link SESCI interests on the project site.
7	1	Certified Wood: specify at least 50% of building materials to be wood-based and certified from environmentally responsible forestry operations.	none		No significant link SESCI interests on the project site.
		Indoor Environment Quality			
Prereq		**Minimum IAQ Performance**: establish indoor air quality performance to meet the ASHRAE 62-999 voluntary ventilation standard	moderate	PC, D, PS	Operable windows provide fresh air and significant air exchange and also promote passive heating and daylighting.
Prereq		**Environmental Tobacco Smoke Control:** ensure non-smokers experience no exposure to environmental tobacco smoke	none		Operable windows pose a difficulty if they are near areas where smokers congregate. This should not restrict the ability to provide daylight.
1	1	Carbon Dioxide Monitoring: install a CO_2 monitoring system which reports on ventilation performance and allows operational adjustments	low	PC	Use of operable windows for daylighting allows ample natural ventilation to reduce CO_2 levels.
2	1	Ventilation Effectiveness: provide effective delivery and mixing of fresh air to meet ASHRAE 129-1997 standard for mechanically ventilated buildings OR demonstrate suitable air flow patterns for naturally ventilated buildings.	high	PC, D, PS	Well design window layout will not only provide daylight, but will provide cross-ventilation and a means to free air-conditioning during shoulder seasons. Use of windows promotes potential for passive solar.
3.1	1	Construction IAQ Management Plan: maintain indoor air quality during construction and pre-occupancy phases	none		No significant link SESCI interests on the project site.
3.2	1	Construction IAQ Management Plan: conduct an appropriate building flush-out to eliminate any air problems resulting from construction/renovation processes	none		No significant link SESCI interests on the project site.
3.2	1	Construction IAQ Management Plan: conduct an appropriate building flush-out to eliminate any air problems resulting from construction/renovation processes	none		No significant link SESCI interests on the project site.

Credit	Points	Name and Description	Impact	Positive / negative	Role of Passive/Active/Renewables
		Indoor Environment Quality continued			
3.2	1	Construction IAQ Management Plan: conduct an appropriate building flush-out to eliminate any air problems resulting from construction/renovation processes	none		No significant link SESCI interests on the project site.
4.1	1	Low-Emitting Materials: specify adhesives and sealants which are low in volatile organic compounds (VOCs)	none		No significant link SESCI interests on the project site.
4.2	1	Low-Emitting Materials: specify paints and coatings which are low in VOCs	none		No significant link SESCI interests on the project site.
4.3	1	Low-Emitting Materials: specify carpets which are low in VOCs	none		No significant link SESCI interests on the project site..
4.4	1	Low-Emitting Materials: specify composite wood products which are low in VOCs	none		No significant link SESCI interests on the project site.
5	1	Indoor Chemical and Pollutant Source Control: employ floor grills at entries and appropriate exhaust and plumbing in areas where water and chemical concentrate mixing occurs	none		No significant link SESCI interests on the project site.
6.1	1	Controllability of Systems: provide at least one operable window and one lighting control zone per 200 s.f. within 15 feet of the perimeter wall	moderate	PC, D, PS	An operable window with blinds can provide airflow, temperature control and lighting control for perimeter areas. Windows can promote passive solar.
6.2	1	Controllability of Systems: provide airflow, temperature and lighting controls for at least 50% of occupants in non-perimeter areas	moderate	PC, D, PS, SH	Non-perimeter occupants can still rely on diffuse natural light if care is taken to bounce light deeper into the building, such as with light-shelves, skylights or roof monitors.
7.1	1	Thermal Comfort: ensure compliance with ASHRAE 55-1992 for thermal comfort to include humidity control	moderate	PS, PC, D	Designing daylight systems to avoid direct beam light will prevent thermal discomfort from intent solar heat gain. If thermal mass is being used, it will likely have a noticeable effect on the temperature control in the buildings. Diffuse light can provide illumination without undue heat gain.
7.2	1	Thermal Comfort: install a permanent monitoring system for temperature and humidity and provide operator control over humidification/dehumidification	moderate	PS, PC, D	

Credit	Points	Name and Description	Impact	Positive / negative	Role of Passive/Active/Renewables
		Indoor Environment Quality continued			
8.1	1	Daylight and Views: ensure a minimum of 2% daylight factor to 75% of occupies spaces	high	PS, D, PC	Both daylight credits are best achieved with shallow floor-plates. Interior spaces with low partitions only where needed can maintain high levels of natural light, and direct line-of-site to vision glazing. Daylighting can be used to promote passive solar and presence of windows to promote passive cooling. Light shelves and shades promote passive cooling.
8.2	1	Daylight and Views: ensure direct line of site to vision glazing for 90% of regularly occupied areas	high	PS, D, PC	
		Innovation & Design Process			
1	1 - 4	Innovation in Design: extra credits are awarded for substantially exceeding a LEED performance credit, OR for significant performance in other categories, such as acoustic performance, life-cycle costing or education of occupants.	high	ALL	A well designed passive or active solar building, if shown to perform better than its benchmark due to the inherent SESCI strategies may be eligible for one or more innovation credits as a function of the areas incorporated. Similarly, life-cycle costing can take into account the savings from SESCI interest buildings.
2	1	LEED Accredited Professional: include a LEED accredited professional in the project team	moderate	ALL	No inherent link to SESCI. But mightn't a LEED professional be more interested in incorporating aspects of passive and active solar design, renewables, etc.

CONCLUSION

It is not difficult to see how intrinsically connected are the interests of the SESCI groups and the LEED Credit system. It is evident that, given the pervasiveness of the need for passive solar heating, passive cooling and daylighting in satisfying both the Energy and Atmosphere as well as Indoor Environmental Quality sections of the LEED Credit System, that it would be difficult to attain even a Certified Label without significant incorporation of these disciplines. The added incorporation of Active Systems, Renewables and Miscellaneous water related issues, is necessary to achieve levels of Gold and potentially Platinum.

As an increasing number of jurisdictions, governments and organizations look to adopt LEED Standards for their new and renovated construction, it becomes increasingly important for designers to understand the system and the impact of the tool on their areas of expertise. As LEED itself has been designed as an effective environmental marketing tool, so can it be used to more effectively market passive/active/renewables to potential design clients.

REFERENCES

The research in this paper presents an original interpretation of the thesis. The content of the LEED Credit System Version 2.1 and the description of the points have been taken from LEED documents available online at the US Green Building website: http://www.usbgc.org

The general description of the LEED credit system was taken from an article that I co-authored with Caroline Prochazka, a Masters Candidate at the School of Architecture, University of Waterloo.

LEED: A Primer. Canadian Architect Magazine. January 2004.

The online version is available at:

http://www.canadianarchitect.com/issues/ISarticle.asp?id=145884&story_id=209449105534&issue=01012004&PC=

Base information for Table 3: LEED: Areas of Development for the Interests of the Canadian Solar Energy Society was expanded from information supplied by Caroline Prochazka from her Master of Architecture thesis, "Emergent Threshold: Daylight Modeling for Sustainable Design", July 2004, with her permission.

FIGURES

All photographic images included in this paper were taken by the author.