



REPORT

# A Business Case for Green Buildings in Canada

Presented to

Industry Canada



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## **EXECUTIVE SUMMARY**

The purpose of this document is to clearly and holistically define the state of the green building industry in Canada, and to provide a basis for recognizing the many unique and tangible benefits a green building might offer, as well as the challenges and barriers facing the Canadian industry. This Business Case reflects an extensive search of published and unpublished papers and studies focusing on the nature and benefits of green buildings.

Green buildings differ from conventional buildings due to the integration of social and environmental goals. The environmental considerations can be summarized as direct and indirect ecological impacts, such as reduced greenhouse gas emissions or reduced water use. Social considerations can be directly related to a building (such as safe and comfortable air or natural light) or could extend beyond the building (promoting the use of mass transit or urban densification). Green buildings are achieved through a unique project delivery process, and many (but not all) green buildings incorporate some non-standard materials or systems. Essentially, the difference between green and conventional buildings is that green buildings offer healthier and more comfortable interior spaces, and include measures to reduce a building's ecological footprint.

At the current state of development of the industry, green buildings typically cost more than conventional buildings to design and build. However, these cost increases are greatly overshadowed by economic gains associated with the following:

- Life Cycle Operating Costs
- Insurance Rates
- Churn Rates
- Productivity Gains
- Property Values and Absorption Rates

Other benefits of green buildings can include increased retail sales, improved image, risk reduction, and external effects such as effects on infrastructure, the environment, local economy, and international recognition.

The green building industry is in its infancy in Canada, but it is experiencing exponential growth. Interest among most building stakeholders is increasing, and many building owners are currently demanding green buildings for their new facilities. Many others are greening their existing facilities in hopes of attaining some of the benefits noted above. None-the-less, there remain many barriers to green buildings, most notably the lack of general knowledge of green buildings by various building stakeholders, the relative youth of the industry, and systemic tendering and budgeting constraints that too often preclude building -related decisions using a more realistic life cycle cost and value basis.

There is currently a strong business case for Green buildings in Canada when a more holistic, longer-term view of real building costs is incorporated. This business case can be strengthened through focused research and education of building stakeholders.

# 1. INTRODUCTION

## 1.1 Purpose

This Business Case for Green Buildings highlights the benefits of Green Building, as well as the challenges and barriers facing the Green Building Industry in Canada. This document also provides a definition for a Green Building, and provides information on the growth of the green building industry in Canada. The report has been prepared with intended readership from throughout the building industry. All building stakeholders can benefit from this document including building design professionals, various levels of government, real estate professionals, building financiers, and building developers. Readers of this document need not have previous knowledge pertaining to green buildings.

The Business Case reflects an extensive search of published and unpublished papers and studies focusing on the nature and benefits of green buildings. Most of the referenced information is from North America, although a few selected European studies and papers were also included. All of the information was assessed in terms of its relevance to Canada, and only those studies and sources considered applicable, or relevant, have been included. In addition, cautions about applicability have been inserted where the authors had concerns. All documentation was also reviewed with a reliability focus, and heavily biased studies were excluded.

This report was funded by the Sustainable Technologies and Service Industries branch of Industry Canada. This collaborative effort was made possible through the contributions of Morrison Hershfield Ltd. Consulting Engineers, The Athena Sustainable Materials Institute, The International Initiative for a Sustainable Built Environment, Robert Charette, and the Canada Green Building Council.

## 1.2 Report Structure

The remainder of this report is organized as follows:

- Section 2 provides essential background information, including the importance of buildings from an environmental perspective, a discussion of what we mean by green building, the strategies that are typically used in green building, the methods for assessing and rating green buildings, and a commentary on data sources.
- Section 3 focuses on the current state of this unique component of the building industry.
- Section 4 looks at the broader benefits of green building.
- Section 5 then focuses on the economics of the industry, leaning to the extent possible on empirical evidence.

- Section 6 switches to the other side of the ledger, with an overview of the critical challenges and barriers facing the industry.
- Section 7 presents the overall observations and conclusions of the study team.

## **2. BACKGROUND: THE GREEN BUILDING INDUSTRY IN CANADA**

### **2.1 The Importance of Buildings: An Environmental Perspective**

The primary purpose of buildings is as a separator from the exterior environment: buildings allow us to change and regulate interior conditions from those outside. The Canadian climate is recognized as generally inhospitable to people, so Canadians spend about 90% of their time in buildings<sup>1</sup>. There are currently 12.5 million residential homes and around 500,000 commercial / institutional buildings<sup>2</sup> in Canada, and these buildings have a dramatic impact on their occupants and the environment. One estimate suggests that buildings in Canada account for<sup>3</sup>:

- 1/3 of Canada's energy production
- 50% of the extracted natural resources
- 25% of our landfill waste
- 10% of our airborne particulates
- 35% of our greenhouse gases

However, estimates like these reflect the classification system used for categorizing various activities. The numbers are much higher if we reclassify the segments of the energy use pie on the basis of how much transportation and industrial energy is related to the production and movement of building products,

### **2.2 Green Building Definition**

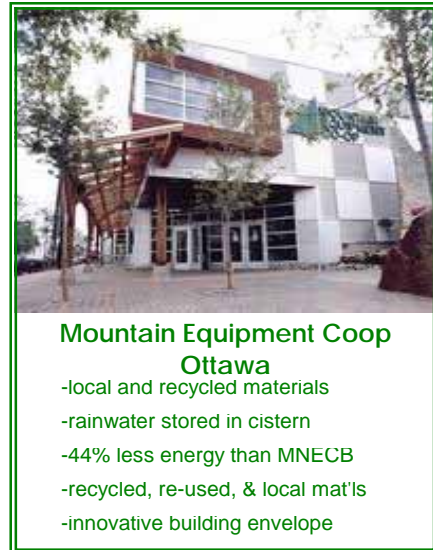
For many people, the term “Green Building” brings images of natural materials, green roofs, radical passive design, and technological gizmos<sup>4</sup>. Even those with a more realistic understanding perceive green buildings as new and different. These perceptions do not necessarily appeal to other building stakeholders, especially key decision makers, so it is important to clearly understand what a green building is and what they look like prior to presenting a business case.

Definitions are usually brief and uncontroversial, but Green building is a special case. Many people have heard that “green” is a good thing, but they search in vain for precise definitions. In addition, there are some overlapping or close to synonymous



terms, such as “energy-efficient building”, “environmental building”, “eco-building”, “sustainable building” and “high-performance building”. Finally, there are an increasing number of buildings on the ground that have been designed according to criteria established in incentive or rating programs<sup>5</sup>, and these are often associated with certain visible “green” features, such as exterior window shading, good daylighting, green (landscaped) roofs, and natural ventilation chimneys. Thus, there is a common misconception that green buildings are solely defined by such obvious features. However, many green building features are subtle or even invisible. A good definition is therefore of considerable importance, and the way that assessment or rating systems handle this is a useful entry point.

It is best to begin with energy, since many people believe that energy lies at the heart of the issue, and energy-efficiency was the first “green” issue to be of general concern (beginning in the late 1970s). For governments, energy and related atmospheric emissions are still a core issue, because of air pollution and greenhouse gas emissions concerns. However, a number of other key issues were added to the list of environmental concerns in the 1980s and 1990s, including ecological damage, water consumption, the role of material selection in affecting embodied energy, emissions and solid waste, and indoor environmental quality (IEQ). Of course, IEQ, including air quality, ventilation, thermal comfort, lighting and noise/acoustics, is not strictly speaking an environmental issue, but it is of such massive importance to the owners, designers and users of buildings that any attempt to deal with performance aspects should consider IEQ. Another issue in this category is construction and operating cost, which some rating systems include to increase their system’s relevance to the industry.



This menu of core issues has emerged as the basis of what is today called green building. Because the set of issues continues to grow, and the margins are unclear, there will continue to be some ambiguity as to a clear definition. As a result, any organization dealing with green building creates its own specific definition, including the Canada Green Building Council (CaGBC), or the ECD Green Globes or the iiSBE GBTool rating systems. These working definitions are not fully satisfactory, since all the multi-criteria rating systems operate on a trade-off basis, and therefore a building with mediocre energy performance but excellent indoor environmental performance might be rated at the same level as another building with the inverse characteristics.

A new factor has emerged in the last few years, and that is the inclusion of an even wider set of planning, social and economic considerations, into what may be called sustainable building assessment of design guidelines. The concept of sustainable building is more relevant to larger projects, or even geographical areas, but green

building definitions are edging into the territory. To maintain focus and clarity in this report, we will confine ourselves to using the term green building.

While the above discussion provides a good understanding of factors considered in green building, it does little to describe how one might differentiate a green building from conventional construction, or the common real characteristics of a green building. Common green building traits include the following:

- Location:
  - NOT on fragile landscapes
  - NOT contributing to urban sprawl
  - Close to mass transportation
- Site:
  - Focus on surface water reduction (holding ponds, porous paving)
  - Zeriscape landscaping (no irrigation)
  - Lower impact on local ecology
  - Increased green space (small building footprint, minimal surface parking)
- Building Exterior
  - Window Canopies or light shelves
  - Alternative energy systems (solar or wind)
  - Green roofs
  - Efficient, targeted exterior lighting (minimizing light pollution)
- Building Interior
  - Minimal materials (exposed structural materials)
  - Flexible layouts (movable walls, raised floors)
  - Occupant controls of heat and light (as opposed to large zone thermostats or light switches)
  - Abundant natural light and access to views
  - Good air quality
  - Plumbing fixtures with reduced water usage characteristics
  - Operational promotion of “green” practices (such as recycling)
- Hidden Attributes
  - Highly efficient building envelopes
  - Materials selected to meet building goals (low environmental embodied effects<sup>6</sup>, low VOC’s)
  - High efficiency mechanical systems integrated with electrical, structural, and architectural elements
  - Efficient lighting systems
  - The use of equipment without materials or components that could damage the environment (e.g., ozone depleting substances in air conditioners)
  - The use of maintenance materials (e.g., detergents) that also meet the green goals
  - Continued measurement and optimization of system performance over time.

The above characteristics are not included in all green building, but most green buildings incorporate many of these common features. In practice, each green building is unique, as they are reflections of specific site, fiscal, and operational parameters.

Examples of green building attributes, from real Canadian buildings, are presented in graphic boxes throughout this report.

### 2.3 The Green Building Project Delivery Process

For typical (non-green) buildings, the various specialties associated with project delivery, from design and construction through operations, are reactive in nature, and develop narrow approaches to respond to particular problems. Each of these specialties typically has a focused (but extensive) knowledge base about their specific fields, and they find solutions to problems solely using their knowledge of their specific fields. For example, a cooling specialist when approached with a problem of an overly hot room, will tend to increase the cooling capacity of the system servicing that room, rather than investigate the reasons that this room is too hot (the excessive heat could, for example, be a building insulation or lighting issue). The end result is a functional but inefficient building comprised of several different materials and systems with little focus on integration between these different materials or systems.

From a design perspective, the key process difference between green and conventional buildings is the concept of integration. Green buildings typically use an integrated design process (IDP), which “uses a multi-disciplinary team of building professionals who work together from the pre-design phase through post-occupancy to optimize the building for environmental sustainability, performance, and cost saving.”<sup>7</sup> The premise of integrated design is that buildings consist of interconnected or interdependent systems, each of which has some effect on other systems. For example, the selection of a type of window has an effect on the heating capacity required. Using an integrated approach, buildings are developed in an iterative manner through promoting input and communication from all building disciplines beginning at the earliest phases of design. The integrated design process also includes input from other building stakeholders, such as the developer and tenants or occupants.



Integrated design is a critical and consistent component in the design and construction of green buildings. The brief description above highlights the benefits of integrated design and the differences between conventional and integrated design. It does not, however, provide a basis for a thorough understanding of these principles and

benefits. For a more detailed description of the Integrated design process, see appendix A.

## 2.4 Green Building Assessment and Rating Systems

LEED<sup>®</sup> (Leadership in Energy & Environmental Design), LEED Canada and Green Globes are popular green building assessment and rating systems used in North America. LEED is the most extensively used and referenced system, including in many of the studies referenced in this document, and it is important that readers have an understanding of LEED.

LEED rating systems award points for meeting specific performance criteria defined in Prerequisites and Credits. Improved building performance is certified (based on the number of points earned by a project) with one of four ratings – Certified, Silver, Gold, or Platinum.

The LEED rating system, developed by the United States Green Building Council (USGBC), was first released in 1999. At that time, it was focused solely on new construction and major renovations. Since that time, other versions of LEED have been, or are being developed, including systems focused on:

- New commercial construction and major renovation projects
- Existing building operations
- Commercial interiors projects
- Core and shell projects
- Homes
- Neighborhood Development



The Canada Green Building Council (CaGBC), which has exclusive rights to LEED in Canada, introduced LEED Canada NC-1.0 in the fall of 2004. Prior to that time, LEED projects in Canada were certified using the American system. LEED Canada NC-1.0 was extensively based on LEED-NC v2.1 (from the USGBC). All LEED projects referenced in this report were certified using the American LEED-NC tool, so they apply to new construction or major renovation.

As noted above, LEED building certifications can be achieved by selecting a required number of credits from a larger set of credits. Accordingly, a LEED rating may not be indicative of how “green” a building is, and identical LEED certification levels on different buildings would not likely be indicative of identical “green” building characteristics. This is particularly valid for the more easily attained certification levels. None-the-less, each credit within LEED is based on sound “green” principles,

and LEED certified buildings tend to be more “green” than typical buildings for this reason.

## **2.5 Data Sources**

In the development of this report, a focus was placed on obtaining Canadian information when possible. However, it was found that American information, particularly with respect to green building studies, was more available and generally more comprehensive. For this reason, it is important to discuss the suitability of using American information in a Business Case for Green Buildings in Canada.

It is generally acknowledged that building designs and construction practices are similar between Canada and the United States. The various economies related to construction are intertwined, and many of the largest construction, engineering, and architecture firms are North American in nature. Further, many of the standards relied upon in the design and operation of building are similar in nature.

Typical business practices are also similar in the two Countries. This is important when equating productivity effects of green buildings. Further, the construction costs of buildings in the United States are similar to those in Canada<sup>8</sup>.

One notable difference between Canada and the United States with respect to buildings is the cost of Heating ventilation and air conditioning (HVAC), which in turn reflects the climatic differences, especially between Canada and the southern U.S.

In general, the social, political, and climatic conditions between Canada and the U.S. were reasonably similar for most of the data sources, and it is believed that these information sources were suitable for Canada. Data sources that focused on Southern U.S. areas, however, were generally believed to be not applicable to Canada. While some are included later in the report, their importance is discounted.

# **3. STATE OF THE GREEN BUILDING INDUSTRY IN CANADA**

## **3.1 History and Growth**

Many common green building attributes have a long history, largely driven by necessity. Prior to the development of cheap electric lighting, there was a focus on natural light that can be seen in most historic buildings. Similarly, historic buildings incorporated many natural ventilation features, and the scarcity and expense of materials prior to the 1900s resulted in trends of re-use or recycling. Modern green buildings differ from these historical buildings primarily through improved interior environmental quality.

The modern movement towards green buildings began in 1962 with the publication of *Silent Spring* by Rachel Carson. This book presented an argument that nature was vulnerable to human intervention, and that conservation and protection of the environment were necessary. The movement towards green buildings accelerated through the energy crisis in the 1970s, and gained momentum in concert with the environmental movement as a whole, and through widely publicized pollution concerns (Sick Building Syndrome, Asbestos, Mold, PCB's). Beginning around 1990, the green building movement entered into a period of exponential growth that we are still in today.

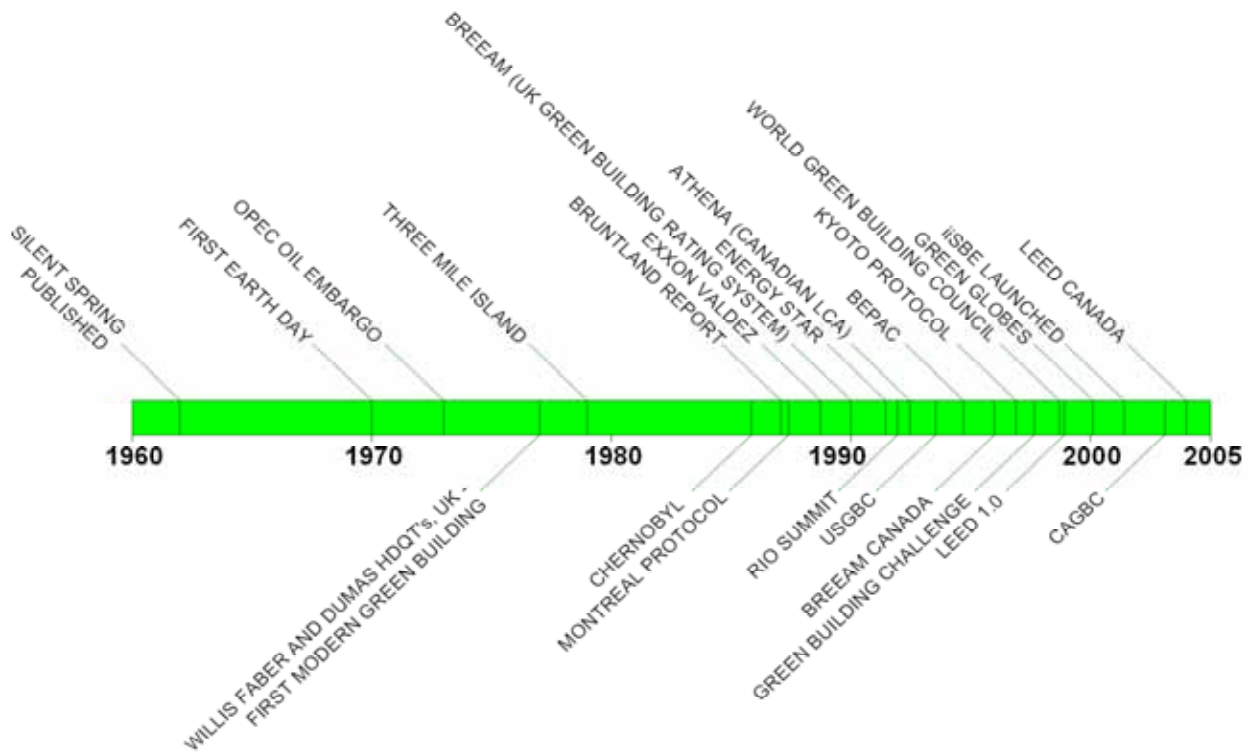


Figure 1: Green Building Time Line<sup>9</sup>

One indicator of the recent surge in interest in the field of green buildings is the growth in membership in the green building councils in Canada and the United States. The Canada Green Building Council (CaGBC) was incorporated in December 2002, yet it currently boasts over 700 members, as shown in figure 2. The United States Green Building Council (USGBC) began in 1993, and has experienced explosive growth<sup>10</sup>, as shown in figure 3.

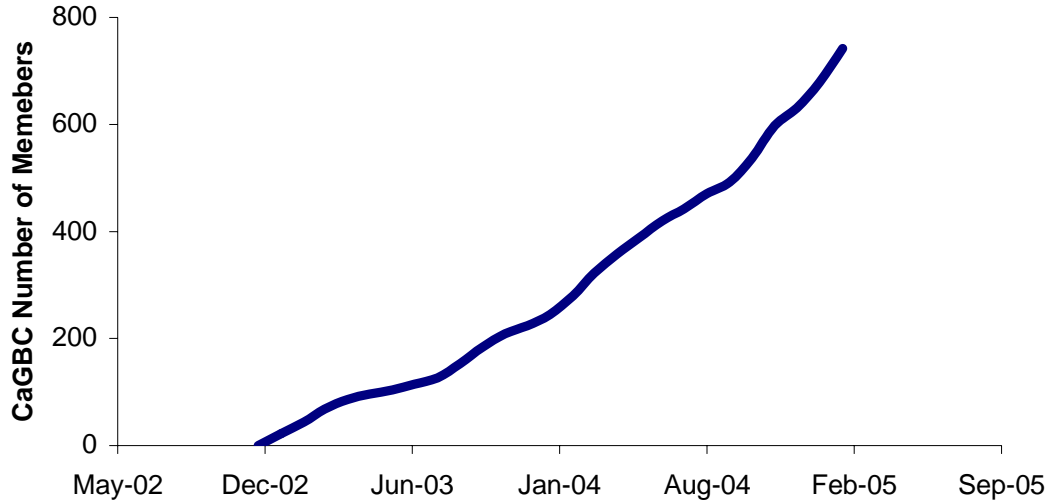


Figure 2: Membership Growth in CaGBC<sup>11</sup>

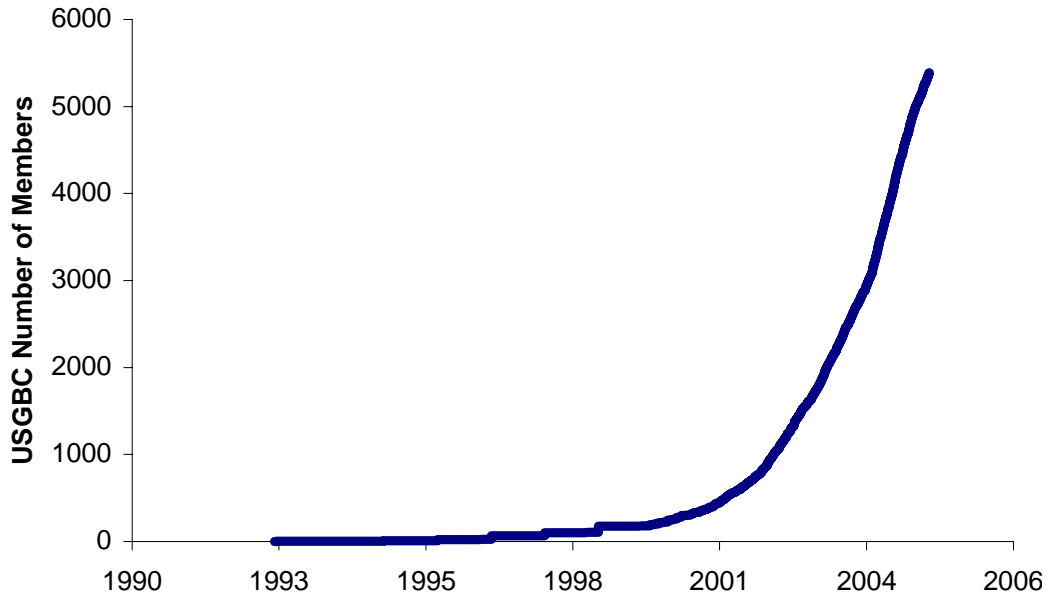


Figure 3: Membership Growth in USGBC<sup>12</sup>

From these figures, it is apparent that interest in green buildings is rising, but it is not possible to determine the basis for this interest. Some involvement is certainly the result of strategic business positioning, while other interest would be more altruistic.

Due to the lack of historical labeling of green buildings in Canada, it is not possible to definitively determine the number of green buildings in Canada, although there are many key examples of Canadian green buildings, such as those within the graphic boxes in this report. As of March of 2005, there are about 150 buildings registered for LEED in Canada, which represents about 1.2%<sup>13</sup> of the total cost of buildings in Canada in 2004. Note that although LEED is the most popular rating system in

Canada, buildings seeking LEED certification represent only a portion of the green buildings in Canada: Other green building projects have been undertaken and are underway that are not seeking LEED certification. This is particularly valid for existing buildings, to which LEED Canada does not currently have a model (unless they are undergoing an extensive renovation). Many building owners and managers of existing buildings are making efforts to green their operations<sup>14</sup>.

In the United States, where the LEED rating system has a longer history, a total of 5 to 8% (by gross floor area) of the new building stock registered with the USGBC in 2004<sup>15</sup>. Given the rate of growth of the U.S. green building industry, coupled with the evident interest in green buildings in Canada, there is every reason to believe that the industry will grow here as well.

## **3.2 Current Status (2005)**

### **3.2.1 Awareness and Expertise**

Most of the stakeholders within the building industry have some concept of the term “green building”, although their understanding is often vague and inaccurate. However, many building stakeholders consider green buildings to be radical, costly, and unnecessary, and many believe the movement towards green buildings is a marketing ploy<sup>16</sup> driven by environmental extremists. There are relatively few people within the building industry who have a thorough and accurate understanding of what a green building is, and how a green building is achieved. However, the recent surge in interest in green buildings is forcing all stakeholders to become quickly informed about this field, so inevitably this general level of understanding will increase in the near future.

Further, the understanding of green buildings differs among the various stakeholders. In general, building designers and building specialists show the greatest interest, while developers, lenders, and even owners seem to have little understanding or interest in green buildings. This is reflected in memberships of the CaGBC, where 75% of the membership companies are professional firms, while less than 2 % belong to financiers, for example.

Similarly, there is limited public knowledge of green buildings even though they provide exceptional performance in two broad areas: social aspects (IAQ, natural light, etc.), and environmental responsibility. One might assume that public opinion on these issues would correlate well with opinions on green buildings. Several recent public opinion polls confirm that Canadians believe the environment<sup>17</sup> is an important issue and that measures to protect the environment should be implemented. From a social perspective, an extensive North American study(see section 4.1) on office building tenant satisfaction determined that tenants highly value comfort in office buildings. This strong Canadian support on these two building related issues can likely equate to similar support for green buildings, on the assumption that the economic argument can be made.



## 4. BENEFITS OF GREEN BUILDINGS

Green buildings offer widespread benefits to a number of building industry stakeholders. The fundamental reduction in relative environmental impacts, coupled with superior interior environmental conditions, benefits building occupants, other stakeholders, and society as a whole. Examples of the specific benefits of green buildings are provided in the following sub-sections. A matrix outlining our combined subjective judgments about how these benefits might apply to different stakeholder groups is provided in Figure 4, followed by a description of each green building benefit.

↑ increasing benefit			Occupant	Neighbor	Owner	Developer	Designer	Investor / Lender	Municipal Government	Provincial Government	Federal Government
Economic											
Occupant Health											
Risk Reduction											
Climate Change Impact											
Ecological											
Decreased Infrastructure Reliance											
Occupant Comfort											

Figure 4: Matrix of Green Building Stakeholder Benefits

### 4.1 Occupant Comfort and Health

Green buildings typically incorporate superior air quality, abundant natural light, access to views, and noise control. Effectively, each of these qualities benefits building occupants, making these building better places to work or live. Building occupants want and value many green building features, such as superior air quality and control of air temperatures. An extensive North American study<sup>18</sup> on office building tenant satisfaction determined that tenants highly value comfort in office

buildings. Specifically, respondents attributed the highest importance to comfortable air temperature (94%) and indoor air quality (94%). Office temperature and the ability to control temperature were the only features that were both “most important” and on the list with which tenants were least satisfied. This study also found that the primary reason that tenants move out is because of heating or cooling problems.

The productivity benefits related to occupant comfort and health are discussed further and quantified in section 4.3.

## **4.2 Ecological**

From a conceptual perspective, a building both gives and takes from the world. It gives us comfortable spaces (when the outdoor environment is not so comfortable), but it also takes natural resources and results in water and air pollution through its operations, as well as through the production and transportation of associated materials. Green buildings strive to protect existing ecologies, and enhance or improve ecologies that may have been damaged in the past. Methodologies often employed with direct ecological benefits are as follows:

- **Protect existing natural spaces:** Green buildings tend not to be constructed on environmentally sensitive lands. If they are constructed on or near green spaces, measures are taken to limit the impact on the local ecology.
- **Enhance existing ecology:** Green buildings often are constructed on previously developed property, with measures taken to restore plant life to building sites by decreasing the site area used for parking, or through the use of green roofs, which provide a more ecologically friendly alternative to conventional roofing systems.
- **Reduce water use:** Water use typically results in draws of clean water from the environment and delivery of contaminated water back to the environment. Excessive water use can also act as a transport mechanism of other contaminants, such as fertilizers used in landscaping. By reducing water use, green buildings minimize the detrimental effects of water use and its effects on local ecologies, such as aquatic life.
- **Reduce material use and use low-impact materials:** All materials carry embodied environmental effects, in that there are environmental and ecological consequences as a result of their production and use through their life cycle. Green buildings promote the use of materials with lower embodied environmental and ecological burdens. Green buildings also typically utilize fewer materials, through efficient design and elimination of unnecessary finish materials (for example, many green buildings employ exposed structural materials, rather than covering these materials with a wall finish). Lastly, green building operations promote recycling in their operation.

- Reduce emissions to air: Green buildings effectively reduce air pollution through reduced energy use, the use of appropriate refrigerants, the use of materials with low off-gassing, and other steps. The reduction in use of fossil fuels at the building site result in lower air pollution contributions at the site, while reduction in electricity use results in lower air pollution associated with power plants.

### 4.3 Reduced Climate Change Impact

Controlling the release of greenhouse gases is an aspect of green building that warrants special mention. Buildings contribute to global climate change through the use of materials and energy, the direct burning of fossil fuels, and the use of electricity generated from fossil fuels.

A full building *Life Cycle Analysis* (LCA) approach can be used to develop the typical production and potential reductions of greenhouse gas emissions related to buildings. LCA is a “compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle.”<sup>19</sup>. From a building perspective, LCA quantifies the environmental effects of the building materials, its operation, and its demolition (i.e. cradle to grave analysis). Using the Athena Environmental Impact Estimator<sup>20</sup> (an LCA software), one can determine that the global climate change contribution associated with a conventional inefficient building can be reduced by more than 70% when both material and energy use effects are minimized using an LCA approach<sup>21</sup>.

The largest building factor affecting global climate change effects is the use of energy for heating and cooling. In addition to using fewer materials and less energy, green buildings often incorporate clean energy, such as photovoltaics or wind power. Through these efforts, the contributions to global climate change by green buildings are significantly reduced.



### 4.4 Economic Benefits

There are significant economic benefits associated with green buildings. These benefits are complex and wide reaching, so section 5 is dedicated solely to this issue.

## 5. THE ECONOMICS OF GREEN BUILDING

Almost by definition, a business case for green buildings comes down to economics. No matter how significant the environmental and occupant benefits of green buildings, there must be a translation into the hard economic realities that are the essence of business decisions. While some aspects of the business case are easily quantified and are therefore fairly straightforward — savings in operating costs from energy conservation, for example — other aspects are much more difficult to define in precise economic terms — productivity gains are a prime example. In addition, there is the thorny problem of the perspective of an analysis in the sense of who pays versus who gains. This section explores all of these issues, starting with the more straightforward direct capital and operating cost elements, and then dealing with the more nebulous elements.

The economic considerations with respect to green buildings can be broken into the following categories:

1. Direct capital costs: costs associated with the original design and construction of the building;
2. Direct operating costs: total costs of building operation, including energy use, water use, maintenance, waste, insurance, taxes etc. over the entire building life or the specified time horizon of the study;
3. Life cycle costing: the method of combining capital and operating costs to determine the net economic effect of an investment;
4. Productivity effects: dollar value related to changes in occupant productivity relative to a typical / conventional building (only for buildings where productivity can be equated to monetary value);
5. Property values and absorption rates: a key factor for speculative developers who cannot necessarily directly capture operating cost and productivity savings;
6. Other indirect or intangible benefits such as increased retail sales and risk reduction; and
7. External or tertiary economic effects, such as reduced reliance on infrastructure (sewers, roads, etc.), reduced green house gases, reduced health costs, etc., that are not readily captured by the private investor.

Capital and operational costs are relatively easy to measure, as the required data is readily quantifiable and available. Productivity effects are difficult to quantify, but are important to consider due to their potential impact. Other indirect and external effects can be wide reaching, and are also difficult to quantify. Each of these issues are addressed in the subsections that follow.

Throughout this chapter, the nature of the business decision for a given project is a recurring theme, as is the analysis perspective. For example, the business case will look quite different for an owner/developer who will also be the occupant of the building, compared to a speculative developer who intends to either sell or lease the space. The analysis perspective is critical when we are considering broader social costs and benefits versus those that accrue directly to the investor. A key issue is the extent to which social effects can translate through taxes and subsidies into legitimate elements of a private sector business case.

This section relies heavily on case studies and other analyses to provide as much substance as possible to the discussion. For the most part, the studies are American as explained in the Introduction. However, they are considered to be broadly applicable to Canada, with some exceptions as noted in the relevant sections.

## 5.1 Direct Capital Costs

Capital costs include the money required to design and construct buildings, or building elements, including interest during construction (IDC). There is a general conception among building stakeholders that the capital costs of green buildings are significantly higher than conventional buildings. Conversely, many within the green building field believe green buildings typically cost less or no more than conventional buildings. The premise within the green building industry is that savings resulting from the elimination of unnecessary systems, or the downsizing of systems through better design, offsets the increased costs resulting from implementing more advanced systems.

Several studies have focused on the capital costs of green buildings. The general consensus of these studies is that green buildings cost around 2% more to design and construct. Several important American studies are summarized below:



### **Cost of Green: A Comprehensive Cost Database and Budgeting**

**Methodology**<sup>22</sup> - Davis Langdon, July 2004: This study was performed by a cost consulting company on 138 real buildings (laboratories, academic, or libraries) across the United States. Forty-five of these buildings were “LEED Seeking” and were labeled green, and the other 93 buildings were defined as conventional.

The authors conclude that there “was no statistically significant difference between the LEED population and the non-LEED population.” However they also note that there was high variation in the construction costs within both green and non-green building categories. Ultimately, they conclude that

comparing the cost of green buildings to conventional buildings using an average cost analysis does not provide meaningful data. However, in an analysis of initial budgets, the authors were able to conclude that “the cost per square foot for buildings seeking LEED certification falls into the existing range of costs for buildings of similar program type” and “many projects can achieve sustainable design within their initial budget, or with a very small supplemental funding.” Figure 5 below shows a histogram of the building costs for all buildings.



Figure 5: Langdon Study: Costs of All Buildings

**The Costs and Financial Benefits of Green Buildings**, Greg Kats, October 2003<sup>23</sup>: This study was performed for California’s Sustainable Building Task Force, and consisted of a thorough literature review and an analysis of 33 actual green buildings across the United States, including a comparison of the real constructed cost with a cost estimate based on a similar non-green building design. These comparative designs were developed specifically for the building to which each is compared, and the authors believe them to be accurate representations for comparative purposes. The green buildings

consisted of eight LEED certified buildings, eighteen LEED Silver buildings, six LEED Gold buildings, and one LEED Platinum building.

The authors conclude that the cost premium for most green buildings is around 2%. Figure 6 provides a summary of the cost implications of green buildings for the various green building levels included in this study. This study also comments on indirect cost implications, which are presented in other sections of this report.

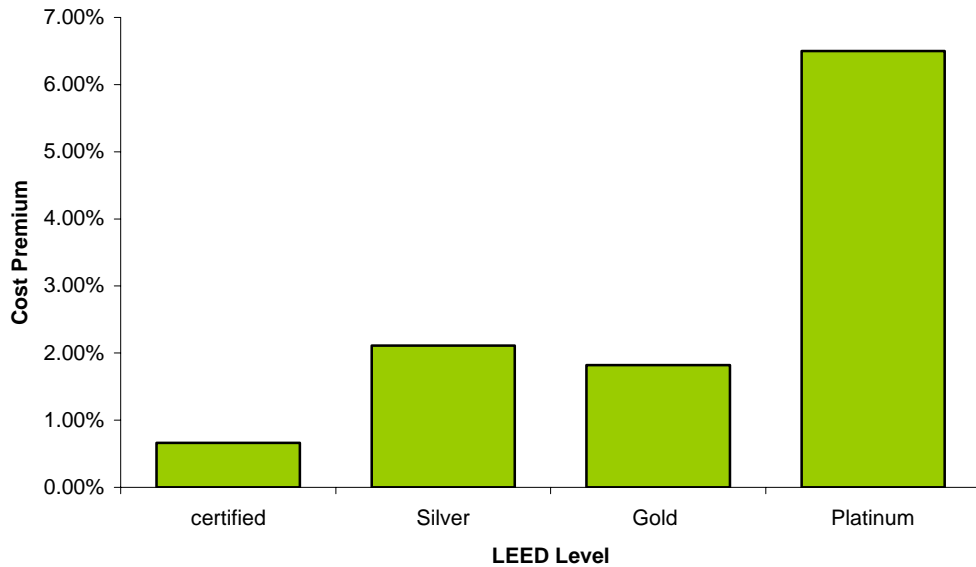


Figure 6: Kats Study: Capital Cost Increases for Green Buildings

**Building For Sustainability<sup>24</sup>:** This study for the David and Lucille Packard Foundation Los Altos Project, October 2002, involved six scenarios of different levels of green for a new 90,000 ft<sup>2</sup> (8360 m<sup>2</sup>) office building. The scenarios, developed through an integrated design exercise involving a “thorough and qualified design team and specialists”, included market (or conventional), LEED certified, LEED silver, LEED Gold, LEED platinum, and a Living Building (A living building is defined in the study as a building that has no net environmental burdens over its life cycle).

The study concluded that capital cost increases ranged for the various levels of green (in order) were 0.9%, 13%, 16%, 21%, and 29%.

From a Canadian context, this study has a number of drawbacks. Firstly, it is based on a building located in California, so the climate is not typical for Canada. Secondly, the cost data also assumes California design conditions, which are different than Canadian conditions. Thirdly, the building type and construction scenarios are limited and do not reflect a typical broad range of construction activity. Fourthly, the data is not based on real buildings. In achieving LEED ratings, construction projects typically focus on aspects of LEED that suit the unique building and site characteristics, so it is difficult to accurately analyze a theoretical building. Given the above drawbacks, we

suggest that this study may not be as applicable within the Canadian context as others noted in this report.

**GSA LEED Cost Study**<sup>25</sup>, Steven Winters Associates, October 2004: This study was performed for the U.S. General Services Administration. The study methodology included a comparison of standard building prototypes that were modified to reflect different LEED ratings. The study did not utilize real building costs. Twelve LEED rating scenarios (6 for each rating type) were developed. The scenarios were defined as follows:

- **New Courthouse:** Two estimates were developed at the conventional, LEED certified, LEED silver and LEED gold levels. At each level, one “low cost” and one “high cost” scenario was developed.
- **Office Building Modernization:** Similarly, two estimates were developed at the conventional, LEED certified, LEED silver and LEED gold levels. At each level, one estimate assumed a minimal façade renovation (window replacement & minor repairs) and the other assumed a full façade replacement.

The authors conclude that green buildings can be achieved at the LEED silver (or occasionally gold) levels for a cost increase of less than 2.5%. When reviewing the data within the report, it can be further surmised that new green building costs could range from a 0.4% reduction to an 8.1% increase dependent on the LEED level achieved, and that major renovation costs to achieve the various green ratings range from a 1.4% to 7.8% increase. Without exception, the higher the LEED level obtained, the higher the cost.

From a Canadian context, this study also has a number of drawbacks. Firstly, it is based on a theoretical building in the southern U.S. (a climate very different from Canada). Secondly, the building types and construction scenarios are limited and do not reflect a typical broad range of construction activity<sup>26</sup>. Thirdly, the data is not based on real buildings (see explanation in Los Altos study above). Given the above drawbacks, we suggest that this study may not be as applicable within the Canadian context as others noted in this report.

**Summary:** Green buildings can be achieved using a number of different methods and to different levels of “green”. In general, the greener a building, the higher the capital costs. However, different building types and sites offer different opportunities to achieve green principles, so the costs associated with utilizing green principles are different from building to building. Accordingly, costs associated with green buildings can vary. None-the-less, the studies noted above indicate that incorporating typical green principles in construction projects results in an increase in capital cost of between 0 and 30%, with the majority of the studies indicating cost increases of less than 8%. Further, in many cases, green buildings can be achieved for capital cost increases of 2% or less. There is little evidence to support that green construction projects cost less than conventional construction projects.



## 5.2 Direct Operating Costs

Direct operating costs include all expenditures incurred to operate and maintain a building over its full life. The obvious costs are those associated with heating and cooling, painting, roof repairs and replacement, and other routine maintenance activities. However, this cost category also includes less obvious costs such as property taxes, insurance, and the costs of reconfiguring space and services to accommodate occupant moves (termed ‘churn’). Excluded are the costs of major renovations, cyclical renewal and residual value or demolitions costs that are considered to be direct capital investments.

### 5.2.1 Insurance Rates

Many of the tangible benefits of green buildings reduce a variety of risks, which should be reflected in insurance rates. Green buildings also tend to be healthier for occupants, which should be reflected in health insurance premiums. The self-reliant nature of green buildings (natural light, off grid electricity, use of site water) should reduce a broad range of liabilities, and the general site locations should reduce risks of property loss due to natural disasters. Lastly, the integrated design of a building can reduce the risk of inappropriate systems or materials being employed, which could affect other insurable risks. Table 1 below displays a variety of risks that are mitigated in green buildings.

	Fire & Wind Damage	Ice & Water Damage	Power Failures	Professional Liability	Health and Safety (Lighting)	Health and Safety (Indoor)
Building Commissioning						
Day lighting						
Demand controlled						
Efficient duct systems						
Efficient windows						
Energy audits & diagnosis						
Health recovery ventilation						
Insulated water pipes						
LED exit signs						
Natural ventilation						
Radiant barriers						
Radiant hydronic cooling						
Radon resistant designs						
Reduced indoor pollutants						
Roof attic insulation						

Table 1: Risk Mitigation of Green Buildings<sup>27</sup>

Some insurance companies offer premium reductions for principals common in green buildings, such as commissioning or reduced reliance on fossil fuel-based heating systems<sup>28</sup> (reduced fire threat), and it could be expected that other premium reductions will become common as the broad range of benefits is more fully recognized.

### 5.2.2 Churn Rates

Churn rate is defined as the frequency with which building occupants are moved, either internally or externally, including those who move but stay within a company, and those who leave a company and are replaced. Green buildings can affect churn rate costs in two manners:

- Green buildings may result in an actual decline in churn rates because of increased occupant comfort and satisfaction. (see section 4.1),
- Green buildings often incorporate systems, such as raised floors and moveable partitions, that reduce the costs of accommodating churn. For example, raised floor systems utilize the spaces beneath the floor for cabling, electrical wiring, and ventilation, and it is generally easier and less costly to relocate specific elements (such as electrical outlets or data ports) in buildings with raised floor systems. Raised floor systems can reduce costs associated with churn by 0.40 \$/ft<sup>2</sup>/yr<sup>29</sup> (4.31 \$/m<sup>2</sup>/yr).

## 5.3 Life Cycle Costing

Life Cycle Costing is the methodology employed to evaluate the economic performance of additional investments that may be required for green buildings. It is based on discounting all future costs and benefits to dollars of a specific reference year that are referred to as Present Value (PV) dollars. This makes possible the meaningful quantification of costs and benefits and the comparison of alternatives based on the same economic measure or reference dollar.

The reduced operating cost payoff that generally follows from an investment in green building can be estimated when all factors are analyzed using a long term life cycle costing (LCC) approach (20-50 years). In fact, it can be argued that life cycle cost based decisions, or at least a longer term outlook, are the key reasons to pursue a green building from a private investor perspective. Studies have shown that the present value of the life cycle cost savings associated with green buildings can greatly outweigh capital cost increases.

There are a variety of economic measures that can be used in a life cycle costing approach other than simple payback (SPB), which does not allow for the time value of money (interest or discount rate). For example, the Net Present Value (NPV) is defined as the Present Value of benefits minus the Present Value of the Initial investment for a specified time period. A negative NPV reflects an investment that has not been recovered and is therefore not cost effective; a positive NPV reflects an

investment that has been recovered and is cost-effective. NPV is a realistic representation of cost effects, as it takes into account interest rates and price escalation.

A number of studies reflecting life cycle costs of green buildings are described below:

- The study by Greg Kats (see section 5.1) develops a 20 year present value savings of \$5.79/ft<sup>2</sup> (\$62.32/m<sup>2</sup>) for energy savings, \$0.51/ft<sup>2</sup> (\$5.49/m<sup>2</sup>) for water savings, \$0.03/ft<sup>2</sup> (\$0.32/m<sup>2</sup>) for waste savings, and \$8.47/ft<sup>2</sup> (\$91.17/m<sup>2</sup>) as a result of commissioning. The cost increase to make these projects green was \$4/ft<sup>2</sup> (\$43/m<sup>2</sup>), so the NPV was estimated at \$10.80/ft<sup>2</sup> (\$116.25/m<sup>2</sup>). Based on the project financial criteria, the Adjusted Internal Rate of Return (AIRR) for this investment would be about 14%, or double the project discount rate of 7%. By this scenario, a 100,000 ft<sup>2</sup> (9,300 m<sup>2</sup>) building would achieve a direct benefit of over one million dollars over a twenty year period by incorporating green principals in its construction. Note that the NPV is calculated over 20 years, which is less than a typical building life. If a longer time frame were taken into account, the life cycle benefits of constructing a green building would increase further.
- The Los Altos study (see section 5.1) develops sixty year cost reductions (with defined interest and inflation rates) of between \$195/ft<sup>2</sup> (\$2100/m<sup>2</sup>) and \$470/ft<sup>2</sup> (\$5000/m<sup>2</sup>) for the various levels of green. As stated earlier, we would suggest this study might not be an accurate representation of Canadian costs.
- A 2002 economic study on implementing energy efficiency measures into the new and existing building stock in the European Union determined that double the cost of implementing energy efficiency measures would be realized over the life cycle of the buildings<sup>30</sup>.

## 5.4 Productivity and Salary Cost Gains

In commercial/ institutional buildings, payroll costs greatly overshadow all other costs, including those involved in the design, construction, and operation of a building<sup>31</sup>, as shown in Figure 7. The data in Figure 7 can be massaged to indicate that an increase in worker productivity of 1% equates to about \$2/ft<sup>2</sup>/yr (\$21.50/m<sup>2</sup>) (a 1% productivity increase equates to approximately 5 minutes of time per day).

It seems evident, therefore, that any productivity gains attributable to a green building should be included in the life cycle cost analysis, especially for an owner-occupied building. However, this seems to be the exception rather than the rule for a number of reasons, not the least of which is the difficulty

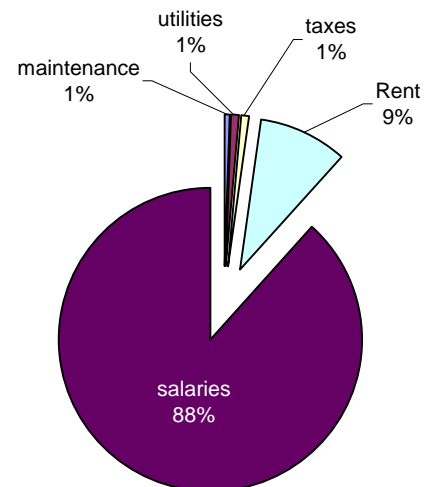


Figure 7: Annual Commercial Expenses

of properly attributing such gains as reduced absenteeism and staff turnover rates.

In the case of speculative or leased facilities, it is more difficult to assign a market value to occupant productivity gains and have them properly reflected in the business case at the decision-making point. Nevertheless, there is sufficient evidence quantifying the effects to justify taking them into account on some basis. Though the owner of a leased facility does not financially benefit directly from increased user productivity, some indirect benefits can be achieved if a convincing message of significant benefits can be conveyed to the user; this will allow rental fees to be increased and occupancy rates to increase (See Section 5.5). For most commercial buildings, even a conservative estimate of the potential reduction in salary costs and productivity gains will loom large in any calculation, as indicated in the following case studies.

- A detailed 2003 California study<sup>32</sup> on office worker productivity reached the following conclusions:
  - a) The study found that an increase in daylight illumination levels from 1 to 20 foot-candles resulted in a 13% improvement in productivity.
  - b) Daylight illumination levels did not affect the long term memory.
  - c) An ample and pleasant view was consistently found to be associated with better office worker performance. Office workers were found to perform 10% to 25% better on tests of mental function and memory recall when they had the best possible view verses those with no view.
  - d) Glare from windows decreased performance by 15% to 21%.
  - e) Increased ventilation was associated performance improvements of 4 to 17%.
  - f) Physical comfort conditions were found to affect worker performance by up to 20% (plus or minus, compared to the norm) with a “high statistical significance”.
- A study<sup>33</sup> by Lawrence Berkeley National Laboratory concluded that improvements to indoor environments common in green buildings could reduce health care costs and work losses as follows:
  - a) from communicable respiratory diseases by 9 to 20%
  - b) from reduced allergies and asthma from 18 to 25%
  - c) from non specific health and discomfort effects by 20 to 50%
- The Center for Building Performance at Carnegie Mellon University in the U.S. developed a database of studies that applies to technical characteristics of buildings, such as lighting or ventilation, and how they relate to tenant responses, such as productivity. This data was used by Kats in their “The Cost and Financial

Benefits of Green Buildings” publication (see section 5.1) to develop summaries of existing published studies. These summaries included the following:

- a) Thirteen studies were found that focused on the relationship between individual productivity and increased ventilation control. The studies concluded productivity increases between 0.48 and 11%, with most studies clustering around 1% and an average of 1.8%.
  - b) Seven studies were found that focused on the relationship between individual productivity and increased temperature control. The studies concluded productivity increases between 0.2 and 3%, with an average of 1.2%.
  - c) Eight studies were found that focused on the relationship between individual productivity and increased lighting control. The studies concluded productivity increases between 3 and 15%, with an average of 7.1%.
- Based on a wide review of research, it was estimated that workers with control of thermal conditions might show performance increases of 7% for clerical tasks, 2.7% for logical thinking tasks, 3% for skilled manual work and 8.6% for very rapid manual work<sup>34</sup>.
  - A study of absenteeism<sup>35</sup> of 3,720 employees in the Eastern United States found that absenteeism was 35% lower in offices with higher ventilation rates, a common trait of green buildings.
  - In addition to the above, a number of case studies present arguments of increased productivity in green buildings, as indicated below:
    - a) A post office in Reno Nevada realized a 6% increase in productivity through a Green retrofit.<sup>36</sup>
    - b) A “high benefit lighting” retrofit at the San Diego Federal Building and Courthouse” resulted in productivity increases of 3 and 15% in the office and courthouse areas.<sup>37</sup>
    - c) A lighting retrofit at Pennsylvania Power and Light resulted in productivity increases in drafting engineers’ offices of 13% and a 25% reduction in sick leave<sup>38</sup>.
    - d) The West Bend Mutual Insurance Company headquarters incorporated day lighting, reduced energy use, and personal workspace controls. It was subject to a rigorous study by Renesselaer Polytechnic Institute, which concluded that “the new building produced an increase in productivity of approximately 16%”<sup>39</sup>

- e) The ING bank in Switzerland found that employee absenteeism decreased by 15% in a green building compared to an older existing building.<sup>40</sup>

Beyond the above, there have been several prominent and reasonably extensive studies on the effect of day lighting in schools, as summarized below. Although these studies are not purely economic, they do demonstrate a method to quantify some benefits of green building. Further, an argument could be made that student performance could be correlated to the performance of “knowledge workers”, whose tasks include reading comprehension, synthesis of information, writing, calculation, and communications.<sup>41</sup>

- A 2003 American Study<sup>42</sup> on student performance and the indoor environment concluded:
  - Good views support student learning
  - Direct sun penetration and glare negatively impact student learning
  - The acoustic environment is important for learning
  - Poor ventilation and indoor air quality are correlated with lower student performance
- A 1999 American study analyzed standard test scores of over 21,000 students in the United States and found that “students with the most day lighting in their classrooms progressed 20% faster on math tests and 26% better on reading tests than those with the least [natural light]”<sup>43</sup>
- A North Carolina study<sup>44</sup> compared standardized test scores of three daylit schools to comparable typical schools in North Carolina, and found an average test score improvement of 5% in the daylit classrooms.
- An Alberta two year study<sup>45</sup> on full spectrum lighting concluded:
  - Natural lighting affected the health of students: The students in natural lit classrooms attended school 3.2 to 3.8 days more per year
  - Naturally lit libraries were quieter
  - Students in naturally lit classrooms had 9 times less dental decay and grew in height an average of 2.1 cm more than those in classroom with no natural light over a two year period. The authors conclude this is due to additional vitamin D from full spectrum light.



Summary: There are a number of reasons that it is difficult to summarize the above studies into one number:

- Many of the studies focused on productivity comparisons between extraordinarily poor interior environments and those within green buildings. These studies likely do not reflect productivity increases between typical building environments and green buildings. In effect they reflect the best case scenario for productivity gains.
- Many of the existing studies relied on relatively small sample sizes and did not confirm results or prove them through repeatability.
- Many of the studies focused on particular aspects of interior environments, such as natural lighting or ventilation control. It is not clear how the results of these studies would affect the results of other aspects of green buildings (what happens when several building traits are combined?)
- Case studies tend to be published only when the results are strongly positive, and the methods by which these results are obtained are rarely provided (questionable statistics)

Nevertheless, there certainly is a strong indication that occupant productivity is greater, and that salary costs are reduced, in green buildings compared to conventional buildings. The magnitude of this difference is not clear, but it would be reasonable to assume a productivity gain of between 2 and 10% when moving from an average building to a green building that incorporates high quality natural light, exceptional ventilation, and possibly user controls. For most office buildings, even the 2% gain will be sufficient to more than compensate for any extra costs associated with the design and construction of a green building.

## 5.5 Property Values and Absorption Rates

There have been few thorough and reliable studies on the relationship between property values and green buildings. But this is another aspect that should be quantified and then included in the economic calculations. It is an element that should be especially relevant to speculative developers who intend to either sell or lease a new building, although it can also have a bearing on the decision process in general; even developers who intend to occupy a building will have an eye on the market value of the asset.

As indicated below, there are many factors that will or could result in an increase in property values for green buildings. Unfortunately, the real estate industry may not fully comprehend the benefits of green buildings (see section 3.2.1), or they may not convey the benefits of a green building to prospective purchasers. In that case, the benefits may not be properly reflected in selling prices or lease rates.

- An extensive American office building tenant survey determined that tenants “highly value intelligent features”, such as efficient HVAC systems and automatic sensors for lighting, and that “72% of who want an intelligent feature would be willing to pay additional rent to have the feature made available”<sup>46</sup>

- Many governments in Canada are mandating green buildings for all new construction they will own. Currently, the Federal Government of Canada, the City of Calgary, Markham, and the City of Vancouver have this requirement, and it is believed that many other governments in Canada are considering this as well. The Government of Canada is considering requiring green buildings for their leased stock as well. Based on the simple economics of supply and demand, one could expect green buildings to increase in value due to these requirements. Conversely, the value of conventional buildings could decrease. Some examples<sup>47</sup> of recent green requirements on building projects include:



- The City of Victoria recently put out a request for proposals to redevelop some contaminated harbourfront land. The city mandated that all buildings on the site be LEED silver. However, the successful proponent on this project proposed all buildings be LEED Platinum, and that the entire site be carbon neutral. This was a significant aspect of winning the competition, and penalties for non-compliance are being written into the contract, demonstrating that the green aspect is important to the City.
- The Toronto Waterfront Revitalization Corporation has recently announced that it will require all new construction to be LEED Gold. The total value of this development is estimated at \$1.7 B.
- To the extent that green buildings result in increased income and lower operating expenses, they should be more profitable than conventional buildings. Property appraisers who understand the benefits of green buildings are likely to reflect this in valuations. “Buildings with a green rating may receive a superior capitalization rate than the non-green building. Even a ½% of capitalization rate improvement can equate to significantly higher building value upon sale and refinance”<sup>48</sup>.
- Press attention and publicity make Green Buildings more in demand, which should be reflected in value.

There has also been some evidence of high absorption rates and residential sales<sup>49</sup> of green buildings. For example, the Vancouver Island Technology Park (First LEED Gold Building in Canada) was the most successful leasing project in Victoria, despite it becoming available during a period of high vacancies<sup>50</sup>. There are similar examples of increased demand in the American market.<sup>51</sup>

It is also worth noting the increased demand for green buildings, which will inevitably result in higher valuations. Many governments and



## 5.6 Other Indirect/Intangible Benefits

This sub-section discusses a number of other benefits of green buildings that may be captured by investors and should be reflected in the decision economics. They may not be so readily quantified, and some may be intangible, but they nevertheless affect the value of a green building and should be factored into the business case.

### 5.6.1 Increased Retail Sales

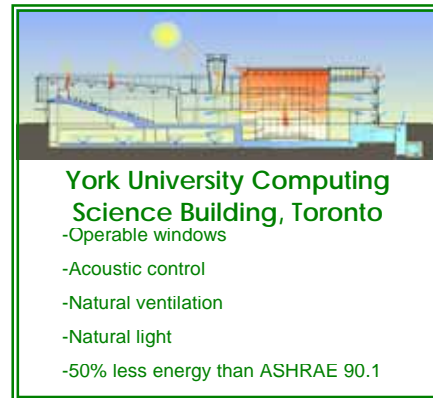
There is some evidence that green buildings, or at least good quality natural lighting, can have a dramatic effect on sales in commercial buildings. Two large American studies focused on this benefit:

- A study<sup>52</sup> was performed on 108 buildings by the Heschong Mahone Group to determine the effects of skylighting on sales. This study measured gross sales over an 18-month period on a sample of 108 commercial buildings (retail chain with similar layouts), two thirds of which utilized skylights. It was determined that sales increased by 40% in the daylit stores. The authors also used statistical analysis to determine the influence of other factors, such as number of hours open, location, and income of clients, but concluded that skylighting had the largest impact on sales.
- A 2003 study<sup>53</sup> by the Heschong Mahone Group built upon the previous study by incorporating methods that accounted for many more variables and other physical differences. This study incorporated a smaller sample (73 stores from one chain) and greater variation in the basic store plan and layout, and the stores incorporated less lateral natural illumination than the previous study. This study concluded sales increases between 0 to 6% for average daylight conditions, but reaffirmed the 40% increase in sales for individual stores, with the most favorable daylighting conditions (longest hours of daylight, ample parking areas).
- A recently completed green banking facility in Victoria spurred a 400% jump in membership from the old location. A second similar building (owned by the same company) in Vancouver found an increase in new members through referrals of 26% compared to the previous year (in a non-green building). The Chief Executive Officer of the company explains the rise in membership and referrals as follows: “Happy staff makes customers happy, which increases business and morale and lowers sick days. Satisfied customers are loyal customers who will do more business and talk to friends and business associates about their satisfaction.”<sup>54</sup>

### 5.6.2 Improved Image

Regardless of the business case, the public generally perceives green buildings as modern, dynamic, and altruistic. Companies associated with green buildings will benefit from these perceptions through employee pride, satisfaction, and well-being, which should in turn be reflected in reduced turnover and improved morale. Other benefits of this improved image include advantages in recruitment of employees.

Companies can clearly demonstrate a commitment to sustainability through building or occupying a green building, particularly if that building was designed with readily apparent green features, such as windmills or photovoltaic panels. The building can be a “symbolic message to visitors, community officials, and the public. Key messages conveyed by a sustainable building include technological advancement, business innovation, and concern for the environment.”<sup>55</sup> These images can be particularly powerful, and can be an important consideration in a company’s decision to pursue occupancy in a green building.



### 5.6.3 Risk Reduction

A number of risks can be reduced through the use of green buildings, as discussed below:

**Air Quality Litigation:** The Environmental Protection Agency in the U.S. classifies indoor air quality as one of the top five environmental health risks today. The “Sick Building Syndrome” (SBS) is a popular issue and often ends up being resolved in the courts<sup>56</sup>. Business owners and operators are increasingly facing legal action from building tenants blaming the building for their health problems. The base cause of SBS is poor building design and / or construction, particularly with respect to the building envelope and mechanical systems. Green buildings emphasize and promote not only safe, but also exceptional air quality, and no functioning green building should suffer from SBS. A similar argument could be made for mold related issues, which are also a popular basis for litigation today.

**Future Proofing:** Green buildings are inherently efficient and safe, so they help to ensure that the building will not be at a competitive disadvantage in the future. A number of potential future risks that are mitigated to some extent in green buildings include:

- Energy conservation protects against future energy price increases.
- Water conservation protects against water fee increases.
- Green building occupants are generally more comfortable and content, so it can be expected they will be less litigious within a more general context.

- A documented effort to build or occupy a healthy green building demonstrates a level of due diligence that could stand as an important defense against future law suits or changes in legislation, even for currently unknown problems. For example, it has been said that the decision of the Ford Motor Company to install a 454,000 ft<sup>2</sup> (140,000 m<sup>2</sup>) green roof on its new Dearborn, Michigan plant primarily to protect against future liabilities under the Water Pollution Act<sup>57</sup>. Ford's CEO, William Clay Ford, spoke of the two billion dollar modernization: "This is not environmental philanthropy, it is sound business, which for the first time balances the business needs of auto manufacturing with ecological and social concerns."<sup>58</sup>

**Self Reliance:** Green buildings often incorporate natural lighting and ventilation and internal energy and water generation, making them less reliant on external grids, and less vulnerable to grid-related problems or failures such as brown-outs or black-outs, water shortages, or contaminated water. This element is becoming more important in today's world because of to the perceived risk of terrorism.

## 5.7 External Effects

External effects include costs or benefits of a project that accrue to society and are not normally captured in a private decision framework. The extent to which they can be factored to a business case is a function of the extent to which they can be converted from the external to the internal sides of the ledger. This is a critical factor in any assessment of the costs and benefits of green buildings. For example, the costs of green roofs are borne by the developer or investor, while much of the benefit accrues at a broader societal level (e.g., reduced heat island effects and reduced storm water runoff).

If a government is the investor, or if a private developer is compensated for including features that produce benefits at a societal level, then the business case can encompass the much broader range of effects. For example, there are jurisdictions, such as New York City, that offer tax incentives for green building, thereby providing a direct business case payoff to the investor. Similarly, Arlington Virginia allows higher floor space to land coverage ratios for green buildings.

The remainder of this sub-section highlights examples of external effects that should somehow be taken into account. In each case, there is a payoff to society as a whole and, as the green building sector evolves and becomes prominent, we should see more effort on the part of municipal, provincial and federal governments to at least indirectly compensate investors or provide incentives to make these gains possible.

### 5.7.1 Infrastructure Cost Benefits

Water use (and disposal) is typically provided by governments and is often not cost effective, or even cost neutral. An Alberta study<sup>59</sup> on water use determined that the price charged for fresh water was one third to one half the long run supply cost, and

that prices charged for sewage were approximately one-fifth the long run cost of treatment. In effect, governments are heavily subsidizing water use and treatment.

Green buildings typically incorporate measures to significantly reduce water use. While direct cost savings have already been analyzed and are included in the “direct cost” discussion, the indirect costs associated with infrastructure and government subsidies have not been defined. On the assumption of a green building water use reduction of 30%, associated indirect costs savings can amount to 0.30 to 0.58 \$/ft<sup>2</sup> per year<sup>60</sup> (3.23 to 6.24 \$/m<sup>2</sup>/yr).

### 5.7.2 Environmental Effects or Costs

External environmental costs<sup>61</sup> include pollutants in the form of emissions to air, water and land and the general degradation of the ambient environment. The largest indirect environmental consequence of buildings is their effect on human health. Other impacts, such as damages to ecosystems, crops, structures/monuments and resource depletion are worth considering, but do not have a large associated indirect cost relative to human health.



A study by Lucuik & Meil<sup>62</sup> in 2004 developed a full cost accounting approach by taking into account indirect costs for typical office buildings in Canada. This study developed a total cost of a functional office building (in Vancouver and Toronto), including design, construction, operation, and demolition, but excluding occupant productivity gains, and including both direct and indirect environmental costs. This study concluded that indirect environmental costs were 17% of the total building cost, or approximately \$19/ft<sup>2</sup> (\$210/m<sup>2</sup>). The authors admit that externality costing is in its infancy, and that there is some debate over the specific economic effects of the various labels, “but to completely discount these costs when making decisions about long-lived durable products, such as buildings, is to say the least short-sighted.”

An alternate indicator of the environmental effects of buildings is the carbon trading value of CO<sub>2</sub>. CO<sub>2</sub> values vary considerably by region, and generally range from 2 to 35 \$/Ton (1.80 to 31.75 \$/tonne). However, these values do not reflect actual environmental impacts, but rather a supply and demand function based on commitments to reduce carbon emissions. Based on a 20 year NPV, an American study<sup>63</sup> estimates the cost savings through a 36% pollution reduction to be \$1.18/ft<sup>2</sup> (\$12.7/m<sup>2</sup>) of CO<sub>2</sub> emissions. A recent high level study<sup>64</sup> on the economic implications of meeting Kyoto determined 1 and 2 billion dollars in annual savings are achievable for the residential and commercial building sectors in Canada calculated using a net present value with a time frame between 1997 and 2012.

Effects of this magnitude should surely be encouraged through appropriate incentive programs. When they are, the business case for green buildings will be strengthened immeasurably.

**5.7.3 Job Creation**

There are significant environmental effects associated with the transportation of materials for the construction industry. Accordingly, green building rating systems often promote the use of local or regional materials, which in turn encourages local or regional job creation.

In addition to the above, many green building attributes are labour intensive, rather than material or technology intensive. Examples of this effect include recycling or re-use as opposed to disposal, and increased consultant costs. These represent increases in the labour pool within the region of the building. These costs are not well defined, and tend to vary from project to project, but they are not negligible; one American study<sup>65</sup> determined that the cost benefit of recycling vs. disposal equates to 0.03 to 0.14 \$/ft<sup>2</sup> (0.32 to 1.50 \$/m<sup>2</sup>) for construction projects.

**5.7.4 International Recognition and Export Opportunities**

Green building can also have economic effects on a much broader level as a result of increased international recognition and related export sales.

Canada is a recognized international leader in the movement towards sustainability. The 2005 Environmental Sustainability Index prepared by Yale and Columbia Universities<sup>66</sup> benchmarks the ability of nations to protect the environment by integrating 76 data sets (including natural resource endowments, pollution levels, environmental management efforts) into a smaller set of indicators of environmental sustainability. This study ranked Canada 6<sup>th</sup> in the world and 2<sup>nd</sup> in the Americas. The United States ranked 45<sup>th</sup>. Table 2 below provides the top 10 ranked countries in the world and figure 8 displays a graphical representation of Canada’s score in relation to the entire set of 146 countries.

Rank	Country	Score
1	Finland	75.1
2	Norway	73.4
3	Uruguay	71.8
4	Sweden	71.7
5	Iceland	70.8
6	Canada	64.4
7	Switzerland	63.7
8	Guyana	62.9
9	Argentina	62.7
10	Austria	62.7

Table 2: 2005 Environmental Sustainability Index Leaders

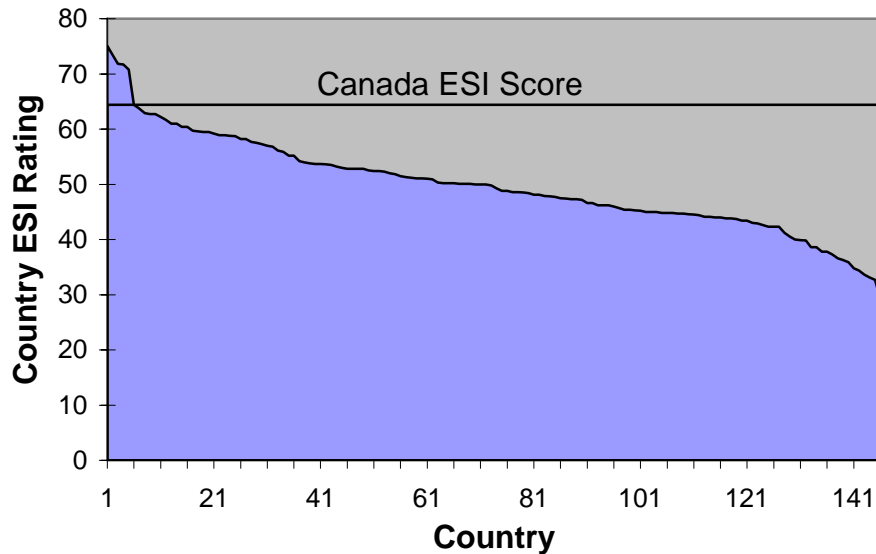


Figure 8: Environmental Sustainability Indices – All Countries

This enviable status of Canada in the field of sustainability can provide international export opportunities. Prime Minister Paul Martin recognized this, in February 2005 speech in which he stated:

*“Meeting our Kyoto commitments is only one part of a much broader national initiative, a major multi-year effort to create a healthier environment and a stronger economy, to deliver cleaner air and cleaner water, to make Canada an even better place to live, and to become a world leader in developing environmental technology.”<sup>67</sup>*

Within the more focused green building field, Canada leads the world on a number of specialty services, systems and materials. Examples of Canada’s international expertise in the green building field are as follows:

- The strategy of integrated design was structured and defined largely by Canadians.
- Canadian Building Envelope specialists are recognized as world leaders in this field<sup>68</sup>. Building envelope expertise is mandatory in the integrated design process.
- The Athena Institute is a world leader in life cycle analysis and the estimation of the environmental impact of materials<sup>69</sup>.
- Canadians have played leading roles in international green building initiatives, such as the green building challenge<sup>70</sup> and the international initiative for the sustainable built environment (iiSBE)<sup>71</sup>.

- Green Roof technology is particularly strong in Canada. Currently, thorough and unparalleled research is being undertaken by the National Research Council to quantify the benefits of green roof technology<sup>72</sup>.

In general, Canadian green building stakeholders, including designers, developers, lenders, and material and system providers stand to gain export opportunities, particularly to the United States, Asia, and South America.

## **6. RISKS, CHALLENGES AND BARRIERS**

Green buildings are perceived as being new and different and people tend to be suspicious of new things. Although many of the features of green buildings have long and proven histories, and the premise of integration is common sense, the general perception by building stakeholders is that green buildings are new and risky. In fact, most of the risks, challenges, and barriers associated with green buildings are due to their relative youth, and most can be alleviated through research and education. Several risks associated with green buildings are discussed below.

### **6.1 Knowledge in building industry**

As noted in section 3.2.1, the current level of knowledge of most building stakeholders is minimal. This is particularly problematic in the lending and building design sectors. A short discussion of the challenges associated with this lack of knowledge in various building stakeholder groups is provided below:

#### **6.1.1 Knowledge of lay people**

Lay people from a critical component on the demand side of the supply and demand curve. Should lay people be convinced of the benefits of green buildings, their pull on the industry would inevitably result in a strong increase in the supply of green buildings.

However, as noted in section 3.2.1, lay people have almost no understanding of green buildings or their benefits. This risk could be reduced through a strong, targeted education scheme.

#### **6.1.2 Lenders**

Most building developers are financed by external lenders, who do not distinguish typical from green building construction. These lenders generally have inadequate knowledge to accurately determine the value of green buildings. As a result, it is in the best interest of developers to minimize construction costs and maximize the building area produced over a set period of time, and they have little incentive to incorporate energy saving or other green building measures.

### **6.1.3 Building Designers and Specialists**

Although building designers and specialists tend to be the most informed about green buildings, there is still widespread misinformation in this sector. Designers are the ones ultimately responsible for achieving functioning green buildings, and a failure to have a thorough understanding of the principles involved can result in poor results.

One of the hallmarks of green buildings is efficiency in general. This efficiency is achieved through integration, which results in each specialty involved in design and operation relying on the results of other specialties. A failure of one particular specialty can cascade into multiple failures of related specialties, so it is critical that a proper level of knowledge is maintained for all green building stakeholders.

The resolution of this issue can be achieved through education of design professionals so that they understand the importance of design team performance coupled with an emphasis on the expertise of design team members

## **6.2 Building codes**

Most building designers rely on Building Codes in the design of their buildings. However, the National Building Code of Canada (NBC) is essentially a set of minimum regulations and requirements for public health, fire safety, and structural sufficiency of buildings.<sup>73</sup> The NBC does not require that buildings be designed to promote health or safety levels above this minimum level, but allows designers to exceed the specified requirements where suitable.

The Model National Energy Code of Canada for Buildings 1997 (MNECB) contains minimum requirements for energy efficiency in new buildings. Like the NBC, the MNECB is in the form of a model code to permit adoption by appropriate authorities. The MNECB contains some very useful information on how to achieve energy efficiency, but the minimum levels are generally considered to be easy to reach and are not near what is achievable in the industry. A requirement of the Canadian Building Incentive Program<sup>74</sup> (CBIP) is to exceed the MNECB requirements by 25%, and it is common for green buildings to exceed the MNECB requirement by 60% or more.

European codes generally reflect many of the hallmarks of green buildings better than North American codes. In Germany, for example, building codes mandate occupants to be located within 7.5 m of a window. Similarly, operable windows in European office buildings are common. There is also a European directive on energy performance of buildings that requires all EU countries to have energy standards in place by January 2006.

Canadian building codes need to be modified to promote and better reflect opportunities available to exceed minimum requirements. In some cases,



consideration should be given to mandating certain requirements to promote characteristics of green buildings, such as natural light or ventilation.

### **6.3 Increased Liabilities**

Green buildings are more efficient users of energy and materials, which can result in reduced safety factors for various systems (see section 6.1.3). Green buildings also tend to utilize non-standard materials and systems. These factors result in increased risk of failure of the affected materials or systems incorporated in green buildings.

These risks can be mitigated by ensuring that the design process is implemented appropriately, and that qualified designers are employed. Essentially, this would involve education of the various building stakeholder groups.

### **6.4 Tendering and Contracting Styles**

Common contracting and tendering styles within the building industry have a number of drawbacks that adversely affect the green building industry. These drawbacks are deeply ingrained in the industry, and may be difficult to resolve. Three important drawbacks are the low cost approach, a focus on time, and a lack of emphasis on performance. Each of these drawbacks is discussed below:

#### **6.4.1 Low cost approach**

Many building projects use first cost as an important factor to determine a suitable action. This first cost approach often fails to achieve the required results, given that low cost frequently relates to low quality. None-the-less, this practice continues due to misconceptions of equality of deliverables (low cost items or services are no worse than higher cost items or services) and because of the perception of required fiscal responsibility.

A quality approach must be promoted to reduce this risk. Decision makers must implement systems that evaluate quality in addition to cost. These systems must be logical, definitive, and auditable, and they must be supported at the highest levels of organizations. In addition, an education program into the risks of using a low cost approach could prove beneficial.

#### **6.4.2 Focus on Time**

Time is money. This adage applies to not only to labour related fields, but also to many building developers. As noted in section 6.1, building developer profits are directly related to how quickly projects are completed; interest during construction can be a very big factor on larger projects and it is generally critical from a business perspective that revenues flow as soon as possible. For good reason, the time imperative is ingrained in the entire building industry, such that specific time constraints are often placed on designers and contractors within all building types.

Green buildings require some additional time in the design and construction phases to ensure that a properly integrated and efficient system is achieved. The problem then, is to accommodate the time requirements of green design and construction within the business case; making sure the team has the proper opportunity to deliver without jeopardizing the bottom. For the most part, this can happen when proper life cycle costing approaches are applied. The additional time requirements must then be incorporated in tender documents, which means high level contracting authorities have to understand the issues — another critical education requirement.

## **6.5 Adoption of Life Cycle Approach**

Despite the sound basis for adopting a life cycle approach, most building stakeholders focus on minimizing direct costs or, at best, using short time frame pay back periods. Many stakeholders believe that basing opinions on anything but a reduced direct cost approach is fiscally irresponsible, when in reality the opposite is usually true. An important reason for this lack of adoption is the typical corporate structure dissociating direct and operating costs: Most constructors are not mandated to reduce operating costs, only to reduce construction cost. This unfortunate reality is even true for owner/developers, who oversee construction of buildings for their own use. Other causal factors associated with this constraint include the following:

- Misunderstanding of the life cycle concept;
- Cash-flow constraints;
- Difficulty in measuring performance (compared to relative ease in measuring direct cost); and
- Poor support from lending institutions.

## **6.6 Common Lease Structures**

Most leasing arrangements, particularly in the office/commercial sectors, provide little incentive to undertake changes that might be beneficial to the environment. For example, many leases have fixed rates regardless of energy or water consumption, yet the lessees have control over most energy and water consuming devices. This situation is exacerbated by a lack of detailed metering by space, so that neither owners nor lessees can easily obtain consumption patterns.

## **6.7 False (Green) Claims**

The recent surge in interest in the field of green buildings, coupled with the relative youth of the industry, has resulted in many misconceptions or exaggerations put forth by owners, designers, manufacturers, or distributors. Within the industry, the term used for this type of misconception is “Greenwash”. Greenwash can apply to building materials, systems, buildings, or companies. Greenwash ultimately discredits the

entire green building industry, as the ultimate goals of green buildings are not achieved through their use. These claims can generally be broken into two groups: materials and performance.

**Material claims:** Given the wide breadth in the definition of a green building, material or system providers often find a material property with limited green characteristics, and market this property, and the material, as being “green”. For example, a material that uses high recycled content might use vast amounts of water in its production, but this material is marketed as green even though the overall environmental impact of this material could be bad. These false claims also have occurred when material or system providers rely on inaccurate information. For example, there have been instances where material system providers have claimed very long durability characteristics, without adequate proof of that claim.

As the green building field matures, and as processes such as life cycle analyses become more common (see section 4.3), it is expected that this risk may be mitigated somewhat. The use of a reliable material rating system would also reduce the likelihood of false material or system claims.

**Performance Claims:** Many people or building stakeholder companies falsely present themselves as capable and knowledgeable within the green building field. When other building stakeholders rely on this expertise, the result can be a failure of the green building to achieve its ultimate goal. This type of misconception permeates many building stakeholder groups.

This issue might be mitigated through the development and adoption of accreditation systems. The Canada Green Building Council currently uses such a system, in which persons prove their knowledge of green buildings and become a “LEED Accredited Professional”. It is the author’s opinion that this system works reasonably well within the design stakeholder group, but fails to meet the needs of some other stakeholders. Consideration should be given to developing similar accreditations for various other stakeholder groups (such as building managers or owners), and through continued education of all stakeholder groups.

There are several current systems, such as Energuide<sup>75</sup>, Energy star<sup>76</sup>, the Environmental Choice (Ecologo) program<sup>77</sup>, or Greenspec<sup>78</sup>, which strive to assist in the selection of green materials and systems. However, these systems have several weaknesses, including a lack of transparency, accuracy, and limited inventory. In addition, users of these tools often do not understand the meaning or intended function of the different rating systems.

People who rely on these tools often do not achieve the objectives of green buildings due to these tool weaknesses. Tool systems must be developed or modified to resolve these problems.

## **6.8 Incomplete and Poor Quality Databases**

Reliable and thorough information respecting tangible benefits of green buildings is not readily available. While there is a significant amount of information available on the benefits, the studies to date have tended to be focused on specific goals (such as economic), and have not typically included all the variables necessary to definitively determine the benefits of green buildings. For example, virtually all of the comparative studies on the benefits of green buildings reviewed compared the change in occupants who were moved from a conventional building to a new building. There are very few studies that use the opposite approach: to measure the negative impacts of occupants moving from a green to a conventional building.

On a related note, many of the available studies use broad green building rating systems as determinates of green status, and conclude that this status is the cause of any found trends. These same studies often exclude variables such as occupant type, or general social conditions, and rarely provide information on the relative impact of specific green building traits. For example, at this time, there is little information on the relative merits of day lighting and good air quality, because both are employed in most green buildings.

Thorough and definitive studies are required, that focus on singular traits of green buildings to determine the effects of these specific green building traits. These studies must have a strong and sound statistical basis.

## **6.9 Weak Research in Improved Productivity**

A key benefit of green buildings is their effect on productivity. As noted in section 4.3, very modest productivity gains can greatly overshadow all increased costs and risks associated with green buildings. If it could be definitively proven that occupant performance and sales are significantly increased in green buildings, then there would certainly be a dramatic increase in demand for green buildings. Armed with this knowledge, companies would risk failure if they did not undertake measures to increase productivity, and early adopters would gain a competitive advantage. This cannot be understated: proven increases in productivity will change the building sector!

There are reasonably extensive studies that indicate green buildings dramatically affect productivity. However, these studies are broad in nature and do not focus on unique green building attributes. Thorough, accurate, and statistically sound research must be undertaken to understand the effects of green buildings on occupant productivity, performance, and sales.

## **6.10 Government support**

The various levels of Government can play a pivotal role towards the promotion and implementation of green buildings in Canada. Governments are also major beneficiaries with respect to green buildings, as many of their benefits are social and

health related. Economic benefits would also benefit governments due to increased tax revenue. Each level of government in Canada has embraced the green building industry in varying degrees, as discussed below:

- The federal government of Canada introduced a “Green Plan” in 1990, and began actively pursuing and measuring sustainability since 1995<sup>79</sup>. The federal government has incorporated changes to affect its own building stock, and has initiated several incentives available to other building stakeholders, such as the Energuide systems and the Commercial Building Incentive Program. Despite the above, there still remains some challenges and weaknesses, as indicated in the 2002 Auditor General’s report: “Sustainable development strategies of federal departments and agencies are not yet fulfilling their potential to influence change toward sustainable development...[The government departments need to] focus their strategies more on what they need to do differently to further sustainable development.”<sup>80</sup>
- Provincial and territorial Government support is fragmented and relatively minimal<sup>81</sup>. Currently, provincial and territorial support largely consists of education and demonstration programs and a focus on energy efficiency within their own building stock.
- Municipal support is also fragmented, despite municipalities being major beneficiaries of green buildings. Some municipalities, such as Vancouver, Markham and Calgary, have mandated green buildings within their own stock. Several municipalities have taken steps to control urban sprawl, and some have provided incentives for energy efficiency of private building owners. Many communities have also taken steps to control pesticide use. However, few municipalities have a clear and defined focus towards promotion of green buildings to stakeholders in their communities.

In addition to the above, a National Climate Change Process<sup>82</sup> was developed through an integrated team of various Canadian governments. This process was developed in response to Canada’s Kyoto commitment. The climate change process indicates that 13% of the greenhouse gas reduction to meet Kyoto would be achieved within the buildings sector, and an additional 26% would be achieved through transportation. The process includes several policy proposals that could affect the demand of green buildings in Canada, including:

- National programs to make single-family housing, multi-unit housing and commercial and public buildings more energy efficient
- Improved national standards for equipment and appliances used in commercial, institutional and residential buildings.
- Priority tax treatment for capital investment in highly energy efficient equipment and facilities
- Enhanced energy efficiency incentives for new commercial buildings

- Measures to promote car sharing and ride sharing
- Comprehensive municipal programs to reduce, re-use, recycle and compost

The implementation strategy of policy proposals have not yet been developed, nor have these proposals been ratified, but they do represent a high level multi-lateral government interest in promoting green buildings.

The various levels of government need to develop and implement clear and focused strategies promoting green building in Canada.

## 6.11 Global Warming Skepticism

Many people have the impression that there is significant scientific disagreement about global warming and its effect on climate change. This impression is brought by a small number of high profile skeptics, most of whom are not scientists<sup>83</sup> and is exacerbated by the media practice of seeking opposing views, despite widespread global acceptance of the reality of global warming. For example, a March 30, 2005 National Post article presented global warming as “brainwashing” that is the result of a “long term attempt by the environmental movement...to moralize every aspect of our material lives. ...They will not be happy until we live in a compact fluorescent dim-bulb world of enforced caulking, composting, and canvas shopping bags.”<sup>84</sup>

This impression is incorrect. In December of 2004, Naomi Oreskes of The University of California performed a literature review using a database of published articles from the Institute for Scientific Information. A search of the database was performed using keywords “global climate change” which resulted in 928 hits. Each of these articles was reviewed, and not one paper disagreed with the consensus position: that climate change is real.

Similarly, the Intergovernmental Panel on Climate Change (created in 1988 by the World Meteorological Organization and the United Nations Environmental Program to evaluate the state of climate science as a basis for informed policy action), states in its most recent assessment, that the consensus of scientific opinion is that Earth's climate is being affected by human activities. Virtually all major scientific bodies in the United States whose members' expertise bears directly on the matter have issued similar statements.

This consensus is widely reflected in Canadian Politics, with strong statements from many political leaders. Prime Minister Paul Martin, in a February 16, 2005 address respecting global warming, stated, “We have a growing understanding that our practices and economy must change – that we must become more efficient and less polluting if we are to help preserve our world”<sup>85</sup>

Clearly, the misconception of weak science with respect to climate change must be put to rest. This is being achieved through strong unilateral and vocal support across multilateral scientific, governmental, and climate change focused organizations. Further, research is continuing in this field, and on the assumption that this future

research will prove the general consensus of the scientific community, it is expected that skepticism will become more scarce and less influential.

Lastly, the effects of climate change are increasingly becoming readily apparent. There is undeniable evidence of warming oceans<sup>86</sup>, melting ice caps<sup>87</sup>, and extraordinary weather events<sup>88</sup>. This type of evidence is indisputable in nature, and understandable by lay people, and will likely result in increased acceptance of the theory and the need to address climate change.

## 7. SUMMARY

For many people, the term “Green Building” brings images of radical design focused solely on the environment. In reality, green buildings simply achieve social and environmental goals well beyond those for conventional buildings. Essentially, the difference between green and conventional buildings is that green buildings offer healthier and more comfortable interior spaces and include measures to reduce their ecological footprint.

The ecological goals are typically achieved by reducing energy and water use through innovative systems and integration. Increased occupant health and safety is achieved by designing and constructing superior indoor environments through better ventilation, a focus on natural light, and the use of appropriate materials. Many of these environmental and social benefits offer economic benefits as well: reduced energy and water use equates to lower operational costs, while improved indoor environment results in productivity gains. Important benefits of green buildings include:

- Superior Occupant Comfort and Health
- Ecological benefits and Reduced Climate Change Impact
- Reduced Operating Costs
- Productivity Gains
- Property Value and Absorption Rate gains
- Increased Retail Sales
- Improved Image
- Risk Reduction

Green buildings are achieved through an integrated process involving many building stakeholders (defined as *Integrated Design*), the result of which is an efficient building meeting the needs of the occupants while at the same time reducing its ecological footprint. Although there are direct monetary savings from the efficiencies achieved, green buildings cost more than conventional buildings to design and construct, largely due to increased design time and the implementation of non-standard materials and systems. However, this increase in capital cost is overshadowed by operational benefits, many of which provide a strong economic case, particularly when occupancy issues are considered.

As part of this work, several American studies were reviewed that quantified the direct economic costs and benefits associated with green buildings. These studies were performed on real and theoretical buildings, with sample sizes up to over a hundred buildings. Without exception, these studies conclude that there is a strong economic basis for green buildings, but only when operational costs are included in the equation. More specifically, whole building studies have concluded that the net present values for pursuing green buildings instead of conventional buildings range from 50 to 400 \$/ft<sup>2</sup> (540 to 4300 \$/m<sup>2</sup>) dependent on



the length of time analyzed (20 to 60 years) and the degree to which the buildings employ green strategies. These studies also generally conclude that the greener the building, the higher the net present value.

Beyond the above are numerous recent North American multi-building studies on the qualitative effects of green buildings. In general, these studies concluded the following:

- Good daylighting increases productivity by 13%, can increase retail sales by 40%, and can increase school test scores by 5%
- Increased ventilation increases productivity by 4 to 17%
- Better quality ventilation reduces sickness by 9 to 50%
- Increase ventilation control increases productivity by 0.5 to 11%
- High glare reduces performance by 15 to 21%

Despite the strong case for green building, this industry is still in its infancy in Canada: It is currently small, but it is growing exponentially. Interest in green buildings is showing a similar rapid rise in growth, but useful and practical knowledge of green buildings by the various building stakeholders, is still generally limited. The portion of current construction in North America that can be defined as green is approaching 10%, but with continued interest, and in understanding the factors driving this movement, the relative number of green buildings will continue to rise.

The barriers to growth and acceptance in green buildings are generally due to the relative youth of the green building industry and the nature of the building sector. The relative youth has resulted in a general lack of knowledge about green buildings, which has compounded into a series of barriers including risks of system failures through inappropriate design, a failure of building owners and lending institutions to value green building benefits, and numerous false claims about green materials, systems, or services. There is also limited statistically sound research into the benefits of green buildings, particularly in the area of productivity, which could be a key element in the acceptance of green buildings. The current structure and practices within the building sector create other barriers, including a failure to consider operational benefits during construction, tendering styles not conducive to building efficiency, a focus on time in the construction period, and building standards and codes that do not reflect the nature of green buildings. Many of these barriers can be removed through education and focused strong research.

In summary, green buildings offer numerous unique benefits when compared to conventional buildings, and there are strong indications that these benefits greatly out-weigh the relatively small increase in construction costs. The benefits of green buildings are increasingly being recognized by building stakeholders, which is resulting in exponential growth in the green building industry in Canada. There is currently a strong business case for Green buildings in Canada when a more holistic, longer-term view of real building costs is incorporated. This business case can be strengthened through focused research and education of building stakeholders.

## 8. END NOTES AND REFERENCES

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<sup>1</sup> Environmental Protection Agency, “The Total Exposure Assessment Methodology (TEAM) Study” 1978: Obtained on assumption that American data applies to Canada

<sup>2</sup> Natural Resources Canada, “Energy End Use Data Handbook 1990 and 1995 to 2001”, 2003. Note that this data is based on both primary and secondary energy.

<sup>3</sup> Data obtained from two sources: The Pembina Institute, “CANMET Energy Technology Sector – Buildings Group” January 2004, and Riccones, Dianna “The Green Buildings Resource Guide. US EPA Region 5”, 2000

<sup>4</sup> Yates (Alan) “Quantifying the Business Benefits of Sustainable Building (Draft for discussion)”, , Centre for Sustainable Construction, BRE, UK, February 2001

<sup>5</sup> such as the NRCan Commercial Buildings Incentive Program (CBIP), or in rating systems, such as the U.S. Energy Star system or LEED.

<sup>6</sup> Embodied Environmental Effects of a material are the environmental impacts associated with the extraction, manufacturing, fabrication, construction, operation, demolition, and transportation of that material. Each material has an environmental burden associated with it due to the environmental effects associated with each phase of its life cycle. Green buildings often incorporate materials with relatively lower embodied environmental effects.

<sup>7</sup> Green Buildings BC – New Buildings Program, “Guide to Value Analysis and the Integrated Design Process”, May 2001

<sup>8</sup> A broad range of whole building costs were developed for commercial and institutional buildings in Canada and the United States using R.S. Means cost data. We found that whole building construction costs in Canada were consistently about 5% less than in the United States.

<sup>9</sup> Source: CaGBC

<sup>10</sup> Source: USGBC

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<sup>11</sup> Source: CaGBC

<sup>12</sup> Source: USGBC

<sup>13</sup> Data obtained from the CaGBC. There are 150 buildings registered to LEED NC 2.1, LEED BC, or LEED Canada, and the average size of these buildings is about 50,000 square feet. If one assumes an average construction cost of \$110/ft<sup>2</sup>, then the total construction cost is about \$825M. The Canadian construction association statistics for 2004 indicate that the total cost of commercial and residential construction in Canada was \$67B.

<sup>14</sup> BOMA BC has recently developed a system (called GO GREEN) to “green” building operations of existing buildings. Information on this system can be found at [Hwww.boma.com](http://www.boma.com)H.

<sup>15</sup> Source: USGBC

<sup>16</sup> Frej (Anne), “Green Buildings and Sustainable Development: Making the Business Case”, Urban Land Institute, Aspen Colorado, August 2003

<sup>17</sup> .In a July 2004 poll by Ipsos (source: “Issue Watch, Canadians’ Public Policies Issues”, Ipsos Canada, Espt/Oct. 2004, Vol 19 Number 7), the environment ranked third (behind health care and education) on a list of issues that are important to Canada today. Since 1990, Canadian interest (based on this same poll) has averaged 9.8%. This displays a consistent interest in the environment by Canadians. A 2002 poll by Ekos Research Associates (source: “INDEPTH: Canada and the Kyoto Protocol”, Ekos Research Associates (for CBC, Radio Canada, and the newspapers The Toronto Star and La Presse), 2002) found that 67 per cent of Canadians support ratification of the Kyoto accord on fighting global warming. Interestingly, this same poll found that 46 per cent of Canadians would agree to a tax increase to reduce greenhouse gases. An Ipsos poll (source: Obtained from the Centre for Research and Information on Canada (CRIC) website, [http://www.cric.ca/en\\_html/guide/climate/climate\\_change.html](http://www.cric.ca/en_html/guide/climate/climate_change.html)) in the same period found 74% supported Kyoto.

<sup>18</sup> “What Office Tenants Want: 1999 BOMA/ULI Office Tenant Survey Report”, referenced in: Kats (Greg), “The Costs and Financial Benefits of Green Buildings – A Report to California’s Sustainable Building Task Force”, Capital E, October 2003

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<sup>19</sup> International Standard ISO 14040, Reference Number ISO 14040:1997(E), p2

<sup>20</sup> Information on Athena available at [Hhttp://www.athenasmi.ca/](http://www.athenasmi.ca/)H

<sup>21</sup> The 70% reduction was derived through an analysis using the Athena Environmental Impact Estimator. Materials on an existing two storey office building were optimized to reduce environmental impact, and it was assumed that the operating energy of the inefficient building was at the MNECB requirements and the operating energy of the green building would be reduced by 65% (which has been achieved on many buildings in Canada). A 60 year life was assumed.

<sup>22</sup> Matthiessen (Lias Fay) and Morris (Peter), “Cost of Green: A Comprehensive Cost Database and Budgeting Methodology”, Davis Langdon Company, July 2004, available from [Hwww.davislangdon.com](http://www.davislangdon.com)H

<sup>23</sup> Kats (Greg), “The Costs and Financial Benefits of Green Buildings – A Report to California’s Sustainable Building Task Force”, Capital E, October 2003

<sup>24</sup> The David and Lucille Packard Foundation, “Building For Sustainability: Six Scenarios for the Los Altos Project”, October 2002

<sup>25</sup> Steven Winters Associates, “GSA LEED Cost Study”, submitted to the U.S. General Services Administration, October 2004:

<sup>26</sup> This limitation is acknowledged by the authors. The authors state, “The construction cost estimates reflect a number of GSA specific design features and project assumptions; as such the numbers must be used with caution. The cost impacts may not be directly transferable to other project types or building owners.”

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<sup>60</sup> Calculation as follows: Water use / person: 1.25 to 2.4 m<sup>3</sup>/m<sup>2</sup> (5 Phase Water Management Protocol, PWGSC, 1997). Average water cost in Canada = 0.86 \$/m<sup>2</sup> (City of Toronto website ([Hwww.toronto.ca](http://www.toronto.ca)H)). Indirect costs assumed to be three times direct cost. Lower Indirect Cost =  $3 \times 0.86 \times 1.25 \times 0.3048^2 = 0.30$ . Upper Indirect Cost =  $3 \times 0.86 \times 2.4 \times 0.3048^2 = 0.58$

<sup>61</sup> Much of this discussion on externality cost estimation is taken from an internal ATHENA Institute report prepared by Dr. Gregory Norris in 2002; a copy of which is available from the Institute.

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<sup>66</sup> “2005 Environmental Sustainable Index, Benchmarking National Environmental Stewardship”, by Yale Center for Environmental Law and Policy and Center of International Earth Science Information Network (Columbia University), in collaboration with World Economic Forum, Geneva, Switzerland and Joint Research Center, European Commission, Ispra, Italy

<sup>67</sup> Address by Prime Minister Paul Martin on the announcement that Canada will host the Conference of the Parties, February 16, 2005, Montreal, Quebec

<sup>68</sup> The climate of Canada is demanding on the building envelopes (roofs, walls, windows) of buildings which has resulted in the development of many highly qualified building envelope specialists in Canada. This expertise is recognized internationally, and has resulted in the export of this specialized knowledge to a number of countries. For example, Canadian building envelope specialists have had large influences on major American publications, such as ASHRAE fundamentals, and Canadians often present in international building science conferences. At the December 2004 buildings IX conference (an international building science conference), 16% of attendees were Canadians (attendees came from 15 countries), and Canadian attendance was only exceeded by Americans, despite the conference location (Southern States) and the country population differences.

<sup>69</sup> Information about Athena can be obtained from [Hhttp://www.athenasmi.ca/H](http://www.athenasmi.ca/H)



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<sup>70</sup> Green Building Challenge information available at [Hhttp://greenbuilding.ca/iisbe/gbc2k5/gbc2k5-start.htm](http://greenbuilding.ca/iisbe/gbc2k5/gbc2k5-start.htm)H

<sup>71</sup> iiSPE information available at [Hhttp://greenbuilding.ca/index.html](http://greenbuilding.ca/index.html)H

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Front cover graphic of Mayo School, Yukon, courtesy of Kobayashi + Zedda Design Group, Whitehorse, Yukon.

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**APPENDIX A**

**THE INTEGRATED DESIGN PROCESS**

# The Integrated Design Process



The Integrated Design Process (IDP) has been developed on the basis of experience gained from a small Canadian demonstration program for high-performance buildings, the C2000 program. This program was designed in 1993 as a small demonstration of very high levels of performance, and its technical requirements cover energy performance, environmental impacts, indoor environment, functionality and a range of other related parameters. The ambitious performance goals of the program led its managers to believe that the incremental costs for design and construction would be substantial, and provision was made for support of incremental costs in both the design and construction phase.

However, after the first six projects were designed and two of them had been completed, it was found that that incremental capital costs were less than expected, partly due to the fact that designers used less sophisticated and expensive technologies than anticipated. Despite this, the projects reached the required performance targets. The designers all agreed that application of the design process required by the C-2000 program was the main reason why high levels of performance could still be reached. It also appeared that most of the benefit of intervention was achieved during the early stages of the design process.

The C-2000 process is now called the *Integrated Design Process* (IDP), and most project interventions are now focused on providing advice on the design process at the very early stage of design. Eight projects have been constructed on this basis, and all have achieved the C-2000 performance requirements, or have come very close, and capital costs have been either slightly above or slightly below base budgets. The most hopeful sign that the IDP approach is taking root is that several owners have subsequently used the same process for buildings that have not benefitted from any subsidy.

## *The Conventional Design Process*

In order to understand what the IDP is, it is useful to first characterize the more conventional design process. The process often begins with the architect and the client agreeing on a design concept, consisting of a general massing scheme, orientation, fenestration and, usually, the general exterior appearance as determined by these characteristics as well as by basic materials. The mechanical and electrical engineers are then asked to implement the design and to suggest appropriate systems.

Although this is vastly oversimplified, such a process is one that is followed by the large majority of general-purpose design firms, and it generally limits the achievable performance to conventional levels. The traditional design process has a mainly linear structure due to the successive contributions of the members of the design team. There is a limited possibility of optimization during the traditional process, while optimization in the later stages of the process is often troublesome or even impossible. For example, little advantage may be taken of passive solar potential, there may be excessive exposure to high solar gain during the summer, and poor daylighting and discomfort for the occupants.

All these potential outcomes reflect a design process that appears to be quick and simple, but actual results are often high operating costs and an interior environment that is sub-standard; and these factors in turn may greatly reduce the long-term rental or asset value of a property. Since the conventional design process usually does not involve computer simulations of predicted energy performance, the resulting poor performance and high operating costs will most often come as a surprise to the owners, operators or users.

If the engineers involved in such a process are clever, they may suggest advanced, high-performance heating, cooling and lighting systems, but their inclusion at a late stage in the design process will result in only marginal performance increases, combined with considerable capital cost increases. The underlying cause is that the introduction of high-performance systems late in the design process cannot overcome the handicaps imposed by initial incompatible or otherwise poor design decisions.

### *The Integrated Design Process*

The Integrated Design Process has impacts on the design team that differentiate it from a conventional design process in several respects. The client takes a more active role than usual; the architect becomes a team leader rather than the sole form-giver; and the structural, mechanical and electrical engineers take on active roles at early design stages. The team always includes an energy specialist and, in some cases, an independent Design Facilitator.

The IDP process contains no elements that are radically new, but integrates well-proven approaches into a systematic total process. The skills and experience of mechanical and electrical engineers, and those of more specialized consultants, can be integrated at the concept design level from the very beginning of the design process. When carried out in a spirit of co-operation among key actors, this results in a design that is highly efficient with minimal, and sometimes zero, incremental capital costs, along with reduced long-term operating and maintenance costs. The benefits of the IDP process are not limited to the improvement of environmental performance. Experience shows that the open inter-disciplinary discussion and synergistic approach will often lead to improvements in the functional program, in the selection of structural systems and in architectural expression.

The IDP process is based on the well-proven observation that changes and improvements in any design process are relatively easy to make at the beginning of the process, but become increasingly difficult and disruptive as the process unfolds. Although this may seem obvious, it is a fact that most clients and designers have not followed up on the implications. As well, the existence of a defined roadmap gives credence and form to the process, making it easier to promote and implement. Typical IDP elements include the following:

- inter-disciplinary work between architects, engineers, costing specialists, operations people and other relevant actors right from the beginning of the design process;
- discussion of the relative importance of various performance issues and the establishment of a consensus on this matter between client and designers;
- budget restrictions applied at the whole-building level, with no strict separation of budgets for individual building systems, such as HVAC or the building structure. This reflects the experience that extra expenditures for one system, e.g. for sun shading devices, may reduce costs in another systems, e.g, capital and operating costs for a cooling system;
- the addition of a specialist in the field of energy engineering and energy simulation;
- testing of various design assumptions through the use of energy simulations throughout the process, to provide relatively objective information on this key aspect of performance;
- the addition of subject specialists (e.g. for daylighting, thermal storage, comfort, materials selection etc.) for short consultations with the design team;
- clear articulation of performance targets and strategies, to be updated throughout the process by the design team; and

- in some cases, a Design Facilitator is added to the team to raise performance issues throughout the process and ensure specialist inputs as required.

Based on experience in Europe and North America, an IDP is especially characterized by a series of design loops per stage of the design process, separated by transitions with decisions about milestones. In each of the design loops the design team members relevant for that stage participate in the process.

The design process itself emphasizes the following broad sequence.

1. Establish performance targets for a broad range of parameters, and develop preliminary strategies to achieve these targets. This sounds obvious, but in the context of an integrated design team approach it can bring engineering skills and perspectives to bear at the concept design stage, thereby helping the owner and architect to avoid committing to a sub-optimal design solution.
2. Minimize heating and cooling loads and maximize daylighting potential through orientation, building configuration, an efficient building envelope and careful consideration of the amount, type and location of fenestration.
3. Meet heating and cooling loads through the maximum use of solar and other renewable technologies and the use of efficient HVAC systems, while maintaining performance targets for indoor air quality, thermal comfort, illumination levels and quality, and noise control.
4. Iterate the process to produce at least two, and preferably three, concept design alternatives, using energy simulations as a test of progress, and then select the most promising of these for further development.

The process diagram and the outline of IDP steps shown in Appendices 1 and 2, give some idea of how IDP may be applied to a typical design project.

### *Future applications of IDP*

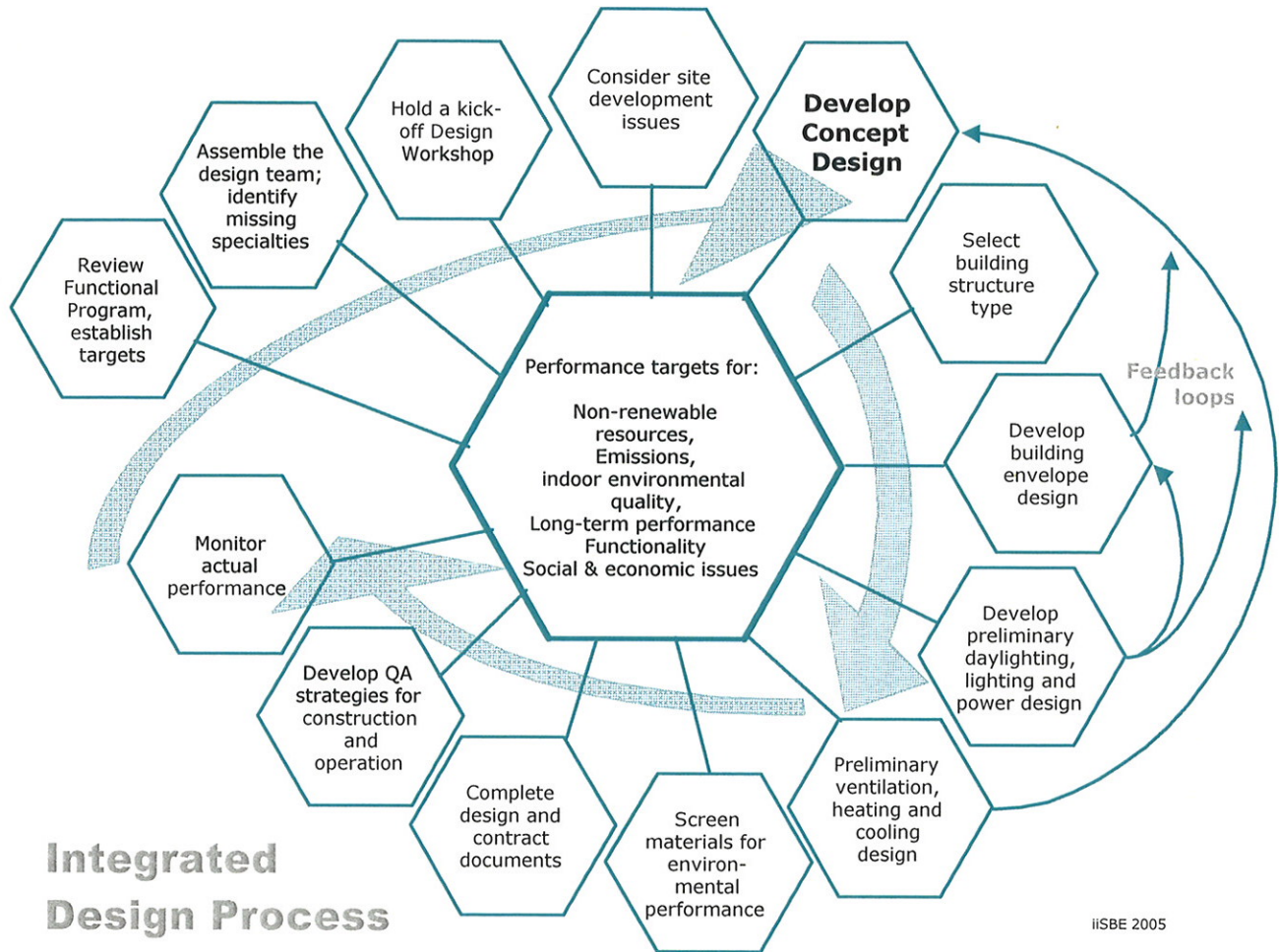
One of the interesting lessons of using IDP is that, unlike many other design support methods or systems, it is applicable to a wide range of situations and building types. Thus, even though IDP was developed for a few building types and assumed new construction, the approach has now been applied to a wide variety of building types and to renovation projects.

We foresee a wide application of the IDP around the world. A generic international version has been developed within Task 23, a working group of the International Energy Agency. What is needed now are the resources to develop supporting software and to develop an educational campaign for international use, especially to developing countries.

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## Appendix 1: Graphic representation of the IDP Process



## Appendix 2: Generic steps in the IDP Process

### A. Assess site conditions

- 01 A01 Assess soil stability and bearing strength
- 02 A02 Assess the ecological quality of the site
- 03 A03 If a brownfield site, take steps to remediate conditions
- 04 A04 Examine soil for presence of radon
- 05 A05 Identify any features in adjacent properties that may place constraints on the design of the subject building
- 06 A06 Assess suitability of any existing structure(s) on the site for adaptation to the new uses planned for the site.
- 07 A07 Identify approximate gross area of existing structure on the site that can be totally or partially re-used.
- 08 A08 Assess suitability of materials and components in any existing structure(s) on the site for re-use in the new building(s) planned for the site.
- 09 A09 Prepare a Site Conditions Report

### B. Examine program; establish performance targets and strategies

- 10 B01 Determine if the proposed space requirements can be satisfied by renovations instead of new construction.
- 11 B02 Consider possible impact of location on the transportation requirements of the facility.
- 12 B03 Assess the capacity of the functional program to support mixed uses and green operations.
- 13 B04 Confirm client's commitment to supporting measures required for high performance.
- 14 B05 Develop an initial statement of performance goals, targets and supporting strategies.
- 15 B07 Ensure that the program is capable of supporting high performance.
- 16 B07 Review budget and pay-back requirements for compatibility with performance goals.
- 17 B08 Prepare a *Functional Program and Performance Goals Report*.

### C. Assemble the Design Team

- 18 C01 Ensure that the proposed design team is aware that the project has high-performance goals.
- 19 C02 Identify and retain design team members with skills and experience related to the program.
- 20 C03 Ensure that contract conditions do not create a disincentive for the mechanical engineer.
- 21 C04 If the budget permits, include performance incentive payments in contracts for the principal designers.

### D. Hold a Design Workshop

- 22 D01 Develop schematic drawings for a reference or baseline design with minimal performance.
- 23 D02 Carry out energy simulations for the reference building.
- 24 D03 Invite design workshop participants, including the client, design team and specialists.
- 25 D04 At the workshop, table the energy simulations to provide a starting point for discussion.
- 26 D05 Develop two or three schematic options for improved performance.
- 27 D06 Hold an open discussion on performance, cost and other implications.
- 28 D07 Carry on with more detailed development of the most attractive option after the workshop, including preliminary energy simulations or estimates.
- 29 D08 Add new talent to the design team if necessary.
- 30 D09 Summarize the results of the workshop in a *Design Workshop Report*, and distribute to all stakeholders

## **E. Consider site development issues**

- 31 E01 Minimize building footprint on site.
- 32 E02 Minimize loss of solar or daylight potential of adjacent property.
- 33 E03 Consider measures to minimize impacts on subsurface ecology and aquifers.
- 34 E04 Develop preliminary landscape plans to provide windbreaks, shading, and to minimize water demand.
- 35 E05 Ensure that the building will form a positive contribution to the streetscape.
- 36 E06 Carry out an Environmental Impact Assessment.
- 37 E07 Summarize site development issues in a *Draft Site Impact Plan*.

## **F. Develop Concept Design.**

- 38 F01 Finalize performance targets
- 39 F02 Develop a concept plan, using functional requirements as a starting point.
- 40 F03 Orient the building to optimize passive solar potential, and relate fenestration requirements to orientation.
- 41 F04 Establish configuration & floor plate depth to balance daylighting & thermal performance.
- 42 F05 Consider the possible roles of natural, hybrid or mechanical ventilation systems.
- 43 F06 Consider whether cooling will be needed.
- 44 F07 Examine the potential role of renewable energy systems.
- 45 F08 Examine the most efficient forms of non-renewable heating, cooling and ventilation systems.
- 46 F09 Determine floor-to-floor heights, taking into account possible future uses.
- 47 F10 Carry out a first set of detailed energy simulations or energy analysis.
- 48 F11 Prepare the *Concept Design Report*.

## **G. Select building structure.**

- 49 G01 Consider column spacing and core position.
- 50 G02 Consider measures to reduce embodied energy of the structure.
- 51 G03 Consider thermal storage options using the structure as a heat sink.
- 52 G04 In residential occupancies, consider appropriate balcony design.
- 53 G05 Decide on building structure type taking into account the considerations above.

## **H. Develop building envelope design**

- 54 H01 Select basic exterior wall systems.
- 55 H02 Assign fenestration on each orientation to optimize daylighting and thermal benefits
- 56 H03 Optimize the daylighting and thermal performance of fenestration.
- 57 H04 Consider the use of operable windows.
- 58 H05 Consider measures to reduce the embodied energy of the building envelope.
- 59 H06 Optimize envelope detailing and thermal performance
- 60 H07 Carry out a second set of detailed energy simulations

## **J. Develop preliminary lighting and power system design.**

- 61 J01 Develop preliminary lighting system design.
- 62 J02 Develop preliminary lighting control system.
- 63 J03 Estimate the power requirements for future tenant and occupant equipment.
- 64 J04 Optimize the energy efficiency of vertical transportation systems.
- 65 J05 Develop strategies to shave peak demand.
- 66 J06 Summarize lighting issues for *Comfort and Productivity Performance Plan*.

**K. Develop preliminary Ventilation, Heating and Cooling system designs.**

- 67 K01 Develop preliminary ventilation system design.
- 68 K02 Develop preliminary design for heating central plant.
- 69 K03 Develop preliminary design for cooling central plant.
- 70 K04 Consider thermal storage options using mechanical systems.
- 71 K05 Develop preliminary design for ventilation, heating, and cooling delivery systems.
- 72 K06 Develop preliminary ventilation, heating and cooling control systems.
- 73 K07 Complete energy simulations assessing whole building design performance.
- 74 K08 Summarize HVAC issues for the *Comfort and Productivity Performance Plan*.
- 75 K09 Prepare a *Design Development Report*.

**L. Select materials.**

- 76 L01 Minimize use of materials or components that rely on scarce material resources.
- 77 L02 Select materials that balance durability and low embodied energy.
- 78 L03 Consider re-use of components and recycled materials.
- 79 L04 Design assemblies and their connections to facilitate future demountability.
- 80 L05 Select indoor finishing materials to minimize VOC and other emissions.

**M. Complete design and documentation.**

- 81 M01 Complete site development plan to minimize potable water consumption.
- 82 M02 Design plumbing and sanitary systems to minimize water consumption.
- 83 M03 Complete appropriate rain screen and pressure equalization envelope details.
- 84 M04 Finalize lighting system design.
- 85 M05 Finalize ventilation, heating, and cooling system designs.
- 86 M06 Confirm adequate space exists for data and communications systems.
- 87 M07 Select building energy management control systems.
- 88 M08 Review the use of materials to minimize waste.
- 89 M09 Carry out a final set of energy simulations.
- 90 M10 Produce a final *Longevity and Adaptability Plan*
- 91 M11 Prepare a final *Life Cycle Cost Report*.
- 92 M12 Produce a final *Occupant Comfort and Productivity Plan*.

**N. Develop QA strategies for construction.**

- 93 N01 Develop plan to minimize C&D wastes during construction.
- 94 N02 Develop *Final Site Impact Management Plan*.
- 95 N03 Develop a *Final Quality Assurance Plan*
- 96 N04 Develop a *Commissioning Plan* for all major systems.
- 97 N05 Prepare the *Pre-Construction Report*.

**P. Develop QA strategies for operation.**

- 98 P01 Appoint an owner's Commissioning Agent.
- 99 P02 Develop a maintenance plan.
- 100 P03 Develop a *Final Environmental Impact Management Plan*.
- 101 P04 Develop lease instruments with tenant incentives to operate space efficiently.
- 102 P05 Train building staff to operate equipment efficiently.
- 103 P06 Prepare a *Project Completion Report*.

**Q. Monitoring**

- 104 Q01 Owner / Operator to provide reports on operations, maintenance, & utility bills.
- 105 Q02 Carry out a Post-Occupancy Evaluation (POE) study