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LEED™: A Tool for Analysis and Comparison Canadian Building Case Studies

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ABSTRACT

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 to assist the building industry in the *design* of more sustainable buildings. In the process of education and the creation of a body of relevant knowledge pertaining to existing buildings that are purported to be "green", the LEED tool can also be used to perform comparative analyses of existing buildings.

Since the goal of LEED™ has been to initiate and promote practices, which limit the negative impact of buildings on the environment and occupants, it is important to bring the body of existing buildings into a LEED related framework as a means to truly assess their "real" performance under this system.

This thesis would naturally follow the intention of the LEED design guideline "to prevent exaggerated or false claims of sustainability, as well as to provide a standard of measurement". Architects, engineers, designers and students of these areas constantly look to existing buildings and published case studies to assist them in creating new buildings. Unless this work is grounded in some means of qualification and comparison, users might inadvertently copy or reference unsuitable material or examples.

Masters students at the School of Architecture, University of Waterloo, as well as a group of undergraduate students, have been using the LEED design guideline to direct/format the research and writing of case studies of existing green buildings. Included in the documentation has been a LEED analysis of each building, *whether or not it was originally conceived with LEED guidelines in mind.* In fact, some of the most significant buildings on the case study list are key Canadian buildings that pre-date LEED, or who have chosen not to pursue a LEED status. These would include Green on the Grand, the Waterloo Green Home, the CMHC Healthy House, and the YMCA Environmental Learning Centre, Boyne Environmental Centre, Telus William Farrell Building, Mountain Equipment Coop Retail Stores, etc. Full research documentation is presently being completed with funding provided by the Ontario Association of Architects through the Grand Valley Society of Architects. The web site should be more or less complete by the time of this conference (it is never intended to be finished and will constantly seek to expand its database) and the paper will discuss the overall findings of the research, as well as the trends in environmental building design over the last decade as highlighted by both the case studies and the introduction of the LEED Certification System.

http://www.fes.uwaterloo.ca/architecture/faculty_projects/terri/684_sust.html

INTRODUCTION

Real *change* does not just "happen". It requires either a catalyst or a series of events to effect evolution. Lasting change requires both success and commitment. Sustainable design has been no different. The directed evolution of green building, from its inception in the mid 1960s to its current state in the year 2004, has been the result of a series of publications, key events, incentive programs, and significant buildings. Passive and Active Solar Design, as well as efforts in the area of renewables were active players from the outset. These systems typically were incorporated into residential or community based projects. Commercial and institutional building has been slow on the uptake, but progress is beginning to be evident.

> "With lifespans of decades or even centuries, buildings are among the most lasting objects we produce. They account for more than one-third of national energy use and over sixty percent of national electricity consumption. Buildings in the United States alone account for almost 10% of global energy use. They also serve as models for much of the new construction in the developing world. A quick sketch or clay model made by an architect in the earliest stages of design can affect building energy consumption well into the future. A thoughtless decision about building orientation may create a cooling load that lasts as much as a century. Decisions about the extent and type of glazing in a commercial or institutional building will affect power use for thousands of business days." *Vital Signs Project Brief.* http://www.arch.ced.berkeley.edu/vitalsigns/brief/vs1.html

For many years green building practices remained vague due to the inability to judge the success or failure of building projects. Buildings were designated "green" or "sustainable" that may have had marginal interest or moderate success in the implementation of green strategies. During the mid 1990s the US Green Building Council was formed. A means to evaluate the relative "greenness" of buildings was sought. The British counterpart, BREEAM, had been developed, but did not suit North American standards and codes. The LEED assessment tool, launched in 1998, post Kyoto, was developed to: establish a common standard of measurement for green buildings; promote integrated, whole building design processes, stimulate environmental building and competition; make consumers more aware of the benefits; and, transform the building market. By awarding buildings bronze, silver, gold and platinum medals, based on their sustainable design qualifications, the tool was designed to respond to commercial marketing strategies. The oldest certified building was the Kandalama Hotel, in Sri Lanka, constructed in 1994, followed by the Energy Resource Center in Downey, California in 1995. Only a handful of buildings were certified in the first few years, but numbers of projects both registered as intending to apply for certification, and those actually certified, are rapidly growing. It would seem that the idea of LEED is catching on. Numerous cities and government organizations have begun to adopt LEED minimum qualifications standards for all new buildings. As of March 2004 there were 1,118 LEED registered projects in the United States, 93 certified. (www.usgbc.org)

In Canada there have been a number of energy or sustainable related incentive programs introduced over the years, with varying degrees of success. These would include the R-2000 Residential program, C-2000 Commercial Building program and ongoing efforts of the Canadian Building Incentive Program (CBIP). Where the LEED program differs from these is in its intentions as a "marketing tool". A visit to almost any LEED certified building sees the award prominently displayed in the lobby.

THE INTENTIONS OF LEED™

The **L**eadership in **E**nergy and **E**nvironmental **D**esign (LEED™) Green Building Rating System is an assessment tool that is being promoted throughout North America to assist the building industry in the *design* of more sustainable buildings. In the process of education and the creation of a body of relevant knowledge pertaining to existing buildings that are purported to be "green", the LEED tool can also be used to perform comparative analyses of existing buildings.

Since the goal of LEED™ has been to initiate and promote practices, which limit the negative impact of buildings on the environment and occupants, it is important to bring the body of existing buildings into a LEED related framework as a means to truly assess their "real" performance under this system.

This thesis would naturally follow the intention of the LEED design guideline "to prevent exaggerated or false claims of sustainability, as well as to provide a standard of measurement". Architects, engineers, designers and constantly look to existing buildings and published case studies to assist them in creating new buildings. Unless this body of Pre-LEED or non-LEED work is grounded in some means of qualification and comparison, users might inadvertently copy or reference unsuitable material or examples.

Figure 1: LEED Gold Award displayed in the front lobby of the White Rock Operations Centre, BC

Canadian Sustainable Design Progress

So what does this mean for the state of Canadian sustainable design when it comes to commercial and institutional buildings? Documentation would indicate that the varying regions of Canada demonstrate varied commitment to sustainable building. Significantly more buildings and LEED accredited professionals are to be found in British Columbia, with Alberta, then Ontario following significantly behind. The green building movement gained significant strength in British Columbia through the creation of LEED BC and the commitment of Vancouver based interest groups. The Canadian Green Building Council was formed in April 2002 to act as a national agency whose interest is to create and market a Canadian version of LEED, which is largely based on LEED BC. In Canada there are 66 LEED registered projects of which, 35 are in British Columbia. All 3 certified projects are also in British Columbia. This West Coast trend is also apparent in the United States, with California, Oregon and Washington State carrying 25% of the LEED buildings.

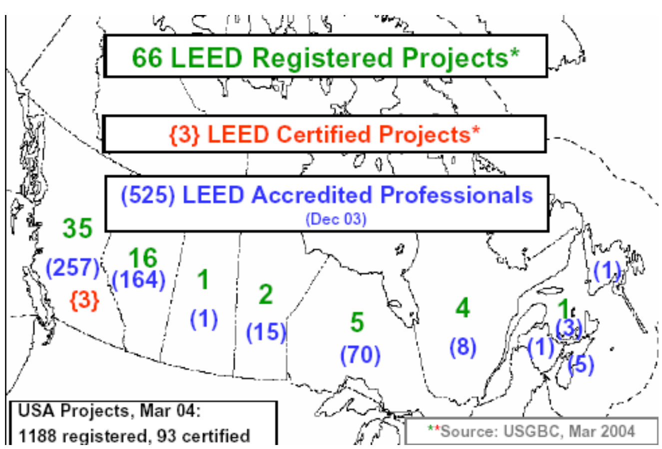


Figure 2: The Status of LEED in Canada as of March 2004

Between March 2004 and the end of June update of the USGBC and CaGBC websites, the Canada wide status of LEED Registered and Certified projects is as follows.

Table 1: LEED Registered and Certified Projects in Canada as of end of June 2004

Province	**BC**	**AB**	**SK**	**MB**	**ON**	**QC**	**NB**	**NS**	**PEI**	**YK**	**NU**	**NWT**
Registered	37	17	1	4	12	5	1	0	1	0	1	0
Increase in 3 months	2	1		2	7	1	1	0	0	0	1	0
Certified		1										
Silver	2											
Gold	3											

Note: Two LEED Projects, the TEF III in Vancouver, LEED Silver, and the Alberta Municipalities Building, Certified, were not included in the detailed data for this paper as their status was not known at the time of data analysis.

The Canadian Green Building Council is in the midst of finalizing a version of the US LEED System for use in Canada. Canadian designers currently submit to the USGBC for LEED Certification. It is to be completed later in 2004. (www.cagbc.ca)

The Green Building Challenge, an international gathering and competition for quality sustainable buildings, has provided a key opportunity to show off, compare, as well as learn, about varying strategies and solutions to sustainable building issues from around the globe. The Challenge started in 1998, and is held every two years. Some of the non-LEED buildings highlighted in this paper were those selected to represent Canada as our national entries. They have been included in the "green database" due to their acclaimed, rather than LEED certified, status.

KEY PROJECTS: HISTORICAL PROGRESSION

This is not to say that all good sustainable buildings are LEED driven. A number of highly successful Canadian examples have been motivated by the same principles that ground LEED, but do not take the certification route (which does cost money…). The ideals include a responsible attitude towards energy and resource use, natural ventilation strategies, sustainable site design as well as the benefits of daylighting as it connects to both indoor environmental quality as well as reduction in electrical consumption. The buildings herein will show some of the main strategies that are now being used primarily in commercial and institutional construction, as well as highlight the creation of articulate mainstream architectural projects.

The investigation of the relationship between green building projects and LEED provides some interesting results. The Canadian projects examined are categorized by: those built "pre-LEED", wherein the LEED rating has been estimated from available information; LEED, wherein the statistical information has been taken from the USGBC website as submitted; and, non-LEED, wherein the buildings have been designed and constructed post invention of LEED but not to meet any LEED criteria. They are acclaimed as green building projects, so a LEED *estimate* has been created from available published information about the projects. These are as accurate as available information and interviews with offices associated with the buildings would allow.

From an architectural design perspective it is interesting to notice a contrast in both the size and profile of early to more recent projects, the latter belonging to a more mainstream high-end sense of "style". Early projects were conceived more often as "demonstration" buildings, whereas later buildings may include, but not use green design, as their primary focus. As well, earlier buildings of the demonstration mode tended towards more rural sites. These are penalized severely under LEED Sustainable Sites Criteria for lack of urban density, use of Greenfield sites as well as lack of access to public transit.

The following Tables (2a, b, c), illustrate a comparison of 23 representative buildings according to their LEED scores (actual or estimated).

Table 2a: Comparison of Key Projects According to LEED Criteria

LEED Rating System Version 2.1

Evaluation of a range of green buildings according to the LEED criteria from across Canada. They are arranged by date of completion and according to whether they are **pre-LEED**, **LEED submitted** or **designed during LEED but not submitted**. Values for LEED buildings have been taken from the USGBC website. Others have been estimated from available information and so may not be 100% accurate. *(Credit given to my research assistant, Caroline Prochazka, for much of the data contained in this table, part of which is also published in her M.Arch. Thesis, 2004, "Emergent Threshold: Daylight Modeling for Sustainable Design".*

		CMHC Healthy House	Boyne River Ecology Centre	Waterloo Green Home	YMCA Burrows Building	Green on the Grand	YMCA Solarium Building	C.K. Choi Building at UBC	Mountain Equipment Coop, Ottawa	Liu Centre UBC	BC Terasen Gas	Bahen Centre for IT	Mayo Replacement School	Jackson-Triggs Winery	York University Comp. Sci.	Richmond City Hall	SSFC Tech. Wing	Nicola Valley Institute	Vancouver Island Tech Park	White Rock Operations Centre	Caisse de Depots	Semihamoo Library and RCMP	Chess Street Works	CCBR (under construction)	Overall		
		ON	ON	ON	ON	ON	ON	BC	ON	BC	BC	ON	YK	ON	ON	BC	ON	BC	BC	BC	QC	BC	BC	ON			
		1992	1993	1993	1995	1996	1996	1996	2000	2000	2000	2001	2001	2001	2001	2002	2002	2002	2003	2003	2003	2004	2004	2005	Number of successful points out of 23	Potential Points for 23 buildings	Performance Percentage
	---Sustainable Sites---																										
Prerequisite 1	Erosion & Sedimentation Control	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y			
Credit 1	Site Selection	1	-	1	1	1	1	1	1	1	1	1	1	-	1	1	1	1	1	1		1	-	1	18	23	**78**
Credit 2	Development Density	-	-	-	-	-	-	-	-	-	-	1		-	1	1	1	-	-	-	1		-	1	6	23	26
Credit 3	Brownfield Redevelopment	-	-	-	-	-	-	-	-	-	-	1		-	-	-	-	-	1	-			1	-	3	23	13
Credit 4.1	Alternative Transportation, Pub. Trans. Access	1	-	1	-	1	-	1	1	1	1	1		-	1	1	1	-	1	1	1	1	1	1	16	23	**70**
Credit 4.2	Alternative Transportation, Bike Stor. & Changerooms	1	-	1	-	1	-	-	1	1	1	-		-	1	1	1	-	1	1			1	-	11	23	48
Credit 4.3	Alternative Transportation, Alt. Fuel Vehicles	-	-	1	-	-	-	-	-	-	1	-		-	-	-	-	-	-	-			1	-	3	23	13
Credit 4.4	Alternative Transportation, Parking Capacity	-	-	-	1	-	1	-	-	-	-	-	1	-	-	-	-	-	1	1	1	1	1	-	8	23	35
Credit 5.1	Reduced Site Disturbance,Open Space	1	1	1	1	-	1	1	-	1	-	-	1	1	-	1	1	1	1	-	1		-	1	13	23	**57**
Credit 5.2	Reduced Site Disturbance,Footprint	-	1	-	1	-	1	1	-	-	-	-	1	1	-	1	1	1	1	-			-	1	10	23	**43**
Credit 6.1	Stormwater Management, Rate and Quantity	1	1	1	1	1	1	1	1	1	1	1		1	1	-	1	1	1	1	1		-	-	16	23	**70**
Credit 6.2	Stormwater Management, Treatment	1	-	1	1	-	1	-	-	-	-	1		-	-	-	1	-	1	-			-	-	6	23	26
Credit 7.1	Landscape: Reduce Non-roof Heat Islands	1	1	1	1	-	1	1	1	1	-	1	1	1	1	1	-	-	1	1		1	1	1	16	23	**70**
Credit 7.2	Landscape: Reduce Roof Heat Islands	-	1	-	1	-	1	-	1	-	-	1		-	1	-	-	1	-	1		1	1	-	9	23	39
Credit 8	Light Pollution Reduction	-	1	1	1	1	1	-	-		-	-	1	1	-	-	1	1	-	1	1	1	-	-	11	23	**48**
	Sustainable Sites Sub Total	7	6	9	9	5	9	6	6	6	5	8	6	5	7	7	9	6	10	8	6	6	7	6	7	14	**50**
	---Water Efficiency---																										
Credit 1.1	Water Efficient Landscaping, Reduce by 50%	1	1	1	1	1	1	1	1	1	1	1	1	-	1	1	1	1	1	1		1	1	-	18	23	**78**
Credit 1.2	Water Efficient Landscaping, No Potable/No Irrigation	1	1	1	1	1	1	1	1	1	-	1	1	-	1	-	1	-	1	1		1	1	-	15	23	**65**
Credit 2	Innovative Wastewater Technologies	1	1	-	1	-	1	1	-	-	1	1		1	-	-	-	-	-	1			1	-	8	23	35
Credit 3.1	Water Use Reduction, 20% Reduction	1	1	1	1	1	1	1	1	1	-	1		1	1	-	1	-	1	1		1	1	-	15	23	**65**
Credit 3.2	Water Use Reduction, 30% Reduction	1	1	1	1	1	1	1	-		-	-		-	1	-	-	-	1	1		1	1	-	10	23	43
	Water Efficiency Sub Total	5	5	4	5	4	5	5	3	3	2	4	2	2	4	1	3	1	4	5	0	4	5	0	3.1	5	**63**

Table 2b: Comparison of Key Projects According to LEED Criteria

	LEED Rating System Version 2.1	CMHC Healthy House	Boyne River Ecology Centre	Waterloo Green Home	YMCA Burrows Building	Green on the Grand	YMCA Solarium Building	C.K. Choi Building at UBC	MEC, Ottawa	Liu Centre UBC	BC Terasen Gas	Bahen Centre for IT	Mayo Replacement School	Jackson-Triggs Winery	York University Comp. Sci.	Richmond City Hall	SSFC Tech. Wing	Nicola Valley Institute	Vancouver Island Tech Park	White Rock Operations Centre	Caisse de Depots	Semiahmoo Library and RCMP	Chess Street Works	CCBR	Number of successful points /23	Potential Points for 23 buildings	Percentage
	---Energy & Atmosphere---																										
Prerequisite 1	Fundamental Building Systems Commissioning	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y			
Prerequisite 2	Minimum Energy Performance	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y			
Prerequisite 3	CFC Reduction in HVAC&R Equipment	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	1	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y			
Credit 1	Optimize Energy Performance (1-10 pts)	10	5	10	8	8	6	8	7	5	3	6	5	5	8	3	5	5	6	8	6	6	6	6	130	23	**87**
Credit 2.1	Renewable Energy, 5%	1	1	1	1	-	-	-	1	-	-	-	1	1	-	-	-	1	-	1			-	-	7	23	30
Credit 2.2	Renewable Energy, 10%	1	1	1	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-			-	-	3	23	13
Credit 2.3	Renewable Energy, 20%	1	1	1	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-			-	-	3	23	13
Credit 3	Additional Commissioning	-	-	-	-	-	-	-	-	-	-	-		-	1	-	1	-	-	-	1	1	1	-	5	23	22
Credit 4	Ozone Depletion	1	1	1	1	1	1	1	1	1	1	-		-	1	-	-	-	-	1			-	-	10	23	43
Credit 5	Measurement & Verification	-	-	1	-	1	-	-	-	-	1	-		-	1	-	-	1	-	-			-	-	5	23	22
Credit 6	Green Power	-	-	-	-	-	-	-	-	-	-	1		-	-	-	-	-	-	1			-	-	2	23	8.7
	Energy and Atmosphere Sub Total	14	9	15	12	10	7	9	9	6	5	7	8	6	11	3	6	7	6	11	7	7	7	6	7.9	17	46
	---Materials & Resources---																										
Prerequisite 1	Storage & Collection of Recyclables	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	-	Y	Y	Y	Y	Y	Y			
Credit 1.1	Building Reuse, Maintain 75% of Existing Shell	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	1	-	1		-	-	2	23	8.7
Credit 1.2	Building Reuse, Maintain 100% of Shell	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	1		-	-	1	23	4.3
Credit 1.3	Building Reuse, Keep 100% of Shell/50% Non-Shell	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	1		-	-	1	23	4.3
Credit 2.1	Construction Waste Management, Divert 50%	-	1	1	1	1	1	1	1	1	1	1		-	1	1	-	-	1	1		1	1	-	15	23	**65**
Credit 2.2	Construction Waste Management, Divert 75%	-	-	1	-	1	-	1	1	-	-	-		-	-	1	-	-	1	1		1	1	-	9	23	39
Credit 3.1	Resource Reuse, Specify 5%	-	-	1	1	1	1	1	1	1	-	1	1	-	1	-	-	-	1	1	1		-	1	14	23	**61**
Credit 3.2	Resource Reuse, Specify 10%	-	-	1	1	1	1	1	1	1	-	1		-	1	-	-	-	-	-	1		-	-	10	23	43
Credit 4.1	Recycled Content, 5% p.c. or 10% (p.c. + p.i.)	1	-	1	1	1	1	1	1	1	1	-	1	-	1	-	-	-	1	1	1	1	1	-	15	23	**65**
Credit 4.2	Recycled Content, 10% p.c. or 20% (p.c. + p.i.)	-	-	1	1	1	1	1	1	-	-	-		-	1	-	-	-	-	-	1	1	1	-	10	23	43
Credit 5.1	Local/Regional Materials, 20% Manufactured Locally	1	1	1	1	1	1	1	1	1	1	1		-	1	1	1	1	1	1		1	1	1	18	23	**78**
Credit 5.2	Local/Regional Materials, 50% Harvested Locally	-	-	-	1	-	1	1	1	1	-	-		-	-	-	-	-	1	1			1	-	8	23	35
Credit 6	Rapidly Renewable Materials	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	1	-	-	1		-	1	3	23	13
Credit 7	Certified Wood	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	1	-	-			-	-	3	23	13
	Materials and Resources Sub Total	2	2	7	7	7	7	8	8	6	3	4	3	0	7	3	1	3	7	6	8	5	6	3	5.2	13	40

Table 2c: Comparison of Key Projects According to LEED Criteria

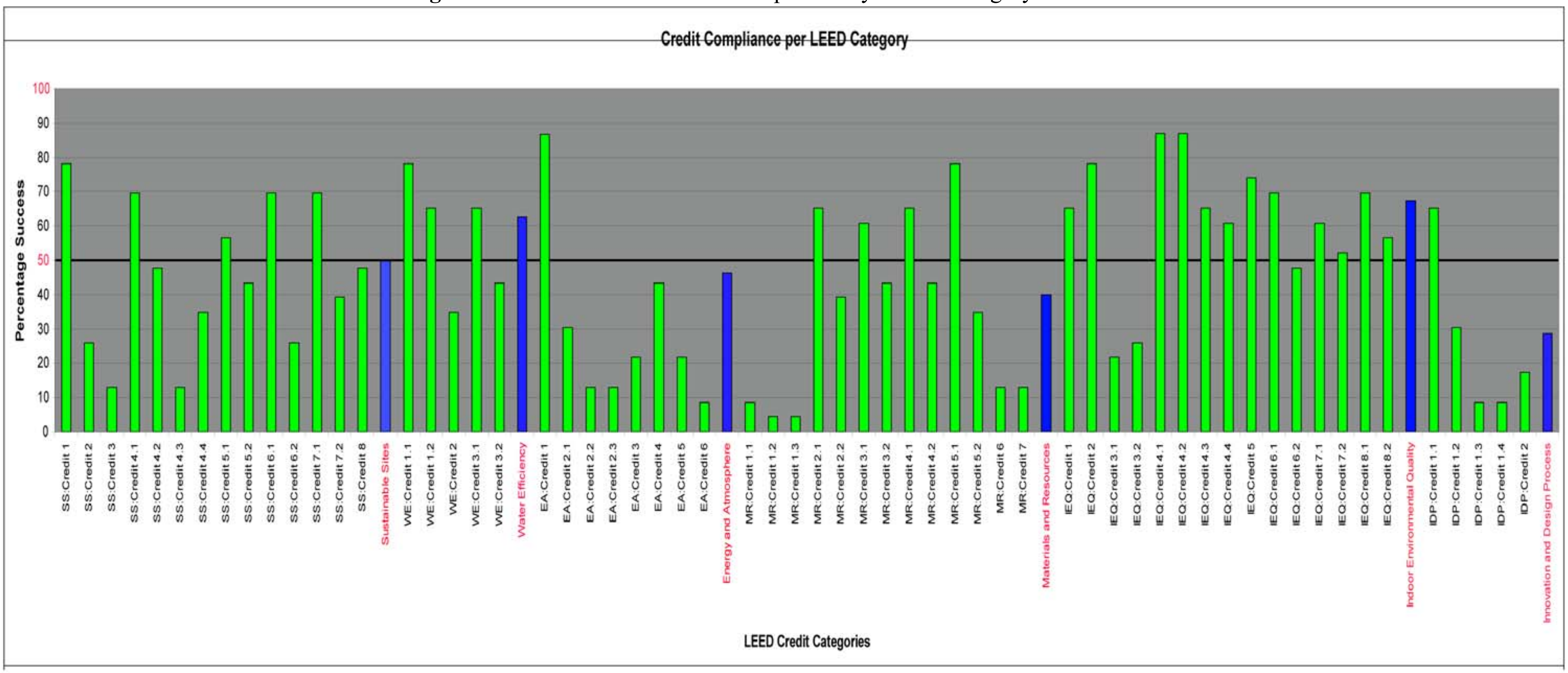
	LEED Rating System Version 2.1	CMHC Healthy House	Boyne River	Waterloo Green Home	YMCA Burrows	Green on the Grand	YMCA Solarium	C.K.	MEC, Ottawa	Liu Centre UBC	BC Terasen Gas	Bahen Centre for IT	Mayo Replacement	Jackson-Triggs Winery	York University.	Richmond City Hall	SSFC Tech. Wing	Nicola Valley Institute	VITP	White Rock	Caisse de Depots	Semihamoo	Chess Street Works	CCBR	Number successful /23	Potential Points /23 bldgs	Performance %
	---Indoor Environment Quality---																										
Prerequisite 1	Minimum IAQ Performance	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y			
Prerequisite 2	Environmental Tobacco Smoke (ETS) Control	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y			
Credit 1	Carbon Dioxide (CO2) Monitoring	-	-	1	1	-	-	-	1		1	1		1	1	1	1	1	1	1	1	1	1	-	15	23	**65**
Credit 2	Increase Ventilation Effectiveness	-	-	1	1	1	1	1	-		1	1	1	1	1	1	1	1	1	-	1	1	1	1	18	23	**78**
Credit 3.1	Construction IAQ Management Plan, During Constr.	-	-	-	-	-	-	-	-		1	-		1	1	1	-	-	-	-			1	-	5	23	22
Credit 3.2	Construction IAQ Management Plan, Pre-Occup.	-	-	-	-	-	-	-	-		-	1		1	1	1	-	-	-	1			1	-	6	23	26
Credit 4.1	Low-Emitting Materials, Adhesives & Sealants	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	20	23	**87**
Credit 4.2	Low-Emitting Materials, Paints	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-	1	1	1	1	1	1	1	1	20	23	**87**
Credit 4.3	Low-Emitting Materials, Carpet	1	-	1	1	1	-	-	-	1	-	1	1	1	1	1	-	1	1	1	1	1	1	-	15	23	**65**
Credit 4.4	Low-Emitting Materials, Composite Wood	1	-	1	1	1	1	1	-	1	-	1	1	1	-	1	-	-	1	1		1	1	-	14	23	**61**
Credit 5	Indoor Chemical & Pollutant Source Control	-	1	-	1	-	1	-	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	17	23	**74**
Credit 6.1	Controllability of Systems, Perimeter	1	1	1	1	1	1	1	-	1	1	-		1	1	1	1	1	-	1	1		1	1	16	23	**70**
Credit 6.2	Controllability of Systems, Non-Perimeter	1	1	1	1	-	1	-	-	-	1	-	1	1	1	1	1	1	-	-	1		-	-	11	23	**48**
Credit 7.1	Thermal Comfort, Comply with ASHRAE 55-1992	-	-	1	1	1	-	-	1	1	1	-	1	1	-	1	1	-	1	1		1	1	-	14	23	**61**
Credit 7.2	Thermal Comfort, Permanent Monitoring System	-	-	1	-	1	-	-	1	-	-	1		1	1	-	1	1	-	-	1	1	1	1	12	23	**52**
Credit 8.1	Daylight & Views, Daylight 75% of Spaces	1	1	1	1	1	1	-	-	1	1	1	1	1	-	1	1	1	-	1	1		1	1	16	23	**70**
Credit 8.2	Daylight & Views, Views for 90% of Spaces	1	1	1	1	-	1	1	-	1	1	-		-	1	1	1	-	1	1	1		-	1	13	23	**57**
	Indoor Environmental Quality Sub Total	8	7	12	12	9	9	6	6	9	11	10	9	14	12	13	11	10	9	11	10	8	13	8	10	15	**67**
	---Innovation & Design Process---																										
Credit 1.1	Innovation in design	1	1	-	1	-	1	1	1	1	-	-	1	1	1	-	-	1	1	1	1	1	1	1	15	23	**65**
Credit 1.2	Innovation in design	-	-	-	-	-	-	-	-		-	-	1	1	-	-	-	-	1	1		1	1	1	7	23	30
Credit 1.3	Innovation in design	-	-	-	-	-	-	-	-		-	-		-	-	-	-	-	1	-			1	-	2	23	9
Credit 1.4	Innovation in design	-	-	-	-	-	-	-	-		-	-		-	-	-	-	-	1	-			1	-	2	23	9
Credit 2	LEEDTM Accredited Professional	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	1	1		1	1	-	4	23	17
	Innovation and Design Process Sub Total	1	1	0	1	0	1	1	1	1	0	0	2	2	1	0	0	1	5	3	1	3	5	2	1.4	5	29
		37	**30**	**47**	**46**	**35**	**38**	**35**	**33**	**31**	**26**	**33**	**30**	**29**	**42**	**27**	**30**	**28**	**41**	**44**	**32**	**33**	**43**	**25**			
	Certified 26-32 points		**30**							**30**	**26**		**28**	**29**		**27**	**30**	**28**						**25**	28	69	40
	Silver 33-38 points	**37**				**35**	**38**	**35**	**33**			**33**									**32**	**33**			34	69	49
	Gold 39-51 points			**47**	**46**										**42**				**41**	**44**			**43**		44	69	64
	Platinum 52-69 points																									69	

EXAMINATION OF PROJECT DATA BY MAJOR LEED CATEGORY:

The figure below illustrates a breakout by LEED credit of the compliance rate of the above projects based on an overall percentage of projects that managed to achieve each point. If a perfect score should achieve 100% compliance (the line at the very top of the chart), we can begin to ascertain which credits are being more successfully completed, and which seem to evade most projects. Categories illustrating the highest success rate are Water Efficiency at 63% and Indoor Environmental Quality at 67% of projects achieving these points. Interestingly, Energy and Atmosphere, which reflects issues of energy efficiency, an area of environmental design that has a longer history of interest, only shows a 46% success rate. Materials and Resources follows at 40% and the “bonus points” for Innovation in Design lag behind at 29%. Admittedly this category is down graded by the selection of projects that are either Pre-LEED or Non-LEED as these would automatically lose the point for using a LEED Accredited Professional.

Some of the least successful credits, the first three in Materials and Resources, rely heavily on building component reuse, and hence would only be awarded to renovation projects, rather than new buildings.

Figure 3: Examination of Credit Compliance by LEED Category for Database



Summary of Data Totals and Certification Categories:

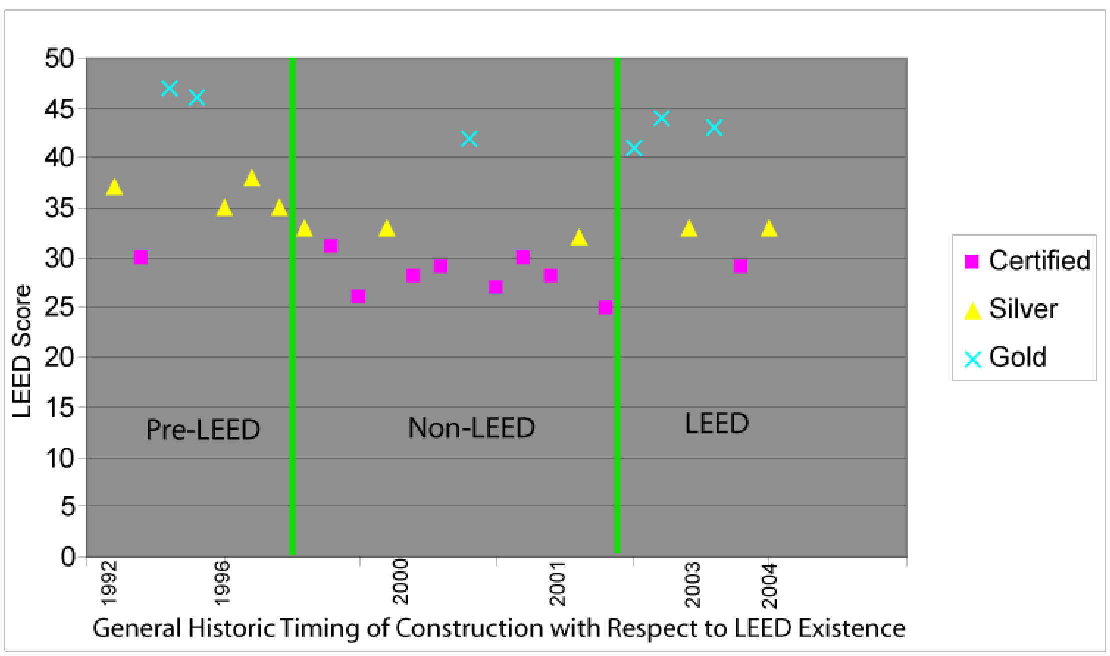
An examination of the certification category data contained in the spreadsheet would give the following totals. Although the sample consists of 23 projects, which may be deemed small, the method of creating the spreadsheet (additive from 15 base to 23 total, added incrementally) – showed little change in totals based on total score or success in each of the base categories (sustainable site, water efficiency, etc.)

Table 3: Summary of Data from Key Building Comparison

Certification Type	Average Score	Score expressed as percentage (based on 69 possible points)	Number of projects of this type out of a possible 23	Percentage of total projects achieving this level of certification
Certified	28	40%	9	39%
Silver	34	35%	8	35%
Gold	44	26%	6	26%
Platinum	No projects of this type			

Although the previous table would indicate a slight tendency towards Certified Buildings over the higher categories, a break-out of the larger table based on the age of the buildings or historic timing of the projects as a function of the introduction of LEED would indicate a tendency for LEED motivated buildings to "aim higher". This is not to infer that all recent buildings are of a higher environmental caliber, only that those whose intentions are motivated by LEED certification seem to be encompassing a larger range of green principles. The projects in the middle range, those constructed with sustainability in mind, but not interested in LEED Certification, tend to produce a generally lower score, indicating a less thorough incorporation of sustainable design interests.

Figure 4: Impact of Age of Building on Certification



Note: This chart reflects the recent addition of certified projects post March 2004.

The connection between the caliber of the Pre-LEED and LEED buildings may have much to do with the agenda of the projects. The early building set is comprised largely of environmental demonstration projects whose primary purpose was to prove aspects of sustainable design viability and function. Those building owners who have decided to file for LEED certification have made a decided effort to achieve a high level of design, which often includes the incorporation of more cutting edge technology.

From a purely mathematical perspective, if the system is graded out of a total of 69 points, then a project needs a "score" of at least 35 point to "pass". Of the set of 23 projects examined in this paper, the median score was 33 points (48%), 2 below a pass. The average score was 35 points, which constitutes a pass. Only 8 of the 23 projects exceeded the passing score of 35 points. All projects that receive a Certified Label (26-32 points) meet less than half of the criteria. Projects in the Silver category (33-38 points) straddle the halfway mark. Only projects receiving a Gold or Platinum rating succeed in exceeding the 50% mark. This might begin to explain why Owners deciding to pay for LEED certification for the projects tend to aim for the higher, perhaps more impressive, classification.

CASE STUDY PROJECTS: HISTORICAL PROGRESSION

It is important to make a visual connection amongst the projects as another means to identify "progress", both in terms of their LEED or sustainable design potential, as well as their "architectural potential". If green architecture is to become the mainstream state of the art method of designing and constructing buildings, then it must be acceptable to owners and the public in architectural as well as environmental terms. I feel that the visual progression illustrated within this paper illustrates a marked change in buildings, generally for the better.

Interestingly, and not for lack of searching, there are no buildings in this study that were completed in the years 1997, 1998 or 1999. Several of the buildings completed in 2000 would have been in their design phase during this period, but a lack of green building in general can be noted during this interim period.

1992

<table>
<tr>
<td></td>
<td><u>ESTIMATED</u> LEED SCORE:
Sustainable Sites: 7/14
Water Efficiency: 5/5
Energy and Atmosphere: 14/17
Materials and Resources: 2/13
Indoor Air Quality: 8/15
Innovation and Design Process: 1/5
Total Score: 37/69 Silver</td>
</tr>
<tr>
<td colspan="2">CMHC Healthy House, Toronto, Ontario. 1992
Martin Liefhebber Architect
The Canadian initiative in the implementation of sustainable design seemed to begin with the Healthy House Design Competition in 1991. The competition asked the industry to develop innovative ways to design homes with a better balance of occupant health, energy efficiency, resource efficiency, environmental responsibility and affordability. The house also addressed densification of the city, sited in a existing back lane garage row. The design succeeded in creating a house whose heating and cooling were passive, whose water systems were cleansed using a Waterloo Biofilter system (on an extremely small site). High efficiency appliances were specified. Photovolatics were installed to supply electricity to the residence. Although successful in and of itself, as a prototype it did not generate repetition, as was the intention.</td>
</tr>
</table>

1995

ESTIMATED LEED SCORE:
Sustainable Sites: 9/14
Water Efficiency: 5/5
Energy and Atmosphere: 12/17
Materials and Resources: 7/13
Indoor Air Quality: 12/15
Innovation and Design Process: 1/5
Total Score: 46/69 Gold

YMCA Burrows Building, Paradise Lake, Ontario. ***1995***
Charles Simon Architect
The Burrows Building was the first green effort to be constructed at the YMCA Camp. It is a primarily passively heated building, using direct solar gain and a central thermal mass wall to store heat. This is supplemented by a unique masonry heater at the centre of the building, which is fired twice a day to maintain a comfort level above the simple direct gain state. Although the building has some electric lights, whose energy comes via the PV on the shading device at the southern front of the building and is stored in batteries in the basement, the building relies on daylighting for the majority of occupied hours. Composting toilets are successfully used. The main wood elements in the building were salvaged and reused from the demolition of a nearby facility in Waterloo, Ontario As a camp and demonstration facility, this building can tolerate thermal performance that lies outside of the comfort zone.

1996

ESTIMATED LEED SCORE:
Sustainable Sites: 9/14
Water Efficiency: 5/5
Energy and Atmosphere: 7/17
Materials and Resources: 7/13
Indoor Air Quality: 9/15
Innovation and Design Process:1 /5
Total Score: 38/69 Silver

YMCA Solarium Building, Paradise Lake, Ontario. ***1996***
Charles Simon Architect
The Solarium Building was completed approximately one year after the Burrows was occupied. It was conceived as an environmental demonstration project, so makes use of a large variety of green strategies. These include the gathering of heat from the main skylit space; a Living Machine to process all water; daylighting to supply light in all spaces; a green roof to increase thermal resistance in the northern half of the building; materials used were largely reclaimed timber products; various mechanical systems are used to distribute the passive heat supply throughout the building. As a demonstration facility that was designed with often less than sophisticated experimental systems, the building internal environment often falls outside of the acceptable comfort zone range.

A Vital Signs study was carried out in 2003 by Caroline Prochazka of the School of Architecture at the University of Waterloo. This study documented actual temperature, relative humidity and lighting levels in the facility over a period. This post occupancy evaluation would suggest changes in future designs to take better advantage of the passive and active systems tested on the project. The full report can be accessed at:
http://www.fes.uwaterloo.ca/architecture/faculty_projects/terri/prochazka/YMCA_Solarium/YMCA_Solarium_index.htm

1996

<u>ESTIMATED</u> LEED SCORE:
Sustainable Sites: 5/14
Water Efficiency: 4/5
Energy and Atmosphere: 10/17
Materials and Resources: 7/13
Indoor Air Quality: 9/15
Innovation and Design Process: 0/5
Total Score: 35/69 Silver

Green on the Grand, Kitchener, Ontario. ***1996***
Snider, Reichard and March Architects with Enermodal Engineering
Green on the Grand was the first C-2000 building to be constructed. The primary focus of the design was to provide adequate daylighting to all interior spaces, as well as to provide a thermally stable interior environment to support its commercial office use. Spectrally selective glazing was used in lieu of shading devices to limit excess solar gain. The envelope is designed to maximize energy efficiency, providing close to 3 times the amount of insulation required by ASHRAE 90.1. The structure makes use of engineered wood products to minimize environmental impact and reduce embodied energy. The water systems use 30% less than a conventional office, making early use of low volume toilets as well as a cooling tower pond that is filled with rainwater. The interior environment is improved by the use of low VOC products. Sensors control both air supply as well as lighting levels. This building was one of the earliest to use chilled ceilings and radiant cooling systems. Some operable windows were provided in recognition of the humid Ontario climate. Post occupancy thoughts by Stephen Carpenter of Enermodal Engineering, energy designer and occupant, would indicate that more could have been provided to improve the quality and personal control of interior spaces. An interview with Carpenter in Fall 2003, now a LEED Accredited Professional, indicated the feeling that the building would have been designed somewhat differently had LEED been a motivating factor at the time of construction.

1996

<u>ESTIMATED</u> LEED SCORE:
Sustainable Sites: 6/14
Water Efficiency: 5/5
Energy and Atmosphere: 9/17
Materials and Resources: 8/13
Indoor Air Quality: 6/15
Innovation and Design Process: 1/5
Total Score: 35/69 Silver

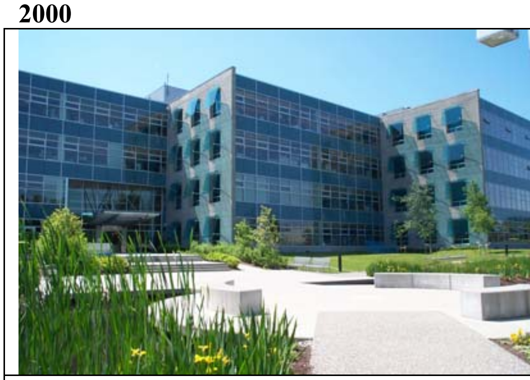
C.K. Choi Centre for Asian Studies, UBC. ***1996***
Matsuzaki Wright Architects
The C.K. Choi Centre was the first building on the UBC Campus whose driving purpose was to create a preeminent sustainable building. It was also one of the first sustainable buildings to use an integrated design process to achieve its goals. The building uses daylighting to light most of the spaces, with dimming switches to control the use of electric lighting. Natural ventilation provides cooling. The three-storey building successfully uses composting toilets to assist with water use reduction. The building was carefully constructed to minimize negative impact on the highly treed site. The timbers that make up the structure were reclaimed from a demolished armory building. The brick used on the exterior is reclaimed. Post occupancy data supports the success of the many environmental features, including reductions in energy consumption for lighting and heating, as well as remarkably reduced water usage due to both the composting toilets as well as rainwater collection for exterior landscape maintenance.

2000

<u>ESTIMATED</u> LEED SCORE:
Sustainable Sites: 6/14
Water Efficiency: 3/5
Energy and Atmosphere: 6/17
Materials and Resources: 6/13
Indoor Air Quality: 9/15
Innovation and Design Process: 1/5
Total Score: 30/69 Certified

Liu Centre UBC. ***2000***
Architectura with Arthur Erickson
The Lui Centre was the second building on the UBC Campus to go green. It is situated next to the C.K.Choi Centre for Asian Studies. Liu is quietly nestled into the densely treed landscape, so site disturbance during construction had to be minimized. There is extensive glazing for complete daylighting of spaces, as well as operable windows to provide natural ventilation and free cooling. The plan organizes itself around two courtyards, again to give all users both daylight and views. The site microclimate helps to keep environments cool. Many recycled materials were used to reduce embodied energy in the building. Wood beams in the circular conference space were reclaimed. Flyash concrete was employed. This new variety of concrete uses slag from the steel industry to replace part of the cement required in the concrete. Cement production creates high quantities of CO_2, so use of the flyash material helps with greenhouse gas emission reduction.

2000



<u>ESTIMATED</u> LEED SCORE:
Sustainable Sites: 5/14
Water Efficiency: 2/5
Energy and Atmosphere: 5/17
Materials and Resources: 3/13
Indoor Air Quality: 11/15
Innovation and Design Process: 0/5
Total Score: 26/69 Certified

Terasen Gas. Surrey, BC (formerly BC Gas) ***2000***
Musson Cattell Mackey Partnership
Terasen Gas also makes use of flyash concrete for its main concrete structure to reduce embodied energy. The building is operating at 63% of the Model National Energy Code for Canada. The building uses differentiated façade shading strategies on the 4 cardinal elevations. The south face uses continuous louvered horizontal shading devices on the exterior, with light shelves along the interior face of the curtain wall. The east and west façades use punched openings in the concrete walls with operable windows that sit behind Azurelite glass shields at each opening to deflect sunlight while still allowing fresh air intake. The north façade is a more typical curtain wall that also incorporates opaque spandrel panels and operable windows. The operable windows on all elevations, combined with central atria in each of the 4 building pods provide natural ventilation. Fresh air is drawn in through the sidewalls, channels through the central atrium and is exhausted at the top. Daylighting and ventilation strategies provide a high level of occupancy comfort and control throughout the building.

Extensive rainwater collection pond systems are used on site to manage site water and provide a stunning natural water system that supports diverse wetland life.

2001

<u>ESTIMATED</u> LEED SCORE:
Sustainable Sites: 7/14
Water Efficiency: 4/5
Energy and Atmosphere: 11/17
Materials and Resources: 7/13
Indoor Air Quality: /1215
Innovation and Design Process: 1/5
Total Score: 42/69 Gold

Photo: Nathaniel Lloyd

York University Computer Science Building. ***2001***
Busby + Associates with Architects Alliance.
Canadian Green Building Challenge Submission 2000
The York University Computer Science Building replaced another Computer Science facility that had outgrown its academic usefulness in only 10 years! For that reason, the planning of the building focused on flexibility and ease of changing the interior partitions, so the same fate would not befall the new facility. Differentiated façade treatment strategies for both daylight and natural ventilation are used. Important to this facility was the use of an "integrated team approach" to the design and planning of the building. The corridor and courtyard spaces are allowed to be slightly less than optimized for comfort to save energy. The computer labs, which generate heat, are situated beside cooler spaces, so that the systems in the building can assist in self balancing. Flyash concrete was used here as well, for CO_2 emissions reduction.

This building scores points for user control in non perimeter spaces by providing ventilation supply beneath the occupant, through the raised floor system, that is user controlled.

2001

<u>ESTIMATED</u> LEED SCORE:
Sustainable Sites: 5/14
Water Efficiency: 2/5
Energy and Atmosphere: 6/17
Materials and Resources:0 /13
Indoor Air Quality: 14/15
Innovation and Design Process: 2/5
Total Score: 29/69 Certified

Jackson Triggs Estate Winery. ***2001***
KPMB Architects
Canadian Green Building Challenge Submission 2002.
This very high profile winery in the Niagara region boasts a brightly daylit interior which helps to cut down on electrical consumption for lighting. Also cooling the building are the oversized overhangs from the large planar roof that extends well beyond the walls of the building. The footprint of the building was kept compact to both minimize site disturbance as well as optimize the land remaining for vine production. The 5:1 ratio of the floor plate size results in an elongated south building face to increase solar gain potential in the winter months. Stormwater collection systems were used on the site as well, discharging collected water to "soak away pits" for controlled re-entry to the groundwater system.

In arriving at the estimated LEED score, no evidence could be found in published document to support claims for any points in the Materials and Resources category. This clearly hurts the overall score and potential for attaining a category beyond "certified.

2001

	*ESTIMATED LEED SCORE:* Sustainable Sites: 8/14 Water Efficiency: 4/5 Energy and Atmosphere: 7/17 Materials and Resources: 4/13 Indoor Air Quality: 10/15 Innovation and Design Process: 0/5 ***Total Score: 33/69 Silver***

Bahen Centre for Information Technology. University of Toronto. ***2001***
Diamond and Schmitt Architects
The Bahen Centre is one of the largest buildings on the UofT campus. It is a complex infill project that has made good use of spatial adjacencies to balance heating loads in the building, as well as atrium spaces and floorplate size to provide good daylighting of the interior spaces. The large heat intensive computer labs are located on the north side of the building, while the lounges and offices face south and east. Differentiated façades were used for sun control, with shading devices, selective glazing, and operable windows to provide ventilation and occupant control of the interior environment. Site water is well managed and accommodated in a series of courtyards around the complex shape of this infill project. The project densifies the city, replacing a series of asphalt-paved parking lots that once occupied the site.

In spite of its dense urban location, the building manages to take advantage of many solar related strategies by looking at setbacks and varied exposure to offset problems with either orientation or overshadowing.

2001

	*ESTIMATED LEED SCORE:* Sustainable Sites: 6/14 Water Efficiency: 2/5 Energy and Atmosphere: 8/17 Materials and Resources:3/13 Indoor Air Quality: 9/15 Innovation and Design Process: 2/5 ***Total Score: 28/69 Certified*** Photo: K+Z Website

Mayo Replacement School. Yukon. ***2001***
Kobayashi + Zedda Architects
Canadian Green Building Challenge Submission 2002
The Mayo school is a multi-purpose facility designed to accommodate the many needs of a small community. Co-existing in the facility for this town of 500 are a K-12 program, recreation center, community library, Yukon College and a First Nations education centre. Extensive daylighting is used, via clerestory windows, to minimize electricity consumption during those times of the year where daylight is plentiful in the north. Recognizing the severity of the climate, and the high price of fuel in the north, the building is constructed to C-2000 standards, with high insulation levels throughout. Materials are sourced as locally as possible as shipping into the extreme north presents difficulty as well as high cost implications.

This case study goes far in proving the viability of an environmental design that is "passive motivated", in the extreme climate of the far north.

2002

PUBLISHED LEED SCORE:
Sustainable Sites: 10/14
Water Efficiency: 4/5
Energy and Atmosphere: 6/17
Materials and Resources: 7/13
Indoor Air Quality: 9/15
Innovation and Design Process: 5/5
Total Score: 41/69 Gold

Photo: Neil Barman

Vancouver Island Technology Park. ***2002***
Bunting Coady Architects & Idealink Architecture
VITP is the only renovation project to be awarded LEED Gold status in Canada. The design team set objectives to improve the 35-acre site while creating 165,000 square feet of renovated, high tech office buildings and 235,000 square feet of new office buildings.

The original building was an abandoned hospital facility that required the removal of asbestos and underground storage tanks. The landscaping design includes 100% stormwater treatment and infiltration onsite, restoration of 97% of the degraded habitat, and native species plantings requiring no irrigation. Alternative transportation was promoted by the negotiated extension of several bus routes to access the site; reduction of parking; and, provision of bicycle facilities and showers.

It was difficult to take advantage of many passive systems as the retention of the pre-existing building was accompanied by a fixed orientation and size.

2003

ESTIMATED LEED SCORE:
Sustainable Sites:6 /14
Water Efficiency: 0/5
Energy and Atmosphere: 7/17
Materials and Resources: 8/13
Indoor Air Quality: 10/15
Innovation and Design Process: 1/5
Total Score: 32/69 Silver

Photo: Ken Lum

Caisse de Depots et Placements. Montreal. ***2003***
Gauthier, Daoust Lestage Inc./Faucher Aubertin Brodeur Gauthier/Les architectes Lemay et associés, in joint venture.
The CDP is perhaps one of the largest, most “high-tech” and most expensive of the recently constructed green projects. Its signature is an “intelligent façade system” that uses a partial double skin to buffer the cold Montreal climate. The façade incorporates user controlled shading devices as well as operable windows for ventilation. Daylighting has been an important part of the design – which in addition to the special façade, includes a series of centralized atria along the length of the building. The building itself is constructed over top of the Autoroute Ville Marie, and uses long span steel trusses to support the building as it sits on top of the expressway, creating a more sustainable urban density.

2003

PUBLISHED LEED SCORE:
Sustainable Sites: 8/14
Water Efficiency: 5/5
Energy and Atmosphere: 11/17
Materials and Resources: 6/13
Indoor Air Quality: 11/15
Innovation and Design Process: 3/5
Total Score: 44/69 Gold

White Rock Operations Building ***2003***
Busby + Associates
This project was the first “new” building to receive LEED Gold in Canada. It did receive some credits for reuse of foundation elements from the existing operations centre. The building has a green roof to reduce the urban heat island effect, gravel parking lots to maximize infiltration of rainwater, and nearly 400 square metres of asphalt that was removed and revegetated with native species. The planting to the north side of the building assists in creating a cool microclimate. Stormwater is collected in a storage tank for flushing toilets, plant watering, and also collected from city streets to help heat and cool the building.

The project includes a commitment to purchase renewable energy, generate solar electric power onsite, and use of high efficiency fixtures and mechanical system to reduce energy consumption. Indoor air quality is enhanced with natural ventilation (often providing effective cross ventilation), operable windows, and direct ventilation in high contaminant areas to reduce pollutants. Daylighting is a main feature in the building with façade differentiation visible by the placement of sunshades, wall trellis, overhangs, and light shelves to optimize lighting and control heat gain.

2004

PUBLISHED LEED SCORE:
Sustainable Sites: 6/14
Water Efficiency: 4/5
Energy and Atmosphere: 7/17
Materials and Resources: 5/13
Indoor Air Quality: 8/15
Innovation and Design Process: 3/5
Total Score: 33/69 Silver

The Semiahmoo Library & RCMP District Office ***2004***
Musson Cattell Mackey Partnership (MCMP), Darrell J. Epp Architect, Norson Construction
This is Canada’s first LEED Silver Library – yet the building serves two functions as it combines the library use on the second floor with the RCMP District Office on the ground floor. The building uses multiple water saving features: in the building, waterless urinals, low flush toilets and low flow water faucets reduce water use by 30% compared to similar buildings constructed to the National Energy Code; outside the drought tolerant native plants in the landscaping minimize the need for irrigation. It is estimated that building will consume about 49% less energy than a similar building constructed to the Model National Energy Code for Buildings. The primary factors responsible for the savings are the overall building design, the design of the mechanical and electrical systems, and the building envelope system, including the reflective roofing material and high performance glass.

To create a more comfortable interior environment for employees and patrons, temperature, humidity, lighting and CO_2 monitoring control equipment were installed. The library is well served by daylighting through both clerestory and wall glazing. Operable windows were not included in the design due to security issues for the library.

2004

PUBLISHED LEED SCORE:
Sustainable Sites: 8/14
Water Efficiency: 5/5
Energy and Atmosphere: 11/17
Materials and Resources: 6/13
Indoor Air Quality: 11/15
Innovation and Design Process: 3/5
Total Score: 43/69 Gold

Chess Street Works Building, Vancouver ***2004***
Omicron Consulting Group
This project, recently completed, brought the total of Certified projects in Canada to 6. This is the first project to be evaluated under LEED BC (CaGBC Press Release, April 14, 2004). The new Operations yard for the City of Vancouver, includes an Administration Building, Parking operations building, garage, warehouse, and vehicle sheds. The administration building (pictured above) is a highly daylit space that also provides user access to natural ventilation through operable windows. Full height atrium spaces promote natural cooling via exhaust windows located at the top. The key sustainable features include: landscaping with local plant materials; vegetated roofs reduce storm water run-off; building orientation is optimized for daylighting and views; low VOC content materials improve indoor air quality; energy efficient lighting; plumbing fixtures that reduce water consumption; operable windows; exterior sunshades reduce solar heat gain; materials with high recycled content reduce raw material extraction; and, a ground-source heat pump/radiant panel system reduces energy use by up to 40%.

THE INTEGRATED DESIGN PROCESS: THE IMPORTANCE OF PEOPLE

The LEED category, Innovation and Design Process, rewards teams for their comprehensive and creative process when addressing sustainable design. It is significant that these 5 points account for 7% of the available points. An examination of the relative success of the 23 projects studied for this paper would indicate a direct relationship with overall sustainable design and the number if Innovation points awarded. The IDP points would also seem to relate to the adoption of the Integrated Design Process. It is evident when perusing the project information on the USGBC site, or even in glancing at the site erected project billboard, that the numbers of involved professionals has increased substantially since the advent of green building interests. The days of the sole practitioner can no longer answer the complex array of interdependent systems that must be simultaneously solved in order to comprehensively design sustainable buildings. Full consultants meetings are required at the outset of any project in order to properly coordinate all areas of concern. Actual use of the Integrated Design Process can be rewarded with Innovation credits on the project.

Interestingly, in speaking with Peter Busby, owner of the design firm responsible for many green and LEED certified Canadian buildings, his office policy requires that all employees acquire LEED accreditation within 4 months of joining the firm. Although not all office projects are submitted for LEED Certification, LEED is recognized as an important and motivating factor in the primarily integrated design process (IDP). Reference to Table 1 would indicate that all LEED certified projects in Canada have shown the involvement of a LEED accredited firm. Keen Engineering often partners with Busby on such projects, and has become notable in their own right for the involvement in, and promotion of, sustainable building design.

CONCLUSION

Green building is coming to be seen as an important and scientifically backed international initiative that is starting to profoundly change the way architects *must* design and build. *It is not a passing trend.* Buildings, and the way that we as occupants live and work in these places, play too large a role in global issues of sustainability, that change must occur. Increasing numbers of cities, government organizations and universities are a creating a trend-setting example by mandating construction to meet or exceed LEED benchmarks. Schools of Architecture in the United States and Canada, for 10 years now, have been proactively changing their curricula to widen sustainable design teaching. Students, whose green education is even now, significantly beyond that of their professional elders, will undoubtedly have a great impact on the profession in years soon to come! A remarkable number of Sustainable Design motivated professional courses are being offered to Architects who must satisfy continuing education credits on an ongoing basis in order to upgrade their skills. The Green courses (Sustainable Design, Marketing Green Design, Building Integrated Photovoltaics, for example) are some of the best-subscribed offerings.

As evidenced by the case studies that were the subject of this paper, the number and caliber of sustainable buildings is growing. LEED is playing a key role in successfully promoting comprehensively designed green buildings that are increasingly part of mainstream architectural design. It is becoming increasingly important, given the relevance of the Integrated Design Process, for all members of the team to be fully familiar with the complete range of green building issues that LEED presents, in order to create the best buildings possible. If we do not become more educated in this process, the likelihood of Platinum is doubtful.

It is also important that green building practices expand to include a larger body of buildings as well as regions of this country. Given the amount of construction east of Manitoba, it is time for Ontario and Quebec to increase their interest and participation.

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 case study information and LEED estimates for **Tables 1 a,b,c:** Comparison of Key Projects According to LEED Criteria was taken from information supplied by Caroline Prochazka from her Master of Architecture thesis, "Emergent Threshold: Daylight Modeling for Sustainable Design", July 2004, with her permission, as well as from masters level research case study research conducted by:

CMHC Healthy House: Ada Leung, Caroline Prochazka
Boyne River Ecology Centre: Caroline Prochazka
Waterloo Green Home: Helena Vamberger
Green on the Grand: Caroline Prochazka
YMCA Solarium Building: Helena Vamberger, Caroline Prochazka
C. K. Choi Building: Ian Pieterse
Mountain Equipment Coop, Ottawa: Caroline Prochazka
Liu Centre UBC: Caroline Prochazka
BC/Terasen Gas: Caroline Prochazka
Bahen Centre: Nathaniel Lloyd, Caroline Prochazka
Mayo Replacement School: Shawna Cochrane
Jackson Triggs Winery: Diana Saragosa
York Univeristy Computer Science Building: Nathaniel Lloyd (also photo credit)
Richmond City Hall: Diana Saragosa
Sir Sandford Fleming Technology Wing: Vincent Plouffe
Nicola Valley Institute of Technology: Ian Pieterse
Vancouver Island Technology Park: Neil Barman (also photo credit)
White Rock Operations Centre: Vincent Plouffe
Caisse de Depots et Placement: Ken Lum (also photo credit)
Centre for Cellular and Biomolecular Research: Ken Lum

My thanks to these students for supporting my research and making this study possible. Full documentation and research papers prepared by these students can be accessed through the Arch 684: Advanced Case Studies in Sustainable Canadian Buildings Website:

http://www.fes.uwaterloo.ca/architecture/faculty_projects/terri/684_sust.html

FIGURES

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