Green Building: An Overview

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A frequent point of debate is the relationship between Green Building and Sustainable Development (SD). We take the view that SD is most applicable at the urban or societal level, since it includes issues of social equity and broad issues of economics, in addition to concerns about ecosystems and human health. We find it difficult to apply these broader societal issues to buildings in a practical way. Instead, many building researchers and designers find it more meaningful to develop models of building performance that is consistent with SD at the societal level. In short, Green Building helps to support a broader Sustainable Development agenda.

A. What are Green Building Issues ?

Taking its lead from the Sustainable Development (SD) agenda, Green Building focuses on improving building performance in areas that are relevant to that agenda. Relevant issues include reduction of Greenhouse Gases (GHG) by reducing emissions of CO_2 and other emissions with similar impacts, reduction of Acidification (emissions of SO_2 equivalents), reduced other impacts on ecosystems, and reduced use of scarce resources such as non-renewable fuels, materials, land and water.. All of this is to be achieved done while maintaining optimum conditions for human health.

While this covers the core issues, several Green Building guidelines and programs cover a broader set of issues on the basis that they need to be included to gain widespread industry support. This reflects the fact that some SD/green issues, such as energy efficiency, have not been strong drivers for industry action during the last decade because of low fuel prices. In the commercial buildings industry the main driver is money; so even those investors, developers and designers who are inclined to support green issues need to find economic gains or at least useful guidance and support on other issues that are relevant to them. These include process improvements, indoor environmental quality, functionality and cost.

In summary, we take the view that green building guidelines and standards must address core environmental issues, but should also cover other issues of relevance to the industry. This approach offers a reasonable expectation of a rising level of support for the adoption of green building principles.

B. Intervention Measures

Regulations can be very effective if well enforced, but they usually define a minimally acceptable level of performance and are therefore normally insufficient to lead the industry towards high standards. Canada has much recent experience in this area due to the development and introduction of the Model National Energy Code for Buildings (MNECB). The design of the regulatory package is sophisticated, since it allows for both default minima and a simulation path for compliance, and also takes into account energy costs and incremental construction costs within a life-cycle cost formula. Studies have shown that the NECB is approximately congruent with current good practice but, despite this, only a few jurisdictions in Canada have adopted it because of industry resistance.

The difficulty of implementation reflects a peculiarly North American context, where regulations have traditionally confined themselves to issues of life safety and health. Any extension of the regulatory sphere is therefore considered by the North American industry to have validity only if measures reflect a strong consensus on a minimum level of action. This, combined with very low energy prices over the last decade, have made it difficult to build a consensus for strong action in the area of energy. Nevertheless, the MNECB is gradually taking root, but at a level of performance which is relatively unchallenging.

What may be called *enabling measures*, such as the development of standards, guidance documents, design tools, training programs and demonstrations, are also useful. Such measures tend to be used by those in the industry who are already convinced of the need for high performance, and so they tend to have limited penetration, but some recent developments in design process support tools show promise (discussed later in this paper). Demonstration projects fill a very important part in convincing the relatively conservative construction industry that modern processes and technologies can bring benefits. Where demonstrations fail, this is possibly even more useful, although there is a tendency to sweep such findings under the carpet. The C-2000 Program is currently the only available national demonstration program.

Financial incentives are of interest, since a financial inducement is likely to be effective in an environment where financial return is a primary objective. Canada has good recent experience with a program called Commercial Buildings Incentive program, or CBIP. For buildings passing the threshold of 25% improvement over MNECB requirements, this program provides incentives of two times the projected energy costs savings of the building, up to a maximum of $80,000 CAD. Approximately 300 projects are now enrolled in the program and it is well received by the industry. For all the success of CBIP, however, the fact remains that to extend the program to, say, 25% of the new building production would not be feasible because of the total costs involved.

The question remains, therefore, of what measures might be implemented that would move all or most of the industry players to reach significantly higher performance levels.

In the field of commercial building, developers and owners are very sensitive to market signals, and if measures could be developed to *affect market demand* in the right direction, they would certainly pay close attention. The first part of a solution is to convince actors on the demand side (investors and tenants) of the advantages and need for improved energy performance and reduced emissions. This will be an on-going matter of information and education, which will not be dealt with here. A problem that is relevant to this paper, however, is that even those demand-side actors who are already convinced, do not generally possess the knowledge to define their performance needs in a clear way. In fact, many building professionals disagree on the exact meaning of performance, so it is evident that there is an important need to develop tools that allow users to differentiate between buildings of varying performance levels. *Performance assessment and labelling tools* can fill this need.

C. Points of Intervention and Relevant Actors

Key points of the normal development process include:

- Planning (of the area in which the building is located);
- Site acquisition;
- Financing;
- Development permit
- Schematic Design;
- Contract Documentation (drawings and specs)
- Procurement;
- Construction;
- Operation; and
- Demolition.

It is generally accepted that the impact of decisions varies inversely with the time in the process the decision is made, while the direct cost of such decisions vary directly with time. In other words, early decisions are usually cheap and have a major impact on the ultimate performance of the building, while later changes are expensive and have little hope of improving performance.

In spite of this finding (reinforced by C-2000 experience) many policy makers focus their efforts on designers and operators. While it is true that the design process occurs relatively early in the lifespan of a building, it is not early enough to affect some of the basic pre-design decisions. And while building operators can seriously degrade building performance, they cannot improve it beyond the potential aimed for by the designers.

If this argument is accepted, it becomes clear that the very early phases of planning, site acquisition and financing are overlooked as potential points to encourage high performance, and that the schematic design phase is critically important. And underlying all of this is the tax structure that provides subtle incentives and disincentives.

The previous argument does not mean that designers, contractors or operators are unimportant as agents of change in the industry; but that there may be a significant number of other actors who are involved in earlier stages and who should become a focus for activity. These include:

- Investors;
- Real estate brokers
- Corporate Tenants;
- Residential purchasers and tenants; and

Given the differences that exist between different regions, it is difficult to predict who the key players would be. However, it would not be unreasonable to include key individuals in the following type of organizations as potential allies in green building education efforts:

- Major development companies with an interest in high performance;
- Banks or other form of investor organizations with an interest in real estate;
- Major commercial real estate brokers;
- Major tenant organizations with an interest in high performance;
- Architectural and engineering associations; and
- Architects and engineers with proven interest in high performance.

D. Programs Available to Support Green Building

The commercial buildings industry is driven almost exclusively by considerations of capital cost and return on investments. This fact, combined with the very low cost of energy during the 1990's, make it difficult to move the industry towards very high levels of energy performance.

Two programs from Natural Resources Canada have previously been mentioned as being of relevance. Highlights of each include:

Table 1: Overview of Characteristics of C-2000 and CBIP Programs

Program	C-2000 Program	CBIP Program
Number of projects to date	8 built or underway, 14 designed	300+ underway or complete
Annual Budget	Approx. $200,000	Approx. $10 million
Performance areas	Energy consumption Environmental Loadings Indoor environment Functionality	Energy consumption Greenhouse Gas emissions
Energy target	50% better than MNECB	25% better than MNECB
Current incentive/support	Varies from $5k to $25 k	3 times annual predicted energy cost saving, up to $80 k
Comments	MNECB stands for the Model National Energy Code for Buildings	

The C-2000 Program

The C-2000 Program was designed in 1993 as a small demonstration of very high levels of performance. Even though it was aimed at a select group of clients known to have an interest in high performance, it was assumed that some level of financial incentive would be required to make the program a success. However, the extent of incentives required and the best point of intervention within the project development process was very much open to question.

C-2000 technical requirements covered energy performance[1], environmental impacts, indoor environment, functionality and a range of other related parameters[2]. It was therefore expected that incremental costs for design and construction would be substantial. After a preliminary analysis of current project costs and an informal survey of designers, provision was made for support of incremental costs in both the design and construction phase. Contributions were provided according to a sliding scale ranging from 7% in large projects to 12% in small projects.

The first two C-2000 projects received support according to this formula in the range of CAD $400,000 to $750,000, and funding of this order of magnitude was also planned for subsequent projects. However, after the first six projects were designed and two of them had been

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[1] At the time, the energy requirement was 50% better than the ASHRAE 90.1 standard (the benchmark is now the Model National Energy Code for Buildings, MNECB). Both are North American standards for good practice.

[2] *C-2000 Program Requirements*, N. Larsson Editor; Natural Resources Canada; Ottawa, October 1993, updated April 1996.

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[3]. A careful investigation of the first two C-2000 projects constructed, Crestwood 8[4] and Green on the Grand[5], indicated that the marginal costs for both projects, including design and construction phases, was 7%-8% more than a conventional building, a rather modest increase. Even more interesting, the designers all agreed that application of the integrated design process required by the C-2000 program was the main reason why high levels of performance could still be reached[6]. It also appeared that most of the benefit of intervention was achieved during the design process.

This turn of events led to changes in the C-2000 Program, so that financial and technical assistance was henceforth only provided for the design process, to cover costs such as the provision of a design facilitator and subject experts, energy simulations, and extra design time for the core design team. 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. Six 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.

Specifically, the following C-2000 requirements have proven to be important:

- Inter-disciplinary work between architects, engineers and operations people 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;
- The provision of a Design Facilitator, to raise performance issues throughout the process and to bring specialized knowledge to the table;
- A clear articulation of performance targets and strategies, to be updated throughout the process;
- The use of energy simulations to provide relatively objective information on a key aspect of performance
- Documentation of major steps and issues raised in the process.

Simple software design support tools have been produced to help design teams enrolled in the C-2000 program. One outlines generic design steps and provides a simple way for designers to record their performance targets and strategies; another facilities the task of having the client and design team reach a consensus on the relative importance of various issues. The C-2000 IDP process is now being used as a model for development of a generic international model, by Task 23 of the International Energy Agency, and discussions are underway with the Royal Architectural Institute of Canada (RAIC) to see if the process can be accepted as an alternative form of delivery of professional services.

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3 The conservative preferences of designers is based primarily on their perception that they might face legal liability problems if they use exotic and unproven technologies.

4 *Technical Report on Bentall Corporation Crestwood 8 C-2000 Building*, April 1996, CETC, Natural Resources Canada.

5 *Technical Report on Green on the Grand C-2000 Building*, April 1996, CETC, Natural Resources Canada.

6 Briefly, the process involves the use of inter-disciplinary teams from the outset of the design process, the use of a Design Facilitator, the availability of technical specialists for quick advice, and the frequent use of energy simulations during the design process.

The Commercial Buildings Incentive Program (CBIP)

In 1997, it was decided to launch a larger national program to move the industry towards energy efficiency. Based on the lessons learned in C-2000, it was decided to focus the financial incentives of new CBIP program on providing incremental costs for the design process. However, several changes in approach were necessary for a program that was intended to be delivered to a large number of clients on a "hands-off" basis. This meant primarily that the program had to be simplified so that customized support would not be necessary. Specifically, this resulted in a narrowing of objectives of CBIP to energy only and a reduction of required performance threshold to a 25% improvement over the MNECB, rather than the 50% required for C-2000. However, the philosophy of placing emphasis on supporting the design process only was retained[7].

The funding available for the CBIP Program was established as two times the predicted annual energy costs, with a maximum incentive level of $80,000. An analysis of preliminary results in the CBIP Program presented in *Advanced Buildings Newsletter*[8], showed that, as of the Fall of 1998, typical CBIP projects were receiving funding in the range of $35,000, because their performance and/or size did not enable them to reach the maximum amount. The incentive has now been increased to three times the predicted annual energy cost to provide a greater incentive for smaller projects, but the $80,000 cap remains.

It should also be noted that the C-2000 and CBIP Programs are now being combined, so that almost all new C-2000 Projects also participate in the CBIP Program. Current C-2000 projects currently receive total financial assistance in the range of $5,000 to $25,000 during the design process only, a considerable reduction from past support levels. However, the combination of programs results in customized support and a total maximum available financial support of up to $100,000 for a small number of projects each year.

Recently a third element has been added to the program mix. The Renewable Energy Deployment Initiative (REDI) has been established by NRCan to promote the adoption of renewable technologies, and program staff have developed software that provides an assessment of the technical and economic potential for renewable energy technologies. Both C-2000 and CBIP staff are now encouraging consideration of renewables at an early stage in their projects.

E. Performance Assessment and Labelling Systems

During the last ten years considerable research has been focused on the development of systems to assess the environmental performance of buildings. Several of these systems have gone the next step, to result in a labelling system that indicates clearly the building's approximate performance to end users. It is best to say "approximate", since building performance includes many factors, only some of which are measurable in an exact sense.

7 *Energy Efficiency Programs for Commercial Buildings: Summary of Discussions*, for Natural Resources Canada, by Ron Robinson, ARC Applied Research Consultants, October 1997, Natural Resources Canada, NG096

8 Preliminary Survey of the Commercial Buildings Incentive Program, Rich Janecky and Nils Larsson, *Advanced Buildings Newsletter* Number 22, September 1999, Green Building Information Council, Ottawa.

The best-known existing system is undoubtedly the Building Research Establishment Environmental Assessment Method (BREEAM), developed by BRE and private-sector researchers in the U.K. This system provides performance labels suitable for marketing purposes, and has captured around 15% to 20% of the new office building market in the U.K. A spin-off system, BREEAM Canada, has been adapted to Canadian conditions, and a North American version is now being developed. Meanwhile, the LEED system has been developed in U.S.A. and is now being implemented by the US Green Building Council, with strong support from U.S. government agencies and private-sector organizations. Several other systems (largely inspired by BREEAM) are in various stages of development in Scandinavia, Hong Kong and elsewhere. There are also more specialized systems of interest that are more closely tied to Life Cycle Assessment (LCA), including ECO QUANTUM (Netherlands), ECO-PRO (Germany), EQUER (France) and Athena (Canada).

Why is there so much interest in this area? The main reason appears to be that researchers and government agencies are viewing performance rating and labelling systems as one of the best methods of moving the performance benchmarks in the marketplace towards a higher level of performance. There is a growing realization that a major jump in performance levels, at least in market economies, will depend on changes in market demand, and that such change cannot occur until building investors and tenants have access to a relatively simple method that allows them to identify buildings that perform to a higher standard.

The advantages of having a global standard for building performance assessment and labelling cannot be over-emphasized. If meaningful information about performance is to be exchanged between countries, then a uniform definition of performance parameters must be developed, even if the calculation tools providing data on, for example, energy consumption and emissions, vary between countries. Further, the rapid growth of global corporations, and their desire to work to a common standard, give this work a significant commercial importance in the medium term.

Canada is currently leading a process called Green Building Challenge (GBC), a consortium of nineteen countries that are developing and testing a new environmental performance assessment system. The GBC project is an attempt to develop a second-generation assessment system; one that is designed from the outset to reflect the very different priorities, technologies, building traditions and even cultural values that exist in various regions and countries. In order to use the system, national teams must first adjust the values and weightings embedded in the system, thereby assuring results that are relevant to local conditions. The direct output of this four-year process will be primarily at the level of R & D; specifically, a thorough understanding of issues involved in designing such a system, as well as a continuing exchange of ideas on the subject by the best researchers in the field. However, public- and private-sector organizations will be encouraged to use the results to develop a new generation of commercial labelling systems, and this is expected to have positive practical results in the near term for industry applications in Korea, Hong Kong, Canada, Japan and several other countries. Those European countries that are already developing their own systems are using the GBC process to exchange ideas and to improve their own systems, and GBC has already influenced the recent version of BREEAM '98.

The project has consisted of two stages: an initial two-year process, which culminated in the GBC '98 conference, a major international event in Vancouver in October 1998; and a new two-year process of development, the results of which will be displayed and reviewed at the international Sustainable Buildings 2000 conference to be held in Maastricht, the Netherlands, in October 2000.

The assessment framework has been produced in the form of software (GBTool) which facilitates a full description of the building and its performance, and also allows users to carry out the assessments relative to regional benchmarks. Participating national teams test the assessment system on case study buildings in each country. At the GBC '98 conference, 34 projects were evaluated in depth, and a further 24 to 30 projects will be reviewed in time for the SB 2000 Conference.

Except for USA, Canada and Japan, the countries participating in the first round (1996 to 1998) were all European, including Austria, Denmark, Finland, France, Germany, Netherlands, Norway, Poland, Sweden, Switzerland, and the UK. All members of the first round have agreed to participate in the second round of work except for Denmark and Switzerland. However, seven new countries have recently joined: Australia, Chile, South Africa, South Korea, Hong Kong, Spain and Wales, bringing the current total to 19 countries. The process is managed by the GBC Technical Secretariat within Natural Resources Canada.

During the second phase of activity (1999-2000), GBTool is being revised to take into account the lessons of GBC '98. The reliability of weighting procedures has been improved, and measures have been taken to improve its overall utility and reliability. Although some direct financial support was provided by Canada to national teams during the first phase, in this phase the Canadian contribution will be limited to central coordination and system development. Thus, each participating country is now expected to finance its own participation in meetings and for testing the system at home.

The Netherlands energy agency, Novem, has agreed to undertake primary responsibility for organizing the next international conference, called Sustainable Buildings 2000 (SB 2000) and to be held in Maastricht, the Netherlands during October 22-25, 2000. Current plans include an exhibit area with display pavilions from each country, organized by the GBC national teams. Each national pavilion will include displays of buildings assessed during the GBC process, but will also include displays of other green buildings of interest, summaries of ecological issues, policies and programs, and exhibits of green industry products. The SB 2000 conference is therefore likely to be a major opportunity for each country to display the state-o-the-art of its industry.

F. Strategies for Public-Sector Implementation

Assuming normal constraints of staff and budget, a Green Building program must select its targets and strategies carefully. The following decisions must be taken:

- What kind of intervention measure should be emphasized (regulation, guideline, demonstration, development of support tools, incentives, market change mechanisms);
- What part of the process to intervene in (planning, site acquisition, financing, schematic design, contract documentation, procurement, construction, operation, demolition);
- Which actors are the most important to influence (investors, owners, tenants, designers, contractors, operators, regulators);
- What implementation strategy should be followed to obtain the best results; and
- What resources are needed (money, skills, manpower).

It is difficult to generalize about which specific strategy is the most promising. However, it is suggested that the work should begin with an emphasis on both tools and procedures to assist the early design phase, and on the development of performance labelling systems that can change market demand. In both cases, positive results are likely to spread more quickly into the industry if a strong emphasis is placed on working with private-sector organizations.

A generic strategy that may be useful might consist of the following steps:

1. Form an organization with links to public- and private-sector groups;
2. Define scope of approach, based on environmental issues (e.g. energy and emissions only or broader);
3. Define performance targets for major building types in existing building stock;
4. Define performance targets for major building types in new building production;
5. Review current design and construction procedures to ensure that they support the overall goals.
6. Review tax policies to ensure that there are no disincentives to implementation;
7. Consider introduction of tax policies to support certain measures (e.g. tax credits for corporations holding certain percentages of buildings in their portfolios that reach certain performance levels);
8. Consider introduction of an energy performance regulation to define minimum performance requirements, and to provide benchmarks for other work;
9. Consider the establishment of a program of direct financial incentives to owners of buildings reaching certain performance levels;
10. Define nature of performance rating/labelling tools and support design tools needed;

It is also recommended that, during the period that the measures above are considered and developed, that some early action should be undertaken, to create public interest and support for the broader goals. This could include some carefully selected demonstration projects for key building types (e.g. new and retrofit residential buildings).

G. What's in it for the Private Sector?

Although programs have been developed to provide incentives for the industry to move towards high performance, experience shows that they are far more effective when the client is convinced that there will be a marketing advantage in following this path.

A building that has undergone a design process that results in a high level of energy efficiency is likely to be of higher quality, and will have lower operating and maintenance costs. Capital cost and design time increases are modest[9], and such buildings have been shown to attract desirable tenants. All these factors are very likely to combine to result in a higher long-term asset value.

For designers, use of the Integrated Design Process offers many engineers to become involved in the early design stage of buildings for the first time; and architects are learning valuable new skills. When this is combined with the incentives available, it is difficult to see any obstacles to widespread participation.

When labeling systems are widely available, more definitive proof of the importance of high performance will be at hand and poorly-performing buildings will hopefully become a relic of the 20th Century.

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[9] *Incremental Costs in the C-2000 and CBIP Programs*; N. Larsson and J. Clark, March 2000, to be issued in a forthcoming issue of *Building research and Information*.

Appendix 1. Setting Performance Targets and Verifying Results

Our experience indicates that, while it is undoubtedly a good idea to aim for performance levels that are "very high" or "the best in town", it is more meaningful to specify performance targets in a way that is objective and comparable. Clearly, it is also highly desirable to verify through monitoring that those targets are reached when the building is in operation, or at least to identify the cause for deviations from the intended performance level.

Performance in some areas is relatively easy to specify and to verify. For example, energy performance can be simulated with reasonable accuracy at the design stage using computer programs and can be verified after construction. There are accepted standards for air quality, thermal comfort and lighting performance which can serve as targets for designers, although it is relatively difficult to assess the achievement of such standards in the design stage. Finally, some parameters are very difficult to assess with any measure of objectivity, although they must be assessed due to their importance in overall performance. For example, the projection of a building's future flexibility and adaptability is subjective, but it can greatly affect the useful life of the building, which leads to environmental advantages. This is one reason that attempts have been made to provide more objective assessments of such "soft" performance measures in GBC.

Despite difficulties in implementation and the need to sometimes accept approximations, the principle of establishing specific performance targets has been proven to be a very useful exercise for clients and designers alike. This is especially so when target-setting is accompanied by a process that establishes relative priorities for various performance issues, and by the development of strategies that may help the design team, contractors and operators to achieve such targets.

Specific performance targets that strike the right balance between ambition and economy have to be developed by the design team, in consultation with the client, but some general recommendations can be made.

Since energy drives emissions, this is a useful place to start. The Model National Energy Code for Buildings (MNECB) serves as a useful benchmark of accepted good practise, while the requirements of the Commercial Buildings Incentive Program (CBIP) and the C-2000 Demonstration Program (see Appendix 1) provide targets of 25% and 50% better than MNECB, respectively. CBIP requirements can be met relatively easily while the C-2000 target is relatively demanding, and requires a client and design team that are committed to an outstanding level of performance.

Other key areas that require performance targets include daylighting, indoor air quality, and many of the other parameters outlined in the GBC performance framework. Standards such as those provided by ASHRAE can be helpful, but in many cases such targets are best established in discussions between performance specialists and the design team.

Appendix 2. Generic Design Steps in C-2000 Software C2k-P

C2k-P is a software tool under development by C-2000 staff.

A. Examine design assumptions and functional program.
A1. Determine if the proposed space requirements can be satisfied by renovations.
A2. Assess the capacity of the program to support mixed uses.
A3. Ensure that the program includes space to support green operations.
A4. Propose measures to reduce the transportation requirements of the facility.
A5. Confirm that the program addresses client performance expectations.
A6. Confirm client commitment to supporting measures required for high performance.
A7. Check budget assumptions for realism.
A8. Prepare the "Functional Program Report" and submit to the C-2000 Program Manager.

B. Consider site development issues.
B1. Minimize building footprint on site.
B2. Consider measures to minimize construction damage to surface ecology.
B3. Consider measures to minimize impacts on subsurface ecology and aquifers.
B4. Develop prelim. landscape plans to provide windbreaks, shading, and minimize potable water demand.
B5. Ensure that the building will form a positive contribution to the streetscape.
B6. Summarize site development issues in a Draft Site Impact Plan.

C. Develop Concept Design.
C1. Orient the building to optimize passive solar potential.
C2. Minimize loss of solar heat or daylight potential of adjacent property.
C3. Develop concept plan to optimize functionality and minimize area and volume.
C4. Organize configuration & floor plate depth to balance daylighting & thermal performance.
C5. Consider floor-to-floor height adequate for other future uses.
C6. Explore feasibility of mixed mode or natural ventilation approach.
C7. Carry out first set of simulations or energy analysis.
C8. Complete preliminary C2k-A design assessments for selected concepts.
C9. Prepare the "Concept Design Report" for submission to the C-2000 Program Manager.

D. Select building structure.
D1. Select structure type.
D2. Consider column spacing and core position adequate for other future uses.
D3. Consider floor to floor heights allowing for underfloor HVAC delivery and cabling.
D4. Consider measures to reduce embodied energy of structure.
D5. Consider thermal storage options using structure.

E. Develop preliminary building envelope design.
E1. Select exterior wall systems appropriate for climate zone.
E2. Minimize the initial embodied energy of building envelope.
E3. Set preliminary targets for envelope performance.
E4. Place fenestration on each orientation to optimize daylighting benefits
E5. Optimize the daylighting and thermal performance of fenestration.
E6. Optimize the envelope thermal performance using performance simulations.

F. Develop preliminary lighting and power system design.
F1. Develop preliminary lighting system design.
F2. Develop preliminary lighting control system.
F3. Estimate the power requirements for future tenant equipment.
F4. Optimize the energy efficiency of vertical transportation systems.

F5. Develop strategies to shave peak demand.
F6. Summarize lighting issues for Comfort and Productivity Performance Plan.

G. Develop preliminary Ventilation, Heating and Cooling system designs.
G1. Develop preliminary ventilation system design.
G2. Develop preliminary design for heating central plant.
G3. Develop preliminary design for cooling central plant.
G4. Consider thermal storage options using mechanical systems.
G5. Develop preliminary design for ventilation, heating, and cooling delivery systems.
G6. Develop preliminary ventilation, heating and cooling control systems.
G7. Complete energy simulations assessing whole building design performance.
G8. Summarize HVAC issues for Comfort and Productivity Performance Plan.
G9. Prepare the Design Development Report, and submit to the C-2000 Program Manager.

H. Select materials.
H1. Minimize use of materials or components that rely on scarce material resources.
H2. Select materials that balance durability and low embodied energy.
H3. Consider re-use of components and recycled materials.
H4. Design assemblies and their connections to facilitate future demountability.
H5. Select indoor finishing materials to minimize VOC and other emissions.

J. Complete site and building design and documentation.
J01. Complete site development plan to minimize potable water consumption.
J02. Design plumbing and sanitary systems to minimize water consumption.
J03. Complete appropriate rain screen and pressure equalization envelope details.
J04. Finalize lighting system design.
J05. Finalize ventilation, heating, and cooling system designs.
J06. Confirm adequate space exists for data and communications systems.
J07. Select building energy management control systems.
J08. Review the use of materials to minimize waste.
J09. Carry out a final set of energy simulations.
J10. Produce a final Longevity and Adaptability Plan
J11. Prepare the final Life Cycle Cost Report.
J12. Produce the final Occupant Comfort and Productivity Plan.

K. Develop QA strategies for construction.
K1. Develop plan to minimize C&D wastes during construction.
K2. Develop Final Site Impact Management Plan.
K3. Develop a Final Quality Assurance Plan
K4. Develop a Commissioning Plan for all major systems.
K5. Prepare the Pre-Construction Report and submit to C-2000 Program Manager.

L. Develop QA strategies for operation.
L1. Appoint an owner's Commissioning Agent.
L2. Develop a maintenance plan.
L3. Develop Final Environmental Impact Management Plan.
L4. Develop lease instruments with tenant incentives to operate space efficiently.
L5. Train building staff to operate equipment efficiently.
L6. Prepare and submit a "Project Completion Report" to the C-2000 Program Manager.

M Monitoring
M1. Owner / Operator to provide annual reports on operations and maintenance, including utility bills.

Appendix 3. GBC Assessment Parameters

In the performance assessment framework developed for the international Green Building Challenge process, a complete range of Green Building issues includes the following, shown at the level of Issue Areas and Categories:

Resource Consumption
- Net consumption of delivered energy
- Net consumption of land
- Net consumption of potable water
- Net consumption of materials

Environmental Loadings
- Emission of greenhouse gases
- Emission of ozone-depleting substances
- Emission of gases leading to acidification
- Solid wastes
- Liquid wastes
- Impacts on Site and Adjacent Properties

Service Quality
- Air Quality and Ventilation
- Thermal Comfort
- Daylighting, Illumination and Visual Access
- Noise and Acoustics
- Flexibility and Adaptability
- Maintenance of Performance
- Controllability of Systems

Pre-Operations Planning
- Construction Process Planning
- Performance Tuning
- Building Operations Planning
- Transportation Management Planning

Economics
- Life cycle costs
- Capital Costs
- Operating and maintenance costs

In the GBTool software, the parameters extend to two more levels of detail; Criteria and Sub-Criteria. The lowest level consists of scoring guide statements, which are intended to assist users to assign performance scores from –2 to +5, where 0 represents minimum industry practise, +3 best practise and +5 the best achievable without regard to cost-effectiveness.