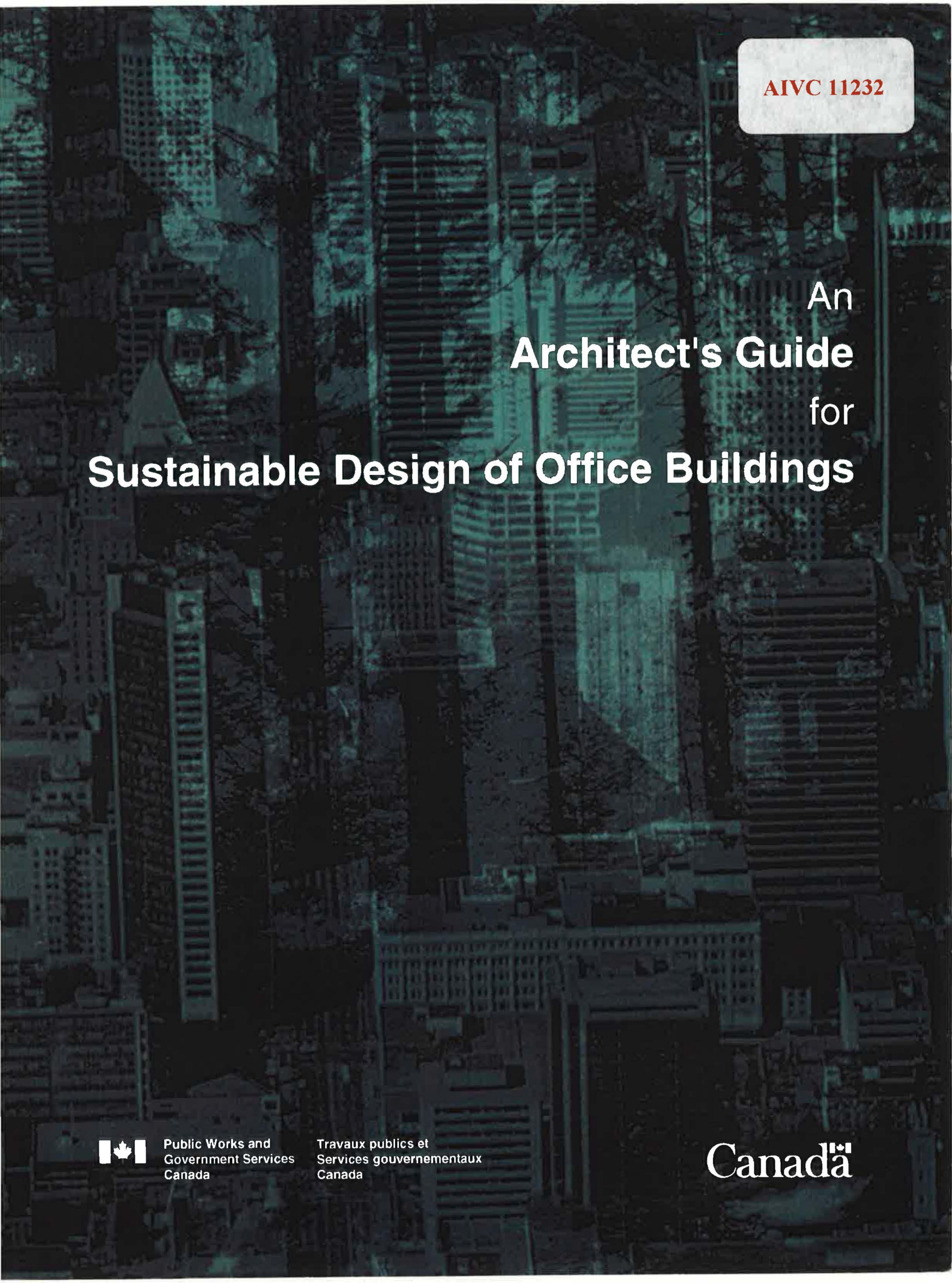

An Architect's Guide for Sustainable Design of Office Buildings

Public Works and Government Services Canada
Travaux publics et Services gouvernementaux Canada

Canada

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Guide de l'architecte pour la conception d'immeubles de bureaux en fonction du développement durable

CONTENTS

INTENT AND SCOPE OF THE GUIDE

INTENT OF GUIDELINES

This guide is directed primarily at *architects* engaged in the renovation of federal office buildings. It presents a set of design issues and strategies in support of *Real Property Services* commitment to upgrading existing federal buildings to meet energy, resource use and health standards consistent with sustainable development principles.

An *Environmental Management System* (EMS) has been prepared to ensure that Real Property Services environmental goals, which are laid out in its *Sustainable Development Strategy* (SDS), will be met effectively and efficiently. The EMS defines responsibilities, accountability, and priorities for dealing with environmental issues. It includes practices, procedures, and processes for implementing environmental management. The EMS also sets out a comprehensive way to monitor progress. Within this context, several environmental initiatives have been undertaken within RPS to fulfil its commitment to sound environmental practices, including the:

- Greening of the *National Master Specifications* to incorporate environmental criteria into various sections;
- Update of *The Environmentally Responsible Construction & Renovation Handbook*, intended for property and facilities managers;
- *Solid Waste Management Reduction Strategy for Property and Facilities Management*;
- Development of building renovation projects under the *Federal Building Initiative* (FBI);
- *Water Audit Methodology Protocol, and Water Management Strategy for Property and Facilities Management*.

SCOPE

As one of the above initiatives, this *Guide* is specifically intended to provide architects with an update on environmental issues for which design strategies are being developed and implemented in the building industry. That includes the improvement of indoor environmental quality; the effective use of site resources; the reduction in the use of energy, water and materials; the reduction of solid waste; and the utilisation of environmentally responsible building materials. Specific environmental issues such as the management of toxic and hazardous substances, and the management of contaminated sites are not within the scope of the *Guide*.

Our understanding of environmental issues and appropriate building design responses to address them is, and will remain, a continually evolving field. As new knowledge develops and is validated by *Real Property Services*, it will be incorporated into later versions of the *Guide*. Moreover, although emphasis has been placed on renovation projects, the vast majority of the environmental issues and strategies identified in the *Guide* are equally applicable to new construction.

ISSUES COVERED

ISSUES COVERED

The Guidelines identify environmental design goals and strategies which extend from, and are consistent with, the *Real Property Services* environmental goals and objectives:

Section One: *Sustainability: A New Agenda for Building Design* provides the general background for the *Guidelines*, identifying the specific environmental goals and objectives, and the new responsibilities it requires of architects engaged in federal building design and renovation.

Section Two: *Health and Well-Being* presents strategies to create healthy indoor environments covering thermal quality, indoor air quality, lighting and acoustic quality.

Section Three: *Site and Landscaping* presents strategies which enhance the microclimate of the site and minimize the adverse impacts of the building.

Section Four: *Energy Use* emphasizes the importance of energy in sustainable building design and identifies architectural and engineering design strategies to reduce building operating energy use.

Section Five: *Materials Use* presents issues and strategies associated with reducing the amounts of materials used in buildings and the selection of environmentally sound alternatives.

Section Six: *Building Water Use* presents issues and strategies associated with reducing the amounts of potable water used in office buildings.

Section Seven: *Waste Reduction* identifies design strategies to support reduce construction waste and to support occupant waste reduction and recycling initiatives.

Within each of these sections, the environmental issues and attendant design strategies for dealing with them are generally organized according to the relative ease with which they can be implemented within a renovation project. Each project, of course, will present unique problems, opportunities and priorities.

1. SUSTAINABILITY:

A New Agenda for Building Design

1.0 INTRODUCTION

Following the publication of the Brundtland Commission's report, *Our Common Future*, [1] sustainability has emerged as a widely held and necessary notion to guide all future human endeavours. Although sustainability is, and will remain, a difficult notion to define in substantive terms, the implications are clear. Sustainability will require that we become less wasteful of natural and human resources, take appropriate steps to maintain a healthy, productive planet and place greater worth on the welfare of future generations. [2]

Sustainability has social, economic and environmental dimensions. Environmental sustainability implies that future generations should enjoy continued access to resources. However, it is the *total capital*, both natural and physical, passed on to future generations that is of primary consequence. [3] Since buildings result from the *transformation* of both renewable and non-renewable natural assets, building design and construction can make a significant contribution to the sustainability debate. [4]

1.0.1 Renewable Resources

Discussion of renewable resource use is only meaningful when set against the biological limits and production capabilities of the biosphere. The continued degradation of the biosphere through over-exploitation and abuse diminishes its ability to produce essential resources but also its ability to recover from such abuses. A prerequisite for sustainability is the maintenance of the functional integrity of the ecosphere so that it can remain resilient to human induced stresses and remain biologically productive. Sustainability will require that the generation of waste and pollution from human activity, including the construction and operation of buildings, be kept within the assimilative capabilities of natural systems.

1.0.2 Non-Renewable Resources

Non-renewable resources, as finite assets, must be used or transformed such that they remain *useful* and *accessible* to future generations. Therefore, in addition to reducing the amount of resources invested in them, buildings must become *useful assets* for future generations. The implications on the quality, longevity and reusability of buildings and the recoverability, reuse and recyclability of their constituent materials and components will be profound.

1.1 FEDERAL ENVIRONMENTAL POLICY FRAMEWORK

Since the release of the *Green Plan* in 1990, and of the *Federal Code of Environmental Stewardship* in 1991, environmental requirements have increased significantly for all federal departments. The *Green Plan* sunset in 1996, to be replaced by a government-wide strategic plan, the *Federal Sustainable Development Strategy.* Environmental requirements will continue to increase as will repo ting requirements to central/regulatory agencies, Parliament and the public. Through amendments to the *Auditor General Act* on December 15, 1995, all federal departments are required to prepare a *Sustainable Development Strategy* (SDS) with concrete goals, objectives and action plans, to be tabled in Parliament by December 1997.

The general intent of the strategy is to provide the departments with the framework to integrate environmental considerations in the management of their activities. This is to be achieved by adopting an approach compatible with sustainable development principles, including adhering to the *Federal Code of Environmental Stewardship* (Table 1.1), to the latest federal policy on *Greening of Government Operations*, [5] and to other related policies. [6]

Within *Public Works and Government Services Canada* (PWGSC), Real Property Services (RPS) have the most input in the development of the departmental SDS. The branch has committed to sound environmental practices (management); and to achieve this goal, environmental goals and objectives have been formulated. They are summarized in *Table 1.2*, together with the potential impact on building design. They address the dual role of RPS as a "provider of services" to clients, and as a "custodian" of Crown-owned and leased inventory of buildings and other property assets.

Table 1.1: Code of Environmental Stewardship

The Federal Government is committed to:

- Detailing so that long life components will not be damaged when shorter life span elements are being replaced;
- Meeting or exceeding the letter and spirit of federal environmental laws and, where appropriate, being compatible with provincial and international standards;
- Improving the level of awareness throughout the public service of the environmental and health benefits and risks of operational decisions and to encourage and recognized employee actions;
- Applying environmentally responsible management strategies to hazardous substances used in operations, specifically with regard to the acquisition, handling, storage, safety in use, transportation and disposal;
- Seeking cost-effective ways of reducing the input of raw materials, toxic substances, energy, water and other resources, and of reducing the generation of waste and noise associated with day-to-day activities;
- Ensuring that environmental considerations are integrated into government purchasing policies and practices;
- Acquiring, managing and disposing of lands in a manner that is environmentally sound including the protection of ecologically significant areas.

1.2 GREENING OF GOVERNMENT

Addressing the environmental agenda will require an explicit restructuring of priorities and a questioning of a host of related assumptions which directly and indirectly shape buildings.

In April 1995, the Federal government approved a coordinated approach to green government operations. The policy on *Greening of Government Operations* commits federal organizations to address a number of specific issues in their sustainable development strategies.

Table 1.2: RPS Environmental Goals and Objectives

1: Toxic or Hazardous Substances and Waste Management

Real Property Services (RPS) will contribute to the prevention, reduction and, where possible, the elimination of impacts of toxic or hazardous substances and wastes on human health and safety.

Table 1.2: RPS Environmental Goals and Objectives

Design consequences:

- *Handling of Polychlorinated Biphenyis (PCBs) when replacing electric lighting installations;*
- *Specification of environmentally sound building materials;*
- *Specification of low maintenance systems and finished;*
- *Site landscaping to treat storm water.*

2: Ozone Depleting Substances Management

RPS will phase out the use of ODSs to respond to the deadlines laid out in the 1987 "Montreal Protocol on Ozone Depleting Substances" and its subsequent amendments.

Design consequences:

- *Reduction or elimination of ozone depleting substances.*

3: Non-Hazardous Solid Waste Reduction

RPS will:

- Contribute to the objective of reducing the amount of office solid waste sent for disposal by at least 50% by the year 2000 relative to 1988 levels;
- Facilitate the reduction of construction, renovation and demolition waste.

Design consequences:

- *Provision of adequate facilities to promote waste recycling programs;*
- *Specification of renewable, recycled content, durable and maintainable materials;*
- *Conscious design and construction planning to minimize construction and demolition waste.*

4: Energy and Water Efficiency in Facilities

RPS will:

- Contribute to the use and promotion of more efficient, environmentally friendly alternative sources of energy to heat, cool, ventilate and provide lighting and power facilities. It will also promote the efficient use of water.
- Reduce gas emissions to respond to Canada's commitment to the requirements of the 1992 'Framework Convention on Climate Change'.

Design consequences:

- *Improved building energy efficiency;*
- *Higher energy performance standards, use of clean; renewable energy sources;*
- *Specification of low embodied energy building materials;*
- *Use of low water consumption appliance and water efficient landscaping strategies.*

5: Contaminated Sites Management

RPS will contribute to the prevention, reduction and, where possible, the elimination of negative impacts of contaminated sites on humans and the environment.

Table 1.2: RPS Environmental Goals and Objectives

6: Land and Marine/Fresh Water Activities Management

RPS will contribute to the prevention, reduction and, where possible, the elimination of negative impacts on humans and the environment in their land and marine/fresh water activities.

Design consequences:

- *Greater understanding about implications of building construction and operation of site;*
- *Landscaping strategies which enhance site ecology;*
- *Construction practices which reduce environmental impact and construction waste.*

Departments and agencies must:

- Meet or exceed federal environmental statutes and regulations;
- Emulate best practices from the public and private sectors;
- Develop and implement environmental management systems, including action plans.

They must give priority to a *pollution prevention* approach in the greening of government operations; this is achieved by using processes, practices, materials, products or energy that avoid or minimize the creation of pollutants and waste, and reduce overall risk to human health and the environment. The *Greening of Government Operations* form an integral part of sustainable development strategies.

The key federal statutes which focus on environmental quality include the:

- Canadian Environmental Protection Act (CEPA)
- Canadian Environmental Assessment Act (CEAA)
- Canada Wildlife Act
- Fisheries Act
- Transportation of Dangerous Goods Act.

In particular, the CEAA is likely to impact the design on new and renovated buildings. Under this Act, a project must be screened for its environmental impacts at the earliest possible stage before any irrecoverable decisions are made. Also, the design must incorporate any mitigative measures that have been identified in any environmental assessment studies conducted to meet CEM requirements. In addition, a monitoring program for the anticipated environmental impacts and for the effectiveness of the corresponding mitigation measures must be included in the design.

1.3 DESIGN PRIORITIES

Legislation and public policy, the free market and infrastructure, natural events, and personal design philosophies all affect progress toward sustainable objectives.

Implicit in all *Real Property Services* goals and objectives toward environmental responsibility are the commitments to address the specific issues laid out in the policy on *Greening of Government Operations*:

- To keep pace with all significant environmental legislation, developments and initiatives;
- To offer services to RPS clients for the management of environmental issues;
- To pursue environmental research, development and demonstration;
- To develop and implement educational programs and aids to train employees involved with environmental activities and services;
- To participate in the development of environmental legislation and communicate RPS environmental expertise.

Table 1.3: Design Responsibilities

The environmental agenda will require architects and other design professionals to:

- Understand the emerging environmental agenda and develop the appropriate knowledge and skills to be able to respond accordingly on all design projects;
- Challenge existing design norms and reassess each design project on its own merits;
- Be open and receptive to emerging environmental ideas and be willing to re-evaluate best practices;
- Establish a coordinated team approach to design in which every member of the design team is, at some level, aware of and can make timely contributions to all the significant design issues;
- Look creatively at reusing existing buildings, materials and components in conjunction with a host of new materials that will become available as the building industry examines innovative ways of turning wastes into resources;
- Develop new skills, knowledge, and attitudes to support renovation work and to learn to be more curators of the built environment rather than creators;

Table 1.3: Design Responsibilities

- Examine the cost effectiveness of environmental strategies within a comprehensive analysis of total renovation costs and not simply evaluate them on the basis of the incremental cost-benefit of the strategy alone.

These collectively mean that design teams working on federal projects will be dealing with clients who:

- Are more aware of environmental issues;
- Are more committed to the implementation of improved environmental strategies within their facilities;
- Expect environmental issues to be explicit in all phases of the design process.

This will affect the knowledge and responsibilities of design professionals and the relationship between them (*Table 1.3*).

The conscious choices architects and other members of the design team face in deciding how to design buildings will have a profound influence on the future health of the planet. Environmentally responsive design involves satisfying human activity using resources efficiently and effectively, and with minimum stress on natural systems. It will affect and dictate whether we build, where we build, what we build and how we build.

We are currently in the early stages of a transition toward sustainability. It will take a considerable amount of time before a comprehensive environmental design ethic creates a realignment of priorities. It is the transition from the current period to such a future time that we can anticipate inevitable contradictions and difficulties. All aspects of 'sustainable' building design and operation will continue to be clarified and redefined.

Sustainability requires first and foremost an attitudinal shift, to embrace new ways of thinking about the processes of production, use and disposal of building. It is incumbent on all those responsible for building design and operation to begin to chart this new direction.

These guidelines emphasize environmentally responsible building design practices which establish the environmental agenda as fundamental design criteria and which result in innovative and progressive methods of construction and operation. Adherence to current economic imperatives must be maintained, but considerable advances are expected to be made in terms of resource efficiency and minimizing environmental impacts. Wherever possible and appropriate, design should challenge existing design norms and adopt innovative, more environmentally appropriate strategies which reduce environmental impacts and operating costs throughout the lifetime of buildings.

Such a realignment will require:

- The continual questioning and re-examination of traditionally held attitudes and approaches to design;
- Transcending professional boundaries between architects, engineer and all others involved in the production of buildings.

Table 1.4: Building Environmental Issues

Health and Well-being	Ecological	
	Resource Use	Ecological Impacts
Thermal Quality	Land Use	Global Warming
Indoor Air Quality	Energy Use	Air Pollution
Lighting Quality	Material Use	Waste
Acoustic Quality	Water Use	

1.4 ENVIRONMENTAL ISSUES

Environmental issues relevant to buildings include both occupant health and well-being and ecological impacts. (See *Table 1.4*)

Health and well-being design issues include the provision and maintenance of thermal, indoor air quality, lighting and acoustic conditions which directly and indirectly affect building occupants.

The ecological design considerations comprises resource use issues and environmental impacts:

- Resource use concerns centre on the depletion of land, energy materials and waters resources and how improved building design can employ them more efficiently and effectively;
- Ecological impacts cover the broad range of adverse impacts caused by the construction, operation and demolition of buildings.

1.5 RENOVATION OF BUILDINGS

Improved energy standards and increased potential for recyclability and reusability in buildings constructed from this point in time alone will not be sufficient to realign the built environment towards a sustainable future. Attention must be directed at the use and upgrading of the existing building stock.

Although the rehabilitation and reuse of buildings was originally a product of the historical preservation movement, today this growing trend also reflects a changing attitude towards resource use and a realisation of the economic and environmental limits to growth. Indeed, the beginning of the next millennium will mark a "shift from the era of building to the era of rebuilding". [7]

Demographic and economic factors, such as an oversupply of commercial buildings, slow economic growth and a decrease in the rate of population growth, have contributed to a decrease in demand for new construction:

- Both the public and private sectors will increasingly be forced to respond to needs for office space by renovating rather than building new;
- Improved energy and environmental standards for new buildings alone will not meet national environmental targets.

PWGSC office facilities consists of some 370 Crown-owned office buildings, amounting to approximately 3 million m^2 and valued at about $2.2 billion. About 85% of these buildings are more than 25 years old. In addition to the aging asset base, significant changes are currently taking place in the federal government that have an impact the demand for new construction: new technologies and trends towards flexible work arrangements are redefining the workplace.

Also, reorganization and consolidation of federal government operations implies substantial rationalization of the Crown portfolio over a 10-15 year period. Integral to RPS strategic directions is the commitment to bring Crown-owned facilities up to full environmental standards as quickly as possible, subject to resource availability.

1.5.1 Extent of Renovation

Renovation can range from relatively straightforward reorganization of interior space through to the complete upgrading of the building envelope and building systems.

Four levels of renovation can be considered:

- Major renovations that generate significant waste because parts of the structure are removed and/or replaced;
- Minor renovation as part of routine repair and maintenance on the building;
- Fit-up projects, where the facility is adjusted from base building standards to fit the needs of the tenants;
- Tenant service renovations which the tenants conduct themselves.

Each renovation project presents its own unique problems and opportunities to provide cost-effective environmental upgrading.

A prerequisite to consider in renovation projects is a detailed audit of the existing environmental characteristics of the building including energy, water and materials. This is not considered in this guide but appropriate procedures are identified in the *Building Renewal Evaluation Guide*. [8]

1.5.2 Environmental Benefits

Although most of the buildings in a city are not landmarks and may possess only marginal cultural and historical significance, they are valued for other reasons, such as the distinctive character and quality that they give to established urban areas.

Despite their lack of landmark status, the more modest buildings that constitute most of the urban fabric of Canadian cities represent a huge investment of capital and resources. Demolition of these buildings is a "flagrant waste of materials and energy", and their conservation becomes more an environmental issue than a cultural one. [9] *Table 1.5* presents the environmental advantages of re-using office buildings.

1.5.3 Economic Benefits

Generalized statements about the cost of renovation versus new construction are difficult to make because of the large number of variables involved. Every project is unique and costs will vary depending on the extent of the work that is required. A large commercial rehabilitation can cost anywhere from 12% less to 9% more than comparable new construction that takes place on an empty site. [10]

Table 1.5: Environmental Benefits of Renovation

1. Conservation of Resources

As supplies of non-renewable resources are depleted, and as the costs of remaining sources increase, the conservation of all resources will become far more important.

- Although reusing buildings undoubtedly conserves resources, buildings are largely composed of materials that are relatively plentiful: gravel, stone, and cement with steel and lumber typically being the next two highest ranking materials;
- The environmental costs producing these materials is currently a more important concern than their conservation.

2. Reduced Environmental Impact

An existing building represents a concentration of natural and manufactured materials, the environmental impacts of which were incurred many years ago.

- Retaining buildings and upgrading or adapting them for new uses reduces the currently environmental damage caused producing materials such as steel and concrete. Reusing buildings requires lower quantities of these materials since a structure is already in place.

3. Energy Invested in Existing Buildings

Reusing old buildings conserves embodied energy.

- Existing buildings represent a past investment of large amounts of energy invested in the processing, manufacturing, transportation, and assembly of their constituent materials. This investment is known as a building's "embodied energy".

4. Energy Efficiency

Many older buildings from the late 19th and early 20th Century can use less energy than newer buildings.

- The thermal mass provided by thick masonry walls tempers heat gains much more effectively than the glass and steel curtain walls of later structures;
- Pre-World Ware II buildings usually relied on natural light and ventilation and their relatively smaller window areas and external shading devices reduced solar heat gains.

5. Reduced Volume of Waste in Landfills

Debris from demolished buildings, if not recycled, is dumped into local landfills.

- With many landfills reaching their capacity, reducing the volume of waste is becoming a critical environmental concern;
- Reusing buildings also saves the energy that would be required to demolish them.

6. Reducing Suburban Sprawl

Reusing and adapting existing or under-utilized buildings can help rejuvenate old neighbourhoods and slow the rate of urban sprawl which destroys agricultural land and increases energy required for commuters.

Table 1.5: Environmental Benefits of Renovation

7. Changed Attitudes

Indirectly, reusing existing buildings encourages the idea of designing for longer life-cycles and taking into account the long term economic and environmental consequences. Reusing old buildings is part of a move away from the "throw-away" mentality of the past.

8. Cultural Heritage

There is a need for cities to preserve their physical memory. Buildings provide a physical link to the past.

- The preservation of buildings helps to maintain a unique sense of an increasingly standardized world;
- Cities are enriched by the character and scale that older buildings add to the built environment.

9. Abundant Supply

In some parts of the county with a long urban history there is a large supply of older buildings that can be utilized for new purposes.

10. Existing Buildings as a Resource Base

The existing building stock represents a vast source of future building material. Although it was created without a view for reuse or recycling of materials, a large portion of it will be re-made into 'new' building.

In a situation where an existing structure must be demolished before new construction can begin, renovating the building instead can cost anywhere from 3 to 16% less. If major elements such as mechanical, electrical, or plumbing systems, windows, roof, etc., can be reused, cost savings will be greater. Construction costs for minor renovations usually range from 40 to 50% of those of a comparable new structure. [11]

Table 1.6 presents the economic advantages of reusing office buildings.

Table 1.6: Economic Benefits of Renovation

1. Demolition Costs

Reusing old buildings saves demolition costs:

- Demolition can account for as much as 5 to 10% of total construction costs;
- In urban areas, where safety concerns can restrict the methods of demolition that can be used, building demolition and removal can be very expensive and time consuming.

2. Land Costs

Reusing an existing building save the high cost of purchasing undeveloped land.

With rising land costs, even in outlying areas, there is less reason to build on vacant land in outlying areas rather than renovating an existing structure in an already built-up area.

Table 1.6: Economic Benefits of Renovation

3. Construction Time

The total amount of construction time required to renovate an old building is generally less than the time required to build a comparable new facility.

- Renovation work can take place year round since contractors can work inside during the winter months and there is no need to wait until spring to do excavation work;
- Less construction time also leads to reduced interest costs and an earlier rent income.

4. Staged Construction

Buildings can be renovated in stages so that one section can be completed and occupied before work begins in another area.

- This provides a source of income for developers during the construction process;
- With higher interest rates, and longer delays in the availability and shipment of required building materials prolonging construction time, the lag between construction and occupancy will become an increasingly important cost factor.

5. Desirable Accommodation

Renovated buildings can be as, if not more, desirable than newer ones and command high rent.

- The unique character of old buildings, a product of their age and craftsmanship, offers a quality rarely obtained in new construction;
- Features such as high ceilings, large windows, ornamental woodwork, often found in old buildings, can greatly improve the marketability of rentable space.

1.6 REFERENCES

1. WCED, (1987) *Our Common Future.* [The Brundtland Report]. Oxford, Oxford University Press (for) UN World Commission on Environment and Development, p. 393.
2. *Creating Opportunity*, The Liberal Plan for Canada, Liberal Party of Canada, Ottawa, 1993.
3. Slow, R., 1993, An Almost Practical Step to Sustainability, reviewed in *Resources*, 110, Resources for the Future, 116 P Street NW, Washington DC, 20036-1400.
4. Hill. R.C., *et al*, 1994, P.A., A Framework for the Attainment of Sustainable Construction, *Proceedings* CIB TG-16, *Sustainable Construction Conference*, Tampa, Florida, 1994, pp. 13-25.
5. *A Guide to Green Government*, 1995, Ministry of Supply and Services, Ottawa, Cat. No., En21-136/1995E.
6. *Directions in Greening of Government Operations*, 1995, Public Works and Government Services Canada, Ottawa, Cat No. 40-497/1-1995E.
7. Levinson, Nancy, "Renovation Scoreboard". *Architectural Record.* Vol. 181. January 1993, p. 70.

8. *Building Renewal Evaluation Guide*, Real Property Services, Public Works and Government Services Canada, Ottawa, 1996.

9. Kalman, H., *The Conservation of Industrial Buildings: Feasibility and Practice.* The Heritage Canada Symposium, 1976, p. 4.

10. Rypkeme, Donovan D., "Making Renovation Feasible." *Architectural Record.* Vol. 80. No. 1. January 1992, p. 27.

11. Rypkeme, Donovan D., 1992.

2. HEALTH AND WELL-BEING

2.0 INTRODUCTION

If salaries are considered as part of building economics, the substantial value of providing environments that are positive and supportive of occupant health and productivity become immediately evident. According to a recent study commissioned by *US National Energy Management Institute*, improving indoor air quality (IAQ) in buildings could result in a payback in terms of productivity and decreases in medical costs in less than two years. [1]

Concern over indoor air quality has become a public health issue through the past two decades as a result of the energy conservation measures in the 1970s which restricted ventilation rates, the increasing use of synthetic building, materials, the introduction of information technologies in offices without the benefit of adequate ventilation, and individuals typically spending between 80 to 90% of their time indoors.

By the early 1980s, research began to demonstrate the correlation between exposure to indoor air pollutants and health problems with symptoms ranging from eye irritation, headaches, and fatigue to respiratory diseases and cancer. These reactions to contaminants have led to the recognition of the notion of *Sick Building Syndrome* (SBS).

The perception of air quality can also be exacerbated by inappropriate thermal, lighting and acoustic conditions. The improvement of the indoor environment thus requires a multi-disciplinary and integrated approach. Architects, as team leaders, have a key role to play in ensuring at the outset of a project that design requirements will incorporate these important considerations.

Office building design objectives include:

- Providing comfortable and healthy work conditions which satisfy the maximum number of building occupants;
- Providing these conditions within an acceptable energy and cost framework;
- Ensuring that such conditions can be operationally maintained.

2.0.1 Environmental Standards

Occupational safety and health is regulated under Canada Labour Code, Part II, Occupational Safety and Health, 1996. Under this policy, government departments have the responsibility to ensure a safe and healthy workplace to occupants of buildings under federal jurisdiction, including the provision of environmental conditions in accordance with prescribed standards.

PWGSC environmental requirements for the design of new and renovated federal facilities are set in *MD 15000, Environmental Standards for Office Accommodation*, [2] published in November 1994, which includes provisions related to ventilation, temperature, relative humidity, and acoustics. MD 15000 incorporates many requirements of ASHRAE Standard 55-1992, *Thermal Environmental Conditions for Human Occupancy* [3] and Standard 22-1989, *Ventilation for Acceptable Indoor Air Quality*, [4] which are generally accepted guidelines for ventilation and Indoor Air Quality (IAQ). The scope of these standards is limited to issues generally under the responsibility of HVAC design engineers.

Indoor air quality standards issues are dealt with more comprehensively in CSA Z 204-94, *Guidelines for Managing Air Quality in Office Building*, Occupational Health and Safety. [5]

Recommendations for good lighting practice are set by the *Illuminating Engineering Society of North America (IESNA)* [6] and PWGSC's Design Standard RPSB/DGSI 1-4:95-1, *Office Lighting*. [7]

2.1 IMPROVING THERMAL QUALITY

Thermal quality can be defined as the absence of discomfort caused by temperature, humidity and air movement conditions that are inappropriate to the task at hand.

Though not directly a health issue, poor thermal conditions can exacerbate dissatisfaction, productivity and morale.

Heating, cooling and humidity control are major energy factors in offices and maintaining a comfortable thermal environment will have a major impact on energy use.

Relative Humidity Control
Humidity control is both a comfort and a health issue. Low humidity levels irritate the bronchia producing more respiratory complaints and also allow dust to disperse more readily. High humidity levels support dust mite and fungal growth and allow airborne bacteria and viruses to survive for longer periods.

HVAC Control
Poorly conceived partitioning and space planning can create uneven and obtrusive heating and cooling control throughout the interior of occupied spaces. Coordination is required between the HVAC supply and the organization of internal spaces and partitioning.

Solar Heat Gain
Air temperature, air movement and relative humidity can be controlled by the mechanical systems. Thermal and visual discomfort can occur through sunlight falling directly in the workplace in the absence of effective solar control.

Thermal Mass
Thermal mass offers the twofold advantages of moderating the temperature of occupied spaces during conditioned periods and thereby minimizing or eliminating the need for mechanical cooling.

Improved control of the thermal environment can be achieved by:

- Providing heating and cooling devices in close proximity to occupants.
- Where general space heating and cooling is provided, considering the effects of partitioning and space planning to ensure even heating and cooling control throughout the interior of occupied spaces;
- Providing for some flexibility, or ability to control local thermal conditions based on specific occupant requirements, while still maintaining reasonable limits overall;
- Designing zones that are as small as is practical;
- Providing controls which correspond to interior partitioning;
- Providing controls which are readily accessible from the space to which they are connected and are easily comprehensive to occupants will encourage their use;
- Planning for the careful admission of direct sunlight into the building interior using effective solar control devices on windows;

- Using the thermal mass inherent in the building to regulate temperature variations.

2.2 IMPROVING INDOOR AIR QUALITY

Appropriate indoor air quality is defined as the absence of air contaminants which may impair the comfort or health of building occupants. Indoor air quality is most appropriately addressed first by removing or controlling sources of pollution and secondly by providing effective ventilation.

Indoor air problems can be minimized by reducing or eliminating contamination created:

- By materials enclosing and within the occupied spaces;
- By occupants, equipment and processes within the occupied spaces;
- Within the mechanical system and its distribution system;
- By the introduction of poor quality outside air due to local or regional air pollution or through inappropriately placed intakes.

2.3 CONTROLLING SOURCES OF POLLUTION

2.3.1 Finishing Materials

Because finishing materials are those directly enclosing an occupied space, their selection is critical from an indoor air quality standpoint.

The shift towards synthetic materials has had a deleterious impact on *Indoor Air Quality*:

- Thirty or forty years ago linoleum, a linseed oil and cork product which is highly durable, was one of the most common types of resilient flooring. Today vinyl, derived from petrochemicals, has largely replaced it;
- Polyvinyl chlorides have been substituted for some metal components and natural rubber has been replaced by neoprene and styrene-butadiene;
- Wood boards that were used as sub floors, and finished flooring have been replaced by plywood and particle board made with glue;
- The urea-formaldehyde binders in particle board and interior rated plywood release chemicals such as acetone and formaldehyde into the indoor environment.

With the exception of asbestos, the components of existing buildings have released much of their volatile contents through years of out-gassing and are now relatively benign. Keeping them in place, if possible, will reduce the amount of emissions from new materials. However, indoor air quality problems will also derive from the damaging effects of water, floor maintenance practices or the replacement by new finishing materials during a renovation.

Building Moisture
Moisture damage in buildings caused by roofing failures, plumbing failures and other accidents can cause microbial contamination of absorbent materials leading to sour odours and possible growth of pathogenic bacteria and fungi.

Indoor air quality can be improved by:

- Evaluating materials for off-gassing, stability under exposure to varied temperatures and moisture levels, resistance to soils and odour contamination, maintenance requirements and durability, with particular attention given to:
- Those used in large quantities;
- Those having potentially high emission rates;
- Those located near the occupant's breathing zone or exposed directly to the ventilation air.
- Taking care to specify that exposed surfaces of materials containing contaminants, i.e., particle board (containing formaldehyde), be sealed or encapsulated and unused assembly holes be plugged during manufacture;
- Requesting written recommendations from the manufacturer regarding maintenance methods having minimal impact on building air quality to ensure maximum effectiveness of product use through time;
- Adequately repairing any moisture damage and, if necessary, discarding contaminated insulation, carpet, etc.

2.3.2 Paints

Interior paints are sources of serious exposure to trades and building occupants throughout their curing period. This period may be several weeks in length and extend well into the occupancy period of a new or renovated building.

Paints listed by the *Environmental Choice Program* [8] or other equivalent authority are preferred choices.

Indoor air quality problems with ***paints*** *can be reduced by:*

- Specifying water based paints with reduced volatile and preservative content, those which meet EcoLogo standards for reduced solvent content, or those which are formulated for minimal VOC emissions;
- Specifying paints which contain no mercury, lead, hexavelant chromium or cadmium compounds in their formulation or tints.

2.3.3 Adhesives

Solvent based adhesives are environmental hazards and are toxic to handle. Both the solutions used to clean up solvent based adhesives, as well as the unused adhesive itself, are hazardous wastes and need be taken to a hazardous waste collection service.

Low emission adhesives are water based and formulated for low emissions and low toxicity according to *Environmental Choice* or other comparable standards. These adhesives contain virtually no aromatic solvents; do not have the strong odours of other adhesives; are safer to install; and have less manufacturing impact and toxic waste.

Indoor air quality problems with ***adhesives*** *can be reduced by:*

- Specifying construction adhesives with low emissions during curing (see paint recommendations above).

2.3.4 Floor Coverings Floor

Floor coverings are important sources of volatile organic compounds, dust, and fibre release due to their large surface area with both short and long term consequences. [9, 1O]

The interaction of indoor air pollutants with interior surfaces is an important indoor air quality problem. A surface can act as a sink by absorbing VOCs emitted from another material, and later desorbing that VOC into the space. Surfaces with the highest accessible surface per unit area such as acoustic tile, carpet and upholstery fabric have the highest sink capacity.

Sources of volatiles and dust from both textile and non-textile floor coverings can be reduced by specifying low emission, easily maintained floor covering construction and low emission installation methods.

A "low emission" resilient floor covering is one which:

- Contains no soft, flexible vinyls (e.g., resilient PVC);
- Contains little or no chloroprene rubber, styrene, butyl rubber or latex;
- Is factory sealed with a durable, no-wax finish.

Carpet
Although natural fibre carpets offer many environmental qualities, cost and limited durability preclude their use in many applications. [11,12]

Carpet choices are often limited to those made of synthetic fibres from petroleum sources - nylon, polyester, polypropylene:

- They are manufactured using continuous looms, usually by bonding the fibres to a backing with flexible latex glue;
- Gases emitted from the latex backing and fibre treatments are a source of indoor air pollution;
- The carpet and under-cushion are typically fixed to an unfinished wood or concrete sub-floor with glue;
- Carpet adhesives especially when solvent based are hazardous to manufacture, install, and present disposal problems;
- Synthetic carpet is non-biodegradable and once discarded and dumped in the landfill, will remain for decades.

A "low emission" carpet installation is one which:

- Eliminates synthetic latex bonding materials;
- Eliminates topical stain resistance materials;
- Eliminates flame retardants;
- Eliminates foamed rubber or plastic backing or pads;
- Has pile which resists soiling and allows easy air movement for cleaning.

Ideally, all carpet installations should be either stretched-in, tackless strip, velcro adhered backing, or "dry adhesive".

However,

- The relative large areas of carpet used in office areas often make it difficult to avoid movement or to use tack strips;
- Any seams would be vulnerable given the considerable traffic to which the carpet can be subjected. Dry adhesive has merits for these reasons, and is releasable for repairs.

*Indoor air quality problems with **floor coverings** can be reduced by:*

- Selecting resilient flooring in common areas that are constructed without soft, plasticized vinyl or rubber and laid with low-toxicity adhesive or without adhesive;
- Keeping carpets away from entrances where they will become soiled and away from water sources;
- Selecting carpets which have fusion bonded, needle-punched or other low emission backing specifically designed for low emission characteristics, and having low pile, tight loop construction installed with dry adhesive minimal adhesive or without adhesive;
- For large carpet projects, requiring detailed testing of the carpet systems, including adhesives and seam sealants and having the carpet manufacturer specify the adhesive and request a warranty of total VOC emission for the installation;
- Specifying off-site airing-out of carpets by requiring the manufacturer or supplier to open packaged materials and store them in a heated and ventilated warehouse from the time of manufacture until delivery to the site.

Floor Maintenance
Air contaminants from maintenance (cleaners, waxes, carpet cleaning and pesticides etc.), are a continuous concern, emphasizing the importance of the selection of low maintenance finish materials.

2.3.5 Gypsum Board

Water-resistant gypsum board, especially those with toxic additives used for retarding fungus growth, can pose environmental problems. The additives incorporated in gypsum board to increase its moisture resistance, may contain chemicals to resist fungus contamination.

The water-resistant agents add a petroleum-based component of thc board, increase the energy required for manufacture, and renders the material unfit for recycling.

Gypsum flbreboard offers many improvements:

- It contains fiberized post-consumer newsprint and, along with wood fibre for reinforcement, is mixed with the gypsum before settlng;
- It requires less energy and generates less pollution;
- It does not have a Kraft paper finish and, as such, has a much harder surface than conventional gypsum board;

- It is not as susceptible to tearing, bulging, and scratching;
- Because of the exactly produced edges, which permit tighter installation fit, less joint compound is required.

2.3.6 Building Flush-Out

The level of volatile organic compounds from construction and interior finish materials is highest immediately after installation and declines with age.

A building flush-out is a sustained period of full ventilation, using 100% outdoor air prior to building occupancy to reduce levels of residual volatiles. A period of at least one week is recommended. A 'flush-out' differs from a 'bake-out' in that the latter is the provision of continuous or periodic ventilation while maintaining elevated indoor air temperatures. Concerns here are the possible warping and damage of interior finishes at these sustained temperatures (approx. 27-28C).

A building flush-out is an essential protocol, but effective source control will minimize or eliminate the need for a building bake-out.

The level of volatile organic compounds from construction and interior finish materials can be diminished by:

- Sustaining a period of full ventilation, using 100% outdoor air after renovation or construction prior to building occupancy to reduce levels of residual volatiles, for a period of at least one week.

2.4 ISOLATING POLLUTANT SOURCES

Office buildings which contain uses such as printing shops, graphics departments etc., producing air contaminants which may affect the health and comfort of office occupants must have provisions to prevent entry of contaminants.

Though fire code and health and safety regulations govern this matter, compliance may not prevent comfort complaints or produce "fail safe" conditions.

Fully isolating distinct sources of pollution by appropriate building zoning, air pressure differentials, provisions for ventilated vestibules, fully separated ventilation systems or other methods will often be required to minimize indoor air quality problems.

Known pollutant sources can be isolated by:

- Making provision to prevent transfer of contaminants which may affect occupant health and comfort to other occupied zones.
- Providing air locks and pressurization to reduce the entry of vehicular exhaust and other outside contaminants.

2.5 MINIMIZING CONTAMINATION WITHIN THE HVAC SYSTEM

Two potential air quality issues and associated health risks in HVAC systems are:

- Loose mineral fibres within the air distributions system, particularly from silencers or return plenums over suspended ceilings, which enter the occupied space;
- Standing water in ventilation systems which incorporate a chiller, humidifier, dehumidifier, heat exchanger, air washer or any other device which may be expected to introduce moisture into the system, either by condensation or moisture injection, can support growth of pathogenic bacteria and fungi.

2.5.1 Mineral Fibre Related Problems

Duct Liners
Conventional wisdom is to minimize or eliminate the use of liner products containing mineral fibre used for acoustic and thermal insulation inside HVAC ducts since:

- Fibrous liners trap dust, making air filtration and duct cleaning less effective;
- Accumulated dust and debris will support microbial contamination if moisture is present;
- Deteriorating fibrous liners are a source of hazardous mineral fibres.

Liner encapsulation is the most common solution today, but requires regular inspections to ensure its integrity.

Ducted Returns
Ducted returns are more likely to stay balanced, less prone to disturbance, deterioration, and dust contamination and are more readily cleaned than non-ducted systems.

Providing ducted returns may require higher ceilings (often available in older buildings) or larger return fan motors and use additional energy, but improved ventilation effectiveness and reduced maintenance are important benefits.

Filtration Performance
Common filtration equipment is not capable of effectively trapping smaller particulates, especially those less than 5 microns. Improved filter systems can remove this particle size range, both protecting building occupants and reducing equipment cleaning requirements. [13]

Loose Mineral
Fibre Quantities of un-contained mineral fibre materials, particularly where exposed in ceilings used as air plenums, because some released fibres are certain to enter the occupied zone. This includes sprayed acoustic coatings and fire protection to the building structure retardants containing more than 10% mineral fibre, and acoustic and thermal insulation batts and panels with exposed glass or mineral fibre materials.

Contamination within the mechanical system can be minimized by:

- Using only minimal amounts of fibrous liners inside HVAC ducts for acoustic and thermal insulation and limiting these uses to the return air path.
- Avoiding the use of suspended ceilings as return air plenums and using ducted returns.
- Where conditions warrant, specifying filter systems which can remove particle size less than five microns to protect building occupants and reduce equipment cleaning requirements.
- Avoiding quantities of uncontained mineral fibre materials in the building, particularly where exposed in ceilings used as air plenums, because some released fibres are certain to enter the occupied zone.

2.5.2 Water Related Problems in Mechanical System

Where the heating, cooling and ventilating system is installed in compliance with MD 15000 recommendations for prevention of standing water, no standing water will normally occur in the air path.

Humidification and condensate systems must be designed and maintained to minimize moisture in ducts and moisture contamination of duct liners.

- Installing the heating, cooling and ventilating system in compliance with MD 15000 and ASHRAE recommendations for prevention of standing water.
- Designing humidification and condensate systems to minimize moisture in ducts and moisture contamination of duct liners.

Cooling Towers
Cooling towers can become sources of hazardous pathogens because they provide conditions for breeding microbes. Therefore, they must be treated. However, treatment methods include caustic and toxic chemicals which are also hazardous.

Treatment by the least hazardous means and spray control design are the most appropriate means of reducing risks from cooling towers:

- The risks from microbes and treatment chemicals can be minimized by locating and designing cooling towers to prevent spray from entering the building and from falling on public areas;
- There is a variety of chemical treatment methods available using different classes of bactericides, fungicides, algicides and buffers or corrosion inhibitors.

Health issues associated with cooling towers can be minimized or eliminated by:

- Locating and designing cooling towers to prevent the release of spray containing microbes and treatment chemicals from entering the building and from falling on public areas.

2.5.3 Access for Maintenance

Many health issues derive from inadequate maintenance of the mechanical systems.

Minimizing indoor air quality problems will require that building operators have easy access to all critical parts of the ventilation distribution system.

Maintenance procedures can be facilitated by:

- Providing sufficient space and access to all relevant parts of the mechanical and ventilation systems in order to facilitate effective, regular maintenance.

2.6 REASSESSING THE LOCATION OF AIR INTAKES

Many indoor air quality problems begin by the introduction of poor air from the outside. Some sites may be located where they are relatively free from urban and industrial pollution. Others, however, are not and may require extraordinary filtration of outdoor air.

Poor intake air quality may also occur as a result of buildings themselves and their proximity to adjacent vehicular access.

Hazardous Outdoor Sources
Building air intakes must be adequately isolated by both vertical and horizontal distance from sources of vehicle exhaust, cooling tower spray, combustion gases, laboratory exhausts and other hazardous air contaminants. [14]

Unpleasant Outdoor Sources
The location of intakes near sources of nuisance odours such as garbage collection areas and plumbing vents can lead to air quality complaints. Problems can be reduced by isolating building air intakes by both vertical and horizontal distance from sources of nuisance air contaminants.

Re-Entrainment
Poorly conceived and located building exhausts can lead to the "re-entrainment" of exhaust air into fresh air intakes. Locating building exhausts well above and horizontally separated from intakes is the most effective means of minimizing this risk.

Air Scrubbing
Office buildings those areas which exceed ambient air pollution guidelines, may require the use of adsorption media to pre-clean ventilation air (e.g., activated carbon filters).

The introduction of the best quality air from the outside can be improved by:

- Adequately isolating building air intakes both vertically and horizontally from sources of vehicle exhaust, cooling tower spray, combustion gases, laboratory exhausts and other hazardous air contaminants;

- Adequately isolating building air intakes both vertically and horizontally from sources of nuisance air contaminants such as garbage collection areas and plumbing;

- Adequately isolating building air intakes from intakes to prevent "re-entrainment" of exhaust air.

2.7 PROVIDING EFFECTIVE VENTILATION

Applicable Standards
Ventilation systems should be designed to meet or preferably exceed those specified in *MD 15000 at the minimum preset ventilation rate, while heating and cooling systems simultaneously maintain thermal comfort within the recommended range.*

2.7.1 Ventilation Effectiveness

It is insufficient to consider only the amount of air delivered to a space - the air must be *delivered* to the occupants. The more directly supply air reaches the "breathing zone", the higher the ventilation effectiveness. Ventilation effectiveness depends on the:

- Path by which supply air moves through an occupied space and reaches an exhaust or return;
- Directness of delivery of ventilation air to the occupants, i.e., diffuser type and location;
- Placement of obstructions to air movement such as partitions and acoustic barriers.

Providing effective ventilation requires coordination between architect, interior designer and mechanical consultants.

Ventilation effectiveness can be improved by:

- Analyzing the impact of air supply and return locations on airflows in typical and unique spaces in order to eliminate short-circuiting and dead air zones;
- Using the most appropriate diffusers and velocities for a given space;
- Where possible, locating return air opening no more than 3m from any typical copy machine to provide dilution of emissions, or dedicated exhaust.

2.7.2 Outdoor Air Economizer Capacity

The outdoor air economizer cycle design allows the use of outdoor air for building coollng during mild weather by increasing the proportion of outdoor air mixed with return system air.

Increasing outdoor air proportions also typically improves indoor air quality and is useful for "flushing periods" at morning start-up and during interior renovations and maintenance.

The ideal performance of the ventilation system will be attained by:

- Specifying 100% economizer capacity, i.e., all supply air can be outdoor air when required.

2.8 IMPROVING LIGHTING QUALITY

Quality illumination is a fundamental necessity for comfort and productivity in the workplace. Well designed, controlled and integrated daylight and electric lighting is necessary for achieving a satisfying and glare-free environment for office work, particularly for workstations with video display terminals (VDTs).

Current IES recommendations implicitly accept the notion of a less general illuminance level in the space but higher in the vicinity of the tasks. Lighting must be designed and provided to satisfy the visual needs of the occupants. Merely complying with the specified illuminance levels for the task will not satisfy this requirement.

Providing a comfortable lighting balance, limiting the effects of transient adaptation and minimizing disability glare can be achieved by:

- Using IES recommendations as a general guide for maximum luminance ratios between the task and its surrounding, particularly for workplaces using *Video Display Terminals* (VDTs).

2.8.1 Lighting Distribution

IES recommendations provide a general guide for maximum luminance ratios between the task and its surroundings to achieve a comfortable balance and limit the effects of transient adaptation and disability glare. [15]

These recommendations are particularly important for work-places using *Video Display Terminals* (VDTs).

Variety in Lighting
Many existing office buildings have ceiling luminaries placed on a regular grid to provide requisite lighting levels. These general lighting strategies often create monotonous luminous conditions and veiling glare on VDT screens which reduce visual comfort and productivity.

Visual comfort is a function of a variety of physical and psychological factors, IES luminance ratios are by no means absolute, especially when dealing with daylight.

Although very bright or dark areas within the field of view may be distracting, variation within these prescribed limits is also desirable to avoid a monotonous environment.

Task-ambient lighting and non-uniform lighting strategies can provide greater definition to the interior, producing more interesting and appropriate lighting conditions.

The quality of the lighting can be improved by:

- Enhancing the visual comfort of occupants engaged in specific tasks by providing the appropriate illuminance, distribution and avoidance of glare;
- Providing users with the ability to control the amount and direction of light at their workstation;
- Enhancing the visual definition of spaces and overall impression created by the space by providing a sense of orientation, guidance, visual focus, spaciousness, privacy, etc.;
- Providing a distribution of lighting within the space such that the surfaces and objects that are of significance to the occupants are lit in an appropriate and relevant manner;
- Providing visual interest by incorporating a variety of fixture types, directed diffusers, indirect lighting, highlighting or other features;
- Designing an effective lighting strategy which recognizes and provides for both ambient light and task light which are fully integrated with each other in the architectural concept and other systems.

2.8.2 Lighting Equipment

Lamps
Two significant lamp characteristics are:

- Luminous efficacy (LumensNVatt)
- Colour Rendering Index - a minimum acceptable value for office work being 75.

Smaller, T-5, T-8 or T-10 lamps with triphosphor coatings offer improved colour rendition and energy efficiency. Trichomatic phosphor lamps use a blend of three rare-earth phosphors that peak in the red, green and blue wavelength regions to create "white" light.

Ballasts
Standard lighting ballasts operate lamps at a 60 hz frequency. While ballasts are new and lamps are replaced regularly, there is no visible flicker, but as ballasts and lamps wear, flicker often begins. Flicker is

a distracting phenomenon and can be a serious problem with video displays, actually affecting comfort and productivity. High frequency ballasts make lamps perform longer without flicker.

For locations sensitive to electronic interference, the use of *hybrid* ballasts is an asset. They combine the benefits of lower operating energy with reduced interference.

The quality of lighting systems can be improved by:

- Specifying lamps with colour rendering indexes greater than 75;
- Specifying electronic ballasts.

2.8.3 Direct lighting and Indirect Systems

Whereas direct lighting is inherently more energy efficient, indirect systems that are integrated with furniture or ceiling systems can provide low-glare and soft, ambient lighting in the workplace.

Diffuse light bounced off the ceiling greatly reduces the potential for direct or indirect glare resulting from sharp contrasts in lighting and is preferred by VDT users.

Combining direct with indirect, or direct/indirect systems with adjustable distribution, can provide *both* improved lighting quality and energy efficiency.

The quality of direct lighting systems can be improved by:

- Selecting fixtures which minimize direct glare and avoid monotonous or disturbing arrangements;
- Minimizing differences between a bright recessed ceiling fixture and adjacent unlighted ceiling tile;
- Specifying luminaries and lighting systems employing advanced optical systems and efficient reflector materials, such as polished reflectors and parabolic diffusers equipped with louvres for adequate cut-off of light at angles exceeding 45° from horizontal.

***Indirect** lighting can be utilized to:*

- Reduce the potentially overall bland appearance often associated with totally indirect lighting strategies;
- Minimize "hot spots" on the ceiling plane.

2.8.4 Natural Lighting

All office buildings typically have windows. However, the interior organizations of interior spaces, height, colour and orientation of the partitioning, the electric lighting and associated controls, often do not take advantage of the potential natural lighting.

If carefully admitted into building interiors, natural light can enhance the environmental quality of the workplace. These benefits can be translated into improved occupant satisfaction and enhanced productivity. Under the right circumstances, a small amount of natural light can be as effective in increasing visual performance as larger amounts of conventional overhead electric lighting.

If major changes to the building's glazing are contemplated, the introduction of quality natural lighting should be an important consideration in the redesign, glazing choice, solar control and electric lighting control strategy.

Daylight
Daylight is typically always welcome in those spaces occupied for prolonged periods, providing that sky glare and the amount of light admitted can be adequately controlled.

Sunlight
The value of sunlight has little to do with quantity. It is more desirable to have a small amount of sunlight within the interior over an extended period of time rather than a large amount of short duration.

Direct sunlight may be an undesirable quality in many spaces within office interiors especially where VDTs are in use and where it falls directly on fixed workplaces. It also adds to the cooling load.

Improved daylighting can be achieved by:

- Planning the interior organization to maximize for the potential benefits of daylighting from existing window configuration;
- Recommending that the internal planning of partitions be organized to enhance the benefits of daylight;
- Selecting internal reflectances which maximize the reflection of daylighting deeper into the building interior;
- Examining the potential benefits and adverse effects of admitting sunlighting into the workplace;

- Planning the interior to provide the greatest possible visual access to the exterior.

Glare
Both direct and reflected glare reduce occupant satisfaction, productivity - initiating actions such as covering windows which ultimately reduces the amount of useful daylight to the building interior.

The use of innovative blinds with separate tilt control for upper and lower sections, or perforated fabric blinds, can achieve reduction in glare while maximizing daylight advantages.

Visual Contact with Exterior
Visual contact with the exterior is important in providing and maintaining cues regarding orientation, time of day, and weather:

- Glass assemblies which transmit more visible light provide an accurate perception of daylight conditions;
- Many types of tinted glass and solar control coatings reduce visible light to the point where daylighting opportunities are eliminated and accurate perception is lost;
- Minimum acceptable levels of glazing light transmission are around 30% but greater than 55% is preferable. Brightness enhancing glazings (e.g., bronze tints) can counter the reduction in the perception of daylight within office interiors.

2.9 IMPROVING ACOUSTIC QUALITY

Appropriate acoustic conditions are a fundamental necessity for comfort and productivity in the workplace. Very moderate systems noise can be an advantage but excessively low ambient noise levels (i.e., low background noise) can lead to a loss of acoustical privacy.

The acoustic conditions within the interior can be improved by:

- Controlling ambient noise entry, and excess internally generated noise at source to maintain appropriate acoustic conditions;
- Using appropriate acoustic separation rather than employing masking sound other than that provided by necessary equipment.

2.9.1 Flanking and Isolation

Noise generated within the building by occupants, their equipment and plumbing is also a common irritant in the workplace and is usually caused by poor sound isolation in floors and walls. This can be remedied, to a large extent, by acoustic barriers and isolation of sources. Measures to reduce sound transmission between occupancies and floors can reduce irritating noise from internal sources.

The integrity of acoustical partitioning can be maintained by:

- Extending partitions above the suspended ceiling;
- Eliminating holes for ducts, pipes, conduits, cables etc.;
- Providing appropriate acoustical treatment on doors, sidelights, etc.;
- Minimizing or eliminating break-in and break-out sound transmission through air ducts passing through the partition.

2.9.2 Low Equipment and Equipment Room Noise

HVAC mechanical noise is a common irritant in the workplace and is usually caused by worn or poorly adjusted equipment or poor sound isolation:

- Noise may be amplified by vibrating sheet metal parts and carried long distances by ducts;
- Equipment rooms are a substantial source of noise in adjacent spaces or in ducts unless designed to appropriate noise reduction standards.

Low noise equipment and isolation of mechanical equipment to achieve a high standard of noise reduction is a valuable comfort asset in the workplace.

Noise generated within the building by occupants, their equipment and plumbing can be controlled by:

- Blocking flanking sound paths through fixed walls and floors and isolating plumbing noise from the structure;
- Evaluating all HVAC systems and equipment rooms for compliance with a NC (Noise Criteria) of 40 or better for all occupied zones.

Window STC

Traffic, airport, rail and industrial noise is also a common irritant in the workplace and is caused by poor sound isolation by envelope elements, particularly windows. It is typically most severe on the first three floors of buildings in dense urban areas or near major transportation or industrial noise sources. Windows designed to reduce sound transmission are readily available and are an effective remedy.

2.10 REFERENCES

1. Air Quality linked to Productivity, *The Construction Specifier*, Construction Specifier Institute, USA, July 1994.
2. *MD 15000 - Environmental Standards for Office Accommodation*, Public Works and Government Services Canada, November 1994, Ottawa.
3. ASHRAE Standard 55-1992, *Thermal Environmental Conditions for Human Occupancy*, American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., Atlanta, GA.
4. ASHRAE Standard 62-1989, American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., Atlanta, GA.
5. CSA Z 204-94, *Guidelines for Managing Air Quality in Office Building*, Occupational Health and Safety, Canadian Standards Association.
6. IESNA, *Recommended Practice, Illuminating Engineering Society of N.A.*, RD-1 (1993), New York, NY.
7. Pasini, I., Office Lighting, Design Standard RPS/DGS1 1-4:951 Real Property Services Branch, Public Works and Government Services Canada, 1994.
8. ECP, Environmental Choice Program, Environment Canada/TerraChoice Environmental Services Inc., Ottawa, Ontario.
9. Leclair, K., and Rousseau, D., *Environmental by Design, Vol. 1: A Source-book of Environmentally Aware Interior Finishes*, Hartley and Marks, Vancouver, 1992.
10. PWGSC, *The Environmentally Responsible Construction & Renovation Handbook,* Public Works and Government Services Canada, Cat. No. En 40-481/1994E.
11. Leclair, K., and Rousseau, D., 1992.
12. PWGSC, *The Environmentally Responsible Construction & Renovation Handbook.*
13. ASHRAE Standard 52-76, "Atmospheric Dust Spot Method", American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., Atlanta, GA.
14. Cole, R.J., Rousseau, D.L., & Theaker, I.G., *Building Environmental Performance Criteria* (BEPAC), The BEPAC Foundation, Vancouver, BC, 1993.
15. IES, *VDT Lighting - IES RP-24, IES Recommended Practice for Lighting Offices Containing Computer Visual Display Terminals* Illuminating Engineering Society of NA, New York, NY.

3. SITE AND LANDSCAPING

3.0 INTRODUCTION

Buildings modify or transform a previously existing natural system. New construction or renovation work should ideally be extended to the surrounding landscape, with the primary goals of:

- Transforming the landscaping to enhance the microclimatic conditions around the building;
- Mitigating the adverse environmental impacts of the building on the site.

These activities must be consistent with the requirements of the *Canadian Environmental Assessment Act* (CEM).

Since the landscaping surrounding buildings is typically highly visible, improvements provide an excellent opportunity to demonstrate a changing emphasis toward environmental responsibility.

Site/landscaping environmental strategies include:

- Use of site resources;
- Restoring site ecology;
- Enhancing site microclimate;
- Re-examining surface parking;
- Using efficient irrigation;
- Controlling storm water;
- Ensuring sound construction practices.

3.1 USING SITE RESOURCES

The transition to sustainability will require increased use of renewable resources.

Each site offers varying degrees of opportunity to use solar heat gain, natural ventilation, daylighting and rainwater advantageously.

Maximizing the use of site resources with involve:

- Examining the complete site for potential access to solar energy and daylight throughout the year;
- Examining the rainfall potential on the complete site;

- Examining the seasonal sun path and prevailing wind directions characteristics of the site and assess potential benefits and problems.

3.2 RESTORING NATURAL ECOLOGY

For those existing buildings where the immediate surrounding natural systems are relatively undisturbed, the goal must be to minimize any potential adverse environmental impacts associated with the building and its operation.

For highly developed sites which are often so transformed and degraded, the opportunities to reconnect a building with natural systems are more difficult, if not, impossible. New landscaping in these cases should be a conscious act of *rehabilitation* by incorporating landscaping strategies into the project that repairs past environmental damage.

The site ecology can be enhanced by:

- Examining the existing water courses and drainage patterns across the site;
- Understanding the natural behaviour of the ecosystem that embraces the site, consistent with the requirements of the Canadian Environmental Assessment Act (CEAA);
- Considering the ecological aspects of the site that are going to be affected and whether the changes are detrimental to their survival, consistent with the requirements of the CEAA;
- Creating critical connections to any adjacent habitats;
- Promoting the establishment of biodiversity;
- Supplementing existing natural vegetation, but avoiding monoculture;
- Clustering plants where space is available to promote large common root systems and protect other plants from wind, sun and reflective heat;
- Considering plant root systems in the design process.

3.3 ENHANCING SITE MICROCLIMATE

The effects of the surrounding landscape can have a profound effect on the solar heat gain, external air temperature and air quality in the vicinity of the building. This landscaping can also improve acoustic conditions.

The choice of ground surfaces and the type and placement of trees and other vegetation provides many opportunities to positively influence the climate stress on the building and the thermal quality of the spaces surrounding buildings. The significance of the immediate surroundings in modifying the microclimatic conditions is greatest in low-rise facilities. [1]

The microclimatic conditions can be modified positively by:

- Planning the new landscape strategy integral to the energy strategy;
- Planning shade walls and paved areas adjacent to the building to reduce solar radiation striking the building during the summer;
- Planting deciduous trees for their summer shading and winter windbreak effects for buildings up to three stories;
- Planting coniferous trees for summer and winter sun shading and windbreak effects;
- Planting shrubs or other vegetation between the building perimeter and sidewalk to reduce heat build up;
- Consolidating or relocating paved areas away from the building perimeter and replace with vegetation to reduce outdoor temperature build up;
- Using ponds and water fountains to reduce ambient outdoor air temperature around buildings, considering their impact of water conservation and maintenance.

3.4 RE-EXAMINING SURFACE PARKING

Significant areas of site landscaping is typically devoted to the parking of motorized vehicles. The current provision of large areas of impervious asphalt limits the amount of water penetrating the subsoil and leads to elevated surface temperatures during the summer.

The use of site landscaping surface parking can be reassessed by:

- Developing alternative transportation strategies and conveniently locating car pooling space;
- Providing options such as covered personnel loading and unloading at building if such options will encourage car pooling or use of mass transit;
- Varying paving materials in parking lots based on traffic use;
- Considering oil grid separators at paved areas.

3.5 USING EFFICIENT IRRIGATION

Considerable amounts of potable water are used to maintain landscaping, particularly in dry regions. Water consumption for landscape maintenance may be reduced by the use of efficient irrigation systems and on site recovery of waste water for irrigation.

There are four basic strategies for water conservation relating to landscape design:

- Use the water that falls on the site more efficiently;
- Design or redesign the landscape and select plant materials so as to reduce the need for water;
- Apply water to planted areas more carefully and precisely;
- Find sources of recycled water to use for irrigation.

3.5.1 Using Site Rainwater

The efficient use of the rainfall on a site is the best way to reduce the need for costlier sources of water. Water that drains off a site without fully wetting the plant material is wasted and must be replaced later.

Rainwater can be used more effective by:

- Using materials for walkways and parking areas which slow down run-off by allowing the water to percolate into the soil;
- Focusing the flow of water by grading the site to direct water towards planted areas rather than off the property and forming saucers can around the base of trees and shrubs to collect and hold water for the plants;
- Storing water on site. On large sites it may be appropriate to use retention basins to store water for use at a later time;
- Handling rainwater in visible, surface channels integrated with the landscaping rather than in buried pipes.

3.5.2 Redesigning the Landscape

A variety of landscape design and management techniques can be utilized to conserve water through creative landscaping. This should result in landscaping with:

- Lower costs and simpler and less expensive irrigation systems;
- Lower maintenance costs because of lower consumption of potable water, lower mowing and lower fertilizing costs.

Water consumption for landscape maintenance may be reduced by:

- Landscaping with tress, hardy shrubs and indigenous plants which may require little or no watering;
- Grouping plants of similar water needs together into hydrozones;
- Increasing the organic content of the soil to improve its water holding capacity;
- Limiting the amount of turf to small areas or using alternative drought resistant native grass types;
- Using mulch material, such as wood chips, to control weeds and reduce evaporation loss;
- Employing water conserving irrigation system, zoned to allow different watering schedules for areas of different water needs;
- Selecting native plants or plants from areas with similar soils and climates which are able to survive on the amount of water that Is naturally available in that region;
- Retaining natural drainage patterns to maintain as much as possible natural contours. Surface drainage rather than subsurface systems.

3.5.3 Applying Water to the Landscape more Precisely

The design and selection of the appropriate irrigation system can reduce water consumption significantly.

Sprinklers are relatively inefficient since a certain percentage of the water is lost to evaporation and run-off. Sprinklers are particularly inefficient during the daytime, when the sun and warm temperatures increase evaporation - on a hot day up to one third of the water can evaporate before it hits the ground. Moreover, sprinkling during hot sun can damage leaf surfaces.

Instead of unselectively flooding an area with water, drip 5 irrigation delivers water directly to the plant. In addition to conserving water, the better control over moisture also promotes better plant growth.

Water consumption for landscape maintenance may be reduced by:

- Using drip irrigation strategies.

3.5.4 Using New Sources for Irrigation

The waste-water generated in a building from both lavatory and kitchen sinks, showers, clothes washers and cooling systems can be reused by means of a dual piping system for irrigating the building's landscape. This reusable waste-water is defined as *grey-water* and contains primarily soap related wastes which must be filtered out through a cleaning process before reuse.

3.6 CONTROLLING STORM WATER

Storm water from large paved sites and roof areas has serious impacts on local ecosystems. Oil and grease, heavy metals, especially copper, lead, and zinc are by far the most prevalent pollutants found in urban run-off. Moreover, storm water management requires storm sewers which are sized for peak periods. Oil accumulation, erosion of natural watercourses receiving peak storm water and flooding of treatment facilities are three of the most common problems.

Storm water from large paved sites and roof areas can be controlled by:

- Design the landscape to retain and filter storm water on-site to protect ecosystems;
- Using large semi-porous areas capable of absorbing water and releasing it slowly, roof ponds or holding tanks specifically designed to reduce peak storm water flow;
- Preserving natural slopes and direction of existing water flows;
- Constructing retention ponds for on-site storm water management, i.e., using large semipermeable areas capable of absorbing and releasing water slowly, or roof ponds or holding tanks;
- Engineering land forms to improve sites ability to catch, hold and absorb water;
- Where feasible, sing roof spaces and terraces for vegetation;
- Minimizing the amount of impervious surfaces and preserving natural areas to retain and filter storm water.

3.7 ENSURING SOUND CONSTRUCTION PRACTICES

The construction process is disruptive of natural systems. Although these effect cannot be avoided they can be reduced through careful practices.

Environmental impacts during construction practices can be reduced by:

- Limiting topsoil removal and stockpiling existing topsoil on-site for reuse;
- Exposing the smallest practical area of soil at any one time during development;
- Requiring a waste management plan from the contractor (See Section 7: Waste Reduction);
- Establishing staging areas and travel routes for construction vehicles;
- Protecting areas and vegetation adjacent to development from construction activity and debris;
- Providing and enforcing parking in specified areas for construction worker's personal vehicles;
- Scheduling the installation of features capable of carrying storm run-off prior to removing any existing vegetative cover.

3.8 REFERENCES

1. *Guiding Principles of Sustainable Design*, US Department of the Interior, National Park Service, Denver Service Centre, September 1993.
2. Robinette, G.O., *Energy Efficient Site Design*, 1983.
3. Townshend, A.R., *Advancing the Light Grey Option*, Research Division, CMHC, April 1993.
4. Shrubsole, D., and Tate, D., ed. *Every Drop Counts* Canadian Water Resources Association, 1994.

4. ENERGY USE

4.0 INTRODUCTION

Energy use is at the centre of the environmental debate and reducing the amount of non-renewable energy needed to operate buildings will remain a key performance issue.

It is estimated that the average yearly cost for energy in Crown-owned facilities is approximately $20/m^2. Although this down 25% from figures available in 1979, energy costs still represent approximately 30% of the O&M total budget in office buildings. PWGSC will pursue further reductions vigorously and cost effectively with due consideration for the quality of the work environment, as pledged in its *Sustainable Development Strategy*.

Global Warming
Although price increases and security of supply of a dwindling resource will continue to remain important concerns, the environmental implications of continued fossil fuel use will guide future policy. The current dependence on fossil fuels and nuclear power, and the attendant production of 'greenhouse gases' and other pollutants imposes a critical pressure on natural systems and human health.

Over the millennia the earth's climatic patterns have changed considerably as a result of natural events. Current increases in global warming and attendant climate change derive largely from the greenhouse effect associated with human activities. The principal atmospheric gases which exacerbate the greenhouse effect are carbon dioxide, water vapour, methane, nitrous oxide and ozone. In 1987, human activities released an estimated 8500 million tonnes of carbon in the form of CO_2 primarily from the burning of fossil fuels; 255 million tonnes of methane and 0.772 million tonnes of CFC's.

Emissions of greenhouse gases need to be reduced by 60-80 percent immediately to stabilize their concentrations at current levels and methane would need a 15-20 percent reduction. [1] Canada, along with 150 nations signed the *Climate Change Convention* in 1992 requiring that developed countries continue to report on actions with the aim of returning their emissions of CO_2 gases to 1990 levels by the end of

2000. This requirement has been incorporated into the departmental *Sustainable Development Strategy*.

Local Air Quality
Many air pollutants such as Oxides of Nitrogen (NOx), Oxides of Sulphur (SOx) and Un-burned Hydrocarbons (Methane, etc.,) emitted during the production of building materials and the burning of fossil fuels also have adverse local and regional environmental impacts: urban smog and acid rain. These create health risk to humans, other species, terrestrial vegetation, and marine life.

The efficient and appropriate use of energy has a substantial impact on the environment in terms of conserving fossil fuels, reducing pollutant air emissions and minimizing consumption and waste. The construction and operation of buildings are significant contributors to the emission of greenhouse gases. It has been estimated that fifty percent of atmospheric carbon dioxide, the main contributor to global warming, comes from buildings and related industries. [2]

Sustainability will require:

- A drastic reduction in the amount of energy required to meet user needs through a significant improvement in the energy efficiency of buildings, their systems and their operation;
- Since our transition to sustainability will parallel our adoption of renewable energy sources, buildings must also be provided with or capable of being modified to accommodate solar and other renewable energy collecting systems;
- A comprehensive view of energy use with the aim of matching the quality of energy to the end-use, and how waste heat from one process can be usefully employed in another.

4.0.1 Life-Cycle Energy Use

Life-cycle building energy use includes the energy required to:

- Produce and transport building materials, components and assemblies and to construct buildings;
- Heat, cool, light and ventilate, run equipment and to maintain and repair buildings;
- Disassembly and demolition at the end of the building or assembly's useful life.

Energy accounting over the past fifteen years has focused almost exclusively on operational energy use in buildings and the development of strategies to reduce it. The energy to produce buildings - their embodied energy - is an emerging environmental concern.

A comprehensive energy and cost analysis includes:

- Evaluating alternative energy strategies and material choices with respect to life-cycle energy use, i.e., operating plus embodied energy use;
- Examining techniques which reduce the recurring embodied energy associated with maintenance, repair and refurbishment over the life of building.

4.1 REDUCING LIGHTING ENERGY

Lighting in office buildings can represent one of the largest component of energy use. Lighting represents one of the most direct means of achieving energy reductions and improved occupant satisfaction.

Daylight
All existing office buildings have windows and offer some potential for daylighting. However, direct sunlight in the workplace and attendant excessive solar heat gain are undesirable.

De-lamping
De-lamping, under-lighting and similar strategies reduce operating energy and can be effective ways of reducing the existing lighting energy use but, if done insensitively, often can sacrifice productivity and user satisfaction. Lighting quality must also be a prominent goal in energy efficient lighting design.

Lighting Levels
Office lighting standards are specified by the PWGSC *Office Lighting.* [3]

Older standards of 700-1000 Lux exceed those in current lighting guidelines. The most appropriate approaches provide 300 to 500 Lux of ambient light, supplemented with user controlled task lighting.

Lighting Energy
ASHRAE/IES 90.1 [4] specifies maximum lighting densities of 1.8 W/ft^2 (19.4 W/m^2) for office uses. A good lighting design should achieve quality lighting of office interiors with lighting densities between 0.9 and 1.3 W/ft^2 (9.5 - 14 W/m^2).

Task/Ambient Lighting
Many lighting strategies in existing buildings would have been premised on the general lighting of the entire office floor. Task-ambient lighting permits a lower overall general lighting and attendant energy reductions.

4.2 ELECTING LIGHTING EQUIPMENT

Lamps
Compact fluorescent and full size fluorescent lamps with small diameters (T-5, T-8 and T-10) and triphosphor coatings offer the best of energy efficiency and colour rendering.

Ballasts
In addition to greater longevity and the elimination of flicker, electronic ballasts offer:

- Considerable operational energy savings;
- Ability to dim fluorescent lamps at lower costs than standard ballasts.

The replacing of older fluorescent light ballasts and other electric equipment may require handling Polychlorinated Biphenyls (PCBs), a hazardous material.

Luminaires
Luminaires and lighting systems employing advanced optical systems and efficient reflector materials, such as polished reflectors and parabolics offer significant energy gains.

Using a good quality flat prismatic lens with a sharp cut-off (such as holophane fish eye lens) is much cheaper and more efficient than using deep cell parabolics.

> *Improved lighting energy efficiency can be achieved by:*
>
> - Specifying smaller T-5, T-8 or T-10 lamps with triphosphor coating;
> - Specifying high frequency ballasts;
> - Specifying low Total Harmonic Distortion ballasts, i.e., 17.5% or less since harmonics can cause interference with electronic equipment, current/voltage surges, overloading of transformers etc.

4.2.1 Lighting Control

Energy benefits from daylight will only accrue if the electric lighting is reduced at those times when daylighting is making a useful contribution to the interior illuminance. This can be done through zone switching or dimming operated by photosensitive controls.

The quality of lighting control can be improved by:

- Providing a mixed approach to lighting control which combines local, manual switching to meet the needs of the users and automatic 'fail-safe' features such as occupancy sensors, etc., to reduce wasted lighting energy;
- Providing manual switching to users in all rooms;
- Providing separate switching in all days lit zones;
- Using a controlled stepped lighting strategy, e.g., using three tube luminaries wired for two switches allows four lighting settings: off, one tube, two tubes or three tubes;
- Using photocell controlled dimming ballasts to adjust output of fixtures in response to daylight;
- Scheduling each area on its own, with override, (often by pressing a number on the phone which signals the computer to switch lights) can reduce demand on the lighting system;
- Specifying time switches and other systems for turning off lights on a particular floor or the entire building.

4.3 SELECTING HVAC CONTROLS

Energy Management Strategies
Introducing more energy efficient technologies and components which depend on regular management involvement and maintenance often leads to an increase in energy use rather than a reduction. This is usually due to failure of occupants and operations management to fully comprehend their operation and sustain their maintenance.

Energy management control systems which are simple to operate, combined with operator training and periodic system evaluation are useful approaches. Such an approach will overcome the problem of increased energy use and, when applied, can demonstrate the savings that will justify the additional investment.

Energy management strategies are best when they:

- Are capable of being operated and maintained simply, efficiently and effectively;

- Have a greater number of HVAC zones with more flexible systems and capable of being reorganized to cover small areas;
- Provide for setback of temperature during unoccupied hours;
- Are designed for optimal heat-up and cool-down strategies prior to building occupancy;
- Accompanied by individual meters or sub-meters within the building;
- Provide continual feedback to users and management on building energy use.

4.4 SELECTING PRIMARY HVAC EQUIPMENT

Primary systems such as boilers, chillers, cooling towers, etc., convert primary energy sources such as fossil fuels and electricity to thermal transport media such as steam, hot water, and chilled water.

The conversion efficiency of the equipment relative to the thermodynamic loads imposed is a critical issue in plant selection.

Sizing Primary Systems
Although primary systems must have the capacity to meet worst-case or “design” conditions, in most circumstances they are actually operating at output levels well below design capacity and outside their most efficient range. Proper equipment sizing can have much greater performance impact than any intrinsic differences between technologies.

System Flexibility
Offices built in the 1950s and 1960s, with their massive central services designed to operate between 9-5 do not lend themselves to after hours operation on a reduced scale. Energy efficiency and greater operational flexibility will require more flexible HVAC systems with more zoning, capable of being reorganized to cover small areas. [5]

System Reliability
Equipment durability and cost can become crucial questions. A system intended for 8-12 hour use may not be good enough for 24 hour use. Round the clock space must be more reliable than conventional space since the number of hours where the building can be closed for maintenance will be less.

*When designing the **primary equipment**, energy and operational performance can be improved by:*

- Examining the potential for using ground source/geothermal, solar and other renewable sources of primary energy prior to looking at conventional sources, and evaluating them on a life-cycle basis;

- Carefully considering the conversion efficiency of the equipment relative to the thermodynamic loads and timing imposed;

- Considering "part-load" efficiencies in plant selection since this level of "turndown" severely hampers the efficiency of many types of primary equipment (as well as adding to initial capital costs);

- Making provision for staged or variable output primary equipment which operates at peak efficiency through the bulk of the heating/cooling season, as well as separate supplementary equipment that operates efficiency only at peak design conditions;

- Where building use requires simultaneous heating and cooling of different thermal zones, using secondary mechanical systems such as area heat pumps to transfer thermal energy to meet these needs and minimize additional purchased energy;

- Reclaiming "waste" heat from building exhaust or condensate fluids to reduce overall energy use;

- Employing air and water-side cooling economizers whenever appropriate;

- Providing durable and reliable equipment in those spaces anticipated for round the clock use;

- Providing easy access to equipment by engineers and contractors.

4.5 SELECTING SECONDARY HVAC EQUIPMENT

The HVAC secondary systems are the "distribution" portion of the HVAC system, and typically includes fans, pumps, ductwork, heating and cooling coils/devices, and associated control systems. Eliminating reheating and re-cooling of distribution fluids as a control strategy in response to the diverse loads occurring throughout a building is central to improving the energy performance of HVAC systems.

Minimizing Fan and Pump Energy
Minimizing volumes and parasitic losses such as static pressure loss to reduce fan and pump energy, and utilizing water instead of air whenever possible are emerging design philosophies. (Water is a much more

efficient energy transport medium than air due to its higher specific heat and better overall controllability.)

Compartmentalization
Secondary system design should address thermal loads, ventilation requirements, and energy transport management on a zone specific basis to minimise parasitic losses and reheating/re-cooling. Decentralization, rather than centralization, is emerging as the prevailing approach to secondary system design.

Secondary System Sizing
Similar to primary systems, appropriate sizing of all secondary systems to the unique characteristics of the project at hand is essential for optimal performance and efficiency.

When designing the ***secondary equipment****, energy and operational performance can be improved by:*

- Designing a decentralized, rather than centralized approach to secondary system design;
- Sizing the systems appropriate to the unique characteristics of the area and load;
- Eliminating reheating and re-cooling of distribution fluids as a control strategy in response to the diverse loads occurring throughout a building;
- Minimizing volumes and parasitic losses such as static pressure loss to reduce fan and pump energy, and utilizing water instead of air whenever possible;
- Employing state-of-the-art and emerging strategies to reduce fan and pump energy;
- Using variable speed fan and pump controls to match system load while minimizing energy consumption.

Energy efficiencies and air quality may be gained by:

- Designing an outdoor air economizer cycle to allow the use of outdoor air for building cooling when outdoor weather conditions permit by increasing the proportion of outdoor air mixed with return system air, up to 100%.

When replacing electric motors, energy efficiency can be improved by:

- Specifying that all newly installed electric motors have efficiencies which meet or exceed those specified in *clause 5.4.3* of *ASHRAE/IES Standard 90.1-1989, "Electrical Motors".*

4.5.1 Service Hot Water

Though the supply of hot water is not usually a major component of office building energy use, savings are possible. Low flow fixtures, pipe insulation and recirculating systems are important strategies.

When replacing equipment, energy improvements can be gained by:

- Using conservation devices such as flow limiters, timed valves etc., on hot water supply;
- Specifying that all newly installed domestic hot water equipment, piping insulation, controls and fixtures meets or exceeds the appropriate sections of *ASHRAE/IES 90.1-1989* Standard;
- Placing water heaters as close as possible to point of use;
- Specifying that all fixtures using hot water which require more than 25 m of pipe length to connect them to a hot water source be fitted with point-of-use heaters;
- Specifying recirculating systems insulated throughout their entire length;
- Examining solar hot water heating systems a life-cycle basis for their feasibility.

4.6 COMMISSIONING GUIDELINES

A substantial number of air quality problems in buildings result from inadequate attention paid to ensuring that all equipment is functioning properly before the occupants move in.

Full building commissioning of electrical, mechanical and other building systems and equipment is an important requirement for each new facility or major renovation.

System performance can be confirmed by:

- Provision of commissioning services according to *ASHRAE Guideline 1-1989: Commissioning of HVAC Systems.*

4.7 USING THERMAL MASS

Thermal mass offers the threefold advantages of:

- Moderating the temperature of occupied spaces during conditioned periods and thereby minimizing or eliminating the need for mechanical cooling;
- Allowing *free pre-cooling* through night-time flushing in some seasons and climates;

- Absorbing useful winter solar gain and thereby offset winter heating requirements.

Mechanical cooling systems can be reduced or eliminated by:

- Reducing solar heat gain into the building through the use of improved solar control devices;
- Using inherent building mass to provide a cooling sink and combine with night-time flushing;
- Providing operable windows to provide effective cross-ventilation of occupied areas;
- Designing sensors linked to the HVAC system so that the terminal serving the zone will adjust accordingly when windows are opened during the heating or cooling season.

4.8 UPGRADING WINDOWS

Windows are a key element affecting building energy performance. They significantly influence heat loss, solar heat gain, daylight and visual access to the exterior.

If the windows are to remain, then issues of repair and maintenance for edge leakage, the possibility of changing the solar transmission by the addition of reflective films or the addition of external solar control devices are the most likely options for improvement.

If windows are to be replaced, then the choice of the replacement glazing and frames will be governed by the following considerations:

Heat Loss
The overall U-Value of a window depends on the area weighted effects of the centre of glass component, the edge of glass component that accounts for the higher heat flow rate through the spacer, and the type of frame.

Solar Heat Gain
Window design and its attendant solar control strategy should maximize useful winter solar heat gain and minimise excess solar gain at other times.

Operable Windows
Operable windows provide the opportunity for natural ventilation when outside conditions permit. To minimise conflict with energy efficiency, sensors can be linked to the HVAC system so that the terminal serving the zone will adjust accordingly when the window is opened during the heating or cooling season.

Admission of Daylight
If integrated with the electric lighting strategy, natural lighting can reduce the building's operating energy costs.

Improved performance can be achieved by:

- Specifying high performance glazings, the thermal resistance of which are based on a comprehensive exploration of building energy use;
- Evaluating the overall U-Value of the window system, not just the glazing;
- Specifying window frames which enhance the overall thermal resistance of the glazing system and provide minimal infiltration and leakage;
- Controlling excess solar gain by the combination of effective external devices and occupant controlled internal blinds to control sky glare;
- Matching high performance glazings to the various orientations of the building and carefully assess the solar transmission characteristics of the glazings used on south-facing windows;
- Carefully considering the use of tinted or reflective glasses to reduce excess solar heat gain since these also reduce daylight and obscure visual access to the exterior.

4.9 UPGRADING WALLS AND ROOFS

Again, if the walls are to remain, then strategies centre on repairing seals and possibly overcladding. [6] If major replacement is planned, then the following issues assume importance:

Thermal Resistance
Thermal resistances for walls and roof assemblies of complex buildings should be designed to the most effective performance standards as determined within an overall analysis of building energy use. Due to the complexity of energy use in large office buildings, a simulation may be required to arrive at the best choice.

Thermal Bridging
Thermal bridges should be minimized or avoided by the use of non-conductive fasteners or the addition of thermal breaks such as insulating cladding.

Air Barrier
The total air barrier assembly should be designed to be continuous throughout the building envelope, structurally supported to resist wind load or pressurization without displacement and have a service

life as long as the life of the building or, at a minimum, be located such that it may be serviced as necessary.

Weather Barrier
Engineered weather barrier systems such as curtain walls and rain screens should be incorporated where building form and site warrant, e.g., all buildings higher than four stories and on low buildings with little shelter bomb wind exposure.

4.10 REFERENCES

1. Houghton, J.T., Jenkins, G.J., Ephraums, J.J., (Editors) *Scientific report on the intergovernmental panel on climate change.* Cambridge Univ. Press, 1990.
2. RIBA, *Initial RIBA Policy Statement on Global Warming and Ozone Depletion*, Royal Institute of British Architects, May 1990.
3. Pasini, I., *Office Lighting*, Design Standard RPSB/DGSI 1-4:95-1, Real Property Services, Public Works and Government Services Canada, Ottawa.
4. Stillman, D., Offices Open All Hours, *The Architects Journal*, Vol. 196, No. 21, 25th November 1992, pp. 47-48.
5. *ASHRAE/IES 90.1.*
6. Brook, M.S., Renovating Curtain Wall, *Canadian Architect*, May 1995, pp. 36-38.

5. MATERIALS USE

5.0 INTRODUCTION

The construction, renovation, maintenance and operation of buildings accounts for very large quantities of materials which are extracted from nature, processed, used and ultimately discarded.

The extraction, transformation, use and disposal of materials all have environmental costs, such as habitat destruction, resource depletion, energy use, air pollution, water pollution and solid waste problems.

In meeting the dictates of sustainability:

- Resources must be used more efficiently and effectively in meeting human needs. Simply stated, we must use significantly less materials per capita;
- Buildings must last longer and their constituent materials and components must remain in the material cycle, i.e., there must be increased durability, reuse and recycling;
- Renewable raw materials must be extracted from nature at rates that can be sustained and non-renewable materials must be extracted with the least disruption to the ecosystem;
- The concept of waste must be eliminated. The building industry must begin to use its own 'waste' to produce 'resources' for future building through increased reuse and recycling, i.e., buildings must be designed and renovated to minimize the use of new resources, and at the end of their useful life to form the resources for other buildings or applications;
- Waste material that is ultimately returned to nature must be radically reduced, and waste should, at the very least, be environmentally benign.

5.1 REDUCTION

Of the three-R's, *Reduction* is the primary method of conservation. If the scale of demand for material goods and energy is not managed, then *Reuse* and *Recycling* is hardly relevant. Moreover, while these latter strategies are still important, can only extend the usefulness of resources and, particularly in the case of recycling, still involve processes with potential environmental impacts.

5.1.1 Planning for the Efficient Use of Space

The potential of an existing building for efficient space use is dictated by its floor plate, floor-to-floor height and structural grid. For new designs or renovations, careful concept development and space planning will pay off in a better match between the building structure and the interior plan.

Interior spaces can be more intensively used by:

- Reviewing all space allocations programming with the view to achieving more with less;
- Carefully designing to optimize the size and configuration of interior spaces;
- Consideration of multi-functional spaces and space-sharing;
- Using or eliminating non-inhabited spaces;
- Open planning of interiors, eliminating inefficient circulation areas, using perceptual volume cues, grouping like functions together;
- Carefully integrating services to reduce building volume, e.g., full service space depth is only required in certain areas not over complete building area.

5.1.2 Eliminating Finishing Materials

A great deal of the interior finishes within buildings are to cover or hide potentially unsightly service spaces or inferior surfaces.

The deliberate exclusion of traditional interior finishing materials or limiting their application to specific areas within an interior where they would be most effective, represents a highly visible way of reducing materials use. Exposed services and self-finishing systems are examples of this approach.

The amount of material can be reduced by:

- Either reducing in amount or eliminating completely typical finishing materials such as wall and floor coverings by restricting their application to specific critical applications.

5.1.3 Longevity

Longevity is central to environmentally responsible building design. Longevity can relate to a building as a whole by adaptive reuse rather than building new, or to its components through increased recycling and use of salvaged materials. The common aim of each is to keep materials within the materials cycle as long as possible without the need for further processing.

Consideration of longevity points to the importance of distinguishing between:

- Strategies which result in immediate environmental benefits such as reusing existing buildings and materials, materials reduction, using materials with increased recycled content, low embodied energy etc.;
- Strategies which result in benefits which are deferred to the future, such as designing for materials recovery, reuse, providing 'reserve' (e.g., additional floor to ceiling height) into buildings for greater adaptability to other uses etc.

A building can be made to last longer by:

- Making building longevity an explicit issue in the overall approach to building design;
- Designing spaces which are not overly specialized for one use since they will have greater potential for flexibility in the future;
- Considering how the building might be adapted for alternative future uses.

5.2 RETAINING AND REUSING MATERIALS

When renovating, a detailed inventory of existing materials can identify which materials and components are viable for reuse or which can be made available for other projects.

5.2.1 Retaining Quality Materials

Some materials commonly found in older buildings should be retained because they may be superior to the contemporary materials that have replaced them. While some new materials offer better performance capabilities or life expectancies that may justify the higher energy costs of production, others have been adopted for purely economic reasons. Some synthetic materials do not weather well, are damaged by ultraviolet light, and pose disposal problems because they are not biodegradable.

In some cases the quality of natural materials have declined over the years. Wood, for example, found in older buildings is generally superior to the lumber that is commonly available today. [1]

5.2.2 Using Salvaged Materials

Building design and operation is currently premised on a single throughput of resources, i.e., materials are used once only and wastes from construction or building operation are typically sent directly to the landfill.

When buildings are renovated or demolished there are often substantial quantities of materials which are salvageable if the time and effort is committed, e.g., millwork, doors, architectural metals, bricks. Lighting and mechanical components may also be salvaged if they are new enough. The salvage of materials and their reuse in other applications reduces demolition waste and avoids the environmental impact of producing new materials.

The reuse of intact, salvaged materials, components or systems in new applications has been limited mostly to the residential market, but is beginning to appear in commercial buildings. Increased reuse of building materials, components and systems will have a profound effect on the way buildings are designed to promote the life of these elements and to facilitate their easy recovery.

Using salvaged materials will require a much more comprehensive view of materials use:

- Materials that cannot be used in the renovation will be removed in such a way that they can be incorporated into other buildings;
- Components that can be reused in their present form, such as lumber, doors, mouldings, and fixtures will have to be carefully removed in order to avoid damage;
- It will require engaging contractors who are willing to undertake such work and allocate the time necessary. It also adds time and money to any project;
- It will require more extensive sourcing of possible components from salvage operations;
- A shift in the perception that 'new' is better;
- Development of an economic infrastructure to support reuse.

5.2.3 Designing for Materials Recovery

Salvaging of materials is currently difficult because:

- Buildings are not designed to facilitate the easy recovery of materials at the end of their effective life;

- Salvaged materials do not enjoy a widespread demand and the mechanisms for sorting, storing, validating, marketing, distributing do not widely exist.

Designing to facilitate the recovery of materials or components for reuse or for more effective recycling relies on the ability to separate material.

Designing with the view to effective resource recovery after the useful life of the building will involve:

- Separating the structural and space enclosure elements and generally long life components from those with short life spans to facilitate change in the future;
- Detailing so that long life components will not be damaged when shorter life span elements are being replaced;
- Keeping components and elements distinct to facilitate removal without damage to themselves or other parts of the building;
- Reducing the mixture of material types used and using 'separable' materials, i.e., making a clear distinction between the building shell, systems and interior finishes and their connection and accessibility;
- Considering greater modularity in building proportions and assemblies;
- Designing and detailing building components and assemblies for ease of disassembly; e.g., where possible, use mechanical fastening rather than adhesives;
- Specify single material components or easily disassembled multi-material components;
- Carefully removing materials that cannot be used in the renovation in such a way that they can be incorporated into other buildings.

5.3 SELECTING LOW ENVIRONMENTAL IMPACT MATERIALS

Much of the current emphasis in environmentally responsible design centres on specifying 'environmental' materials. [2, 3] When renovating, all new materials should ideally have lower environmental impacts over their life-span than those they are replacing. Producing construction and finish materials requires large inputs of raw resources and energy, and incurs emissions of air and water pollutants and solid waste. Although there has been a significant increase in the quality of information to support such comparisons, it is extremely difficult to compare the environmental impacts of different products since there are currently only a few common scales of comparison.

Life cycle assessment of building materials has emerged as the most effective basis by which to compare pare materials and products, and provides information over four stages:

1. Raw materials acquisition;
2. Manufacturing - materials manufacturing, product fabrication, packaging and distribution;
3. Use, reuse and maintenance;
4. Recycling and waste management.

The manufacturers of some building materials are beginning to define and make explicit the environmental strengths of their respective products. However,

- Complete and consistent life-cycle assessment environmental information is not currently available to discern clear choices;
- Many of the manufacturers of "environmental" building materials and systems are new in business and do not have extensive performance or market histories to rely on;
- The selection of new, relatively untested environmental options, as with all new technologies, requires a delicate balance of caution and risk-taking.

In the short term, it is most appropriate to identify materials with lower "environmental cost" using a screening process which includes some of the more established environmental criteria such as:

Recycled Content
True recycled content is the percentage of post-consumer (i.e., returned and recycled after having been used by consumers) used in manufacturing as distinct from the degree of internal recycling within the industry itself.

The production and use of materials draws on limited reserves of raw feed stocks, some of which are renew able and some which are not. Some of these raw materials may come from recycled sources, thereby reducing; the impact of the industry on reserves, and often on energy use.

Recycled content is one of the most easily identified factors which indicates a material with lower environmental impact.

Recyclable Materials
A recyclable material is one which can be returned to a manufacturer and reconstituted into and new product.

Some materials are currently recyclable and other will be in the future through industry advancements and incentives. Consideration should be given to the ability of materials and components to be recovered and recycled, particularly those that may be replaced relatively frequently over the building's life, e.g., reviewing "Takeback" programs on products such as carpet.

Reusable Materials
A reusable material or product is one which can be directly reapplied for essentially the same purpose in its original form.

Reusable materials are clearly durable ones which can hold their value over time. Mover, equal attention must be given to being able to recover these materials and components intact during renovation or demolition so they can be reused either in the same or another project.

Low Embodied Energy Materials
Embodied energy is the amount of energy used to manufacture and install a material or component and is a useful, but not complete indicator, of environmental impact.

Although comprehensive, current embodied energy information is not available for all building materials and components, relative differences can be judged with reasonable confidence. Judgments and comparisons of embodied energy are only relevant between materials, components and assemblies offering the same performance.

Locally Produced Material
Where possible, the specification of locally available building materials is viewed as an environmentally sound strategy since it both involves reduced transportation and packaging and supports a regionally based economy.

Durable Materials
Buildings are maintained and repaired over their lifetime. Since these recurring environmental costs can often outweigh the initial environmental cost of producing and installing the materials and components, the selection of durable materials and components is a key strategy in reducing life-cycle environmental impacts.

The frequency and extent of maintenance and repair is not solely a function of the materials characteristics, but influenced by the way the material in incorporated into a design. Designing for durability also involves considering how to detail and protect materials and components from premature deterioration and prolong their life span.

Manufacturer's warranties can be use to provide a marginal measure of a product durability.

Selecting environmentally sound materials involves:

- Reviewing and evaluating the recycled content of current and emerging materials;
- Specifying materials meeting *Ecologo* standards for recycled content and recyclability;
- Specifying materials and components which can be readily recovered, reused as close to their existing form as possible or which can be easily recycled;
- Selecting materials and components which offer the lowest embodied energy;
- Considering the use of local materials to reduce transportation energy impacts;
- Selecting materials which have a longer service life before replacement;
- Selecting materials that have low maintenance and cleaning requirements.

5.3.1 Wood Products

Tropical Woods
The preservation of tropical hardwoods is critical for the survival of the most varied ecosystems on earth.

The two main efforts to shift wood purchases towards more appropriate choices are wood labelling programs for more sustainably harvested traditional woods and the marketing of species which have been less utilized or wasted in the past.

Domestic Woods
The demand for oak and maple is very large and the supplies of quality wood are shrinking. Moreover, other species such as walnut and cherry are now scarce, making it increasingly important to both limit the use of these materials and seek alternatives.

The environmental impacts associated with wood finishes and millwork can be minimized by:

- Avoiding products listed on the *Convention on International Trade in Endangered Species* (CITES);
- Specifying tropical woods which: are labelled by a recognized authority;
- Considering alternative wood products which incur less environmental impact in their production;
- Selecting laminates on cores of engineered wood, domestic softwood or wood which is less utilized and evaluating other potential environmental concerns associated with their production.

5.4 REFERENCES

1. Kellogg, R.M., and Keith, C.T., "Regional Wood Quality Interests and Coordination - Is There the Interest and Support". Wood Quality Considerations in Tree Improvement Programs. Ottawa: Forintek Canada Corp., 1986, p. 51.
2. Stein, R., *Architecture and Energy*. Garden City, New York: Anchor Press/Doubleday, 1977, p. 101.
3. Leclair, K., and Rousseau, D., Environmental by Design, Vol. 1: A Sourcebook of Environmentally Aware Interior Finishes, Hartley and Marks, Vancouver 1992.
4. PWGSC, *The Environmentally Responsible Construction & Renovation Handbook*, Cat No. En 40-481/1994, Ottawa, 1995.
5. Cole, R.J., Rousseau, D.L., and Theaker, I.G., Building Environmental Performance Assessment Criteria (BEPAC), The BEPAC Foundation, Vancouver, BC., 1993.
6. Dickey, E., and Wellner, P., *The Wood Users Guide*, The RainForest Action Network, San Francisco, 1991.
7. US EPA, 1995, *Comprehensive Guideline for Procurement of Products Containing Recovered Materials*, US Environmental Protection Agency (full text available on: http://www.epa.gov).
8. Penher, R., Building Material Recycling/Re-Use Centre Survey Report, Earthworks Environmental, Winnipeg, 1994.

6. BUILDING WATER USE

6.0 INTRODUCTION

Canada has 20% of the world's freshwater. On average, Canadians use 390 litres a day each - the second highest water use per capita of all developed countries.

Reductions in water use are environmentally desirable in that they decrease the load on both water supply and waste treatment facilities, leading to lower requirements for energy and treatment and to improve the quality of sewage effluents. The opportunities for direct financial savings are extremely variable. Considering PWGSC's situation, total expenditure on water in the National Capital Area was over $12 million in 1995-96. When combined with other federal facilities across the country, this figure would approach $100 million annually. The implementation of water efficiency measures could reduce water consumption by up to 50%. [1]

Water demand in Canada will continue to increase as the population rises over the next decade and will place severe stress on existing infrastructures for the collection, treatment and distribution of water to urban centres. Moreover, although the cost of water is currently relatively inexpensive, the cost of maintaining the existing infrastructure and providing additional supply to meet increasing demand will manifest itself in increased price of water supply to all users.

In meeting the dictates of sustainability:

- The amount of potable water used to support building-related activities should be reduced through the deployment of water efficient appliances;
- Separating and retaining of grey-water should be considered for appropriate applications.

The key strategies for building water conservation are:

- Using less potable water to accomplish sanitary tasks through the use of more efficient appliances;
- Communicating water use to occupants;
- Using water of lower quality such as reclaimed waste water effluent, grey water, or run-off from ground surfaces for toilet flushing or irrigation.

6.1 SPECIFYING WATER EFFICIENT APPLIANCES

Reducing the amount of potable water through the use of more efficient appliances.

The following devices have been identified to be water saving:

Low Flush Toilets
Flush valve toilets and automatic flush urinals are the single largest users of water in many buildings. In offices, toilets may account for 50% of total use. This can be easily reduced by 60% by specifying water conserving flush toilets which are now widely manufactured or adjusting flush valves for minimum acceptable volume.

Toilets and other low flow appliances will reduce water demand without requiring that the user change the pattern of use.

Current CSA standards have fixed the water consumption of toilets at 13.5 L/flush, but market demands have seen an emergence and use of 6 litre water carriage models.

Lavatory Faucets
Full flow lavatory faucets typically deliver 0.25 to 0.3 L/s. Low-flow faucets utilize aeration to function as well or better with far less water. Lower flows achieve a range from 0.03 to 0.16 L/s.

Other features to lower the usage volume are the foot operated faucet and the electronic sensor faucet, both of which disconnect the water flow more reliably than if left to the user.

Hot Water Conservation
Hot water supply is another important cause of water and energy waste in buildings. Where lavatory fixtures are located remote from the hot water source more water is often wasted to bring hot water over the distance than is actually used for washing.

Building water use can be reduced by:

- Reducing the amount of potable water used to support building-related activities through the deployment of water efficient appliances;
- Specifying water conserving flush toilets with a maximum 6 Litres/flush, which meet appropriate CSA Standards;
- Specifying spring loaded lavatory fixtures having a maximum flow rate of 0.14 Litres/second;

- Specifying urinals having a maximum flow rate of 0.06 Litres/second and fitted with manual spring loaded, flush valves or automatic, motion sensor valves;
- Considering the use of electronic proximity devices for controlling lavatory fixtures;
- Shower fixtures should be rated for a maximum flow rate of 0.16 Litres/second;
- Considering the collection, retention and use of rainwater for appropriate applications rather than diverting it to the nearest storm drain.

6.2 WATER CONSERVATION MANAGEMENT

It will become increasingly important to communicate the reasons and benefits underlying water conservation strategies to building users.

Building design can assist in informing users of their actual water savings as well as their responsibility by:

- Providing appropriate signage in rest-room to indicate the high priority placed on water conservation;
- Providing water metering in buildings to determine how much water is being consumed.

6.3 CONSIDERING WATER REUSE

Grey-water, in combination with rainwater, can be stored, filtered and integrated into the water supply to toilets, with or without the possibility of waste heat recovery. (See *Section 3: Site and Landscape*)

Building type, size and the number of its occupants plays a large role in determining the quantity of potable water used, waste-water generated and the feasibility of waste water reuse. The amount of grey-water generated in a building is typically directly proportional to the economic feasibility of its reuse when it is treated on site.

6.4 REFERENCES

1. *Water Management Strategy for Property and Facilities Management*, DRAFT, PWGSC, RPS, March 1996, p. 4.

7. WASTE REDUCTION

7.0 INTRODUCTION

"Solid waste" denotes waste generated from all sources that is land-filled or disposed in some other way, but not reused, recycled, or converted. Sustainability will require the elimination of the concept of waste through increased reuse and recycling.

It is estimated that Canadians produce more than 30 million tonnes of garbage annually, more than 1 tonne per capita. This gives Canada the misfortune of being the world's largest generator per capita of waste. Of this waste, approximately 36.4% is paper, 27.6% is food waste; 6.6% is glass; 6.6% is metals; 6.1% is yard waste; plastics are 4.6%; textiles are 4.3%; wood is 4.2%; and other waste is 3.5%.

Only 10 percent of all wastes are recycled. This level of waste places pressure on existing landfill space and the development of new landfills is a difficult process be cause not only do they often encounter tremendous resistance from local residents but they also occupy valuable land that could be used for other purposes. Ground and surface water contamination and soil gas generation are just two of the many environmental problems of landfills.

The waste generated in PWGSC buildings is estimated at 22,000 tonnes/year.

In response to these high levels of waste, the Canadian Council of Ministers of the Environment agreed in 1989 on the goal of reducing the amount of solid waste sent for disposal in Canada by 50% by the year 2000 relative to the base year 1988.

Ontario is the only province that has developed formal regulations for the reduction, reuse, and recycling of wastes, adopted in March 1994; requiring the implementation of waste audits and waste reduction workplans (Regulation 102/94), as well as source separation programs (Regulation 103/94), in affected facilities, and construction and demolition activities.

As the federal government is committed to abide by the most stringent provincial regulations, these regulations will serve as the standard that the department will use.

7.1 REDUCING CONSTRUCTION & DEMOLITION WASTE

Waste of materials is a concern throughout the full life cycle of a building because waste occurs during construction, maintenance and replacement.

Although construction waste can be reduced through careful on-site practices, design decisions can also facilitate the reduction of construction waste.

Construction waste can be minimized during design through:

- Careful dimensioning and modular design;
- Considering extended material maintenance and replacement cycles;
- Using highly efficient, engineered wood products.

7.1.1 Construction Process

Building construction currently generates considerable waste, much of which could be reduced through more responsible construction management. Contractors must be made aware of new environmental agenda and must be supportive of the overall aims and intentions.

Although it is often difficult to makc direct comparisons between materials, it is important to consider the environmental implications of waste disposal associated with the material and any attendant packaging.

Waste can be reduced during construction by:

- Drafting specifications based on the Code of Practice set out by the Canadian Construction Association. This will emphasize waste reduction and other environmentally sound construction procedures;
- Incorporating contract clauses dealing with these issues and make the contractor aware that they will be enforced;
- Discussing on-site waste and recycling issues with contractor.

7.2 PROVIDING DEDICATED STORAGE SPACE

An effective recycling program requires separation and sorting, short term storage and regular pick-ups:

- Providing storage is a necessary part of an office recycling program for paper, cardboard and other consumer recyclables;

- Recyclables storage refers to separate and dedicated storage for all recyclables, but with at least 75% of its area designed for paper;
- The storage area may be central or distributed throughout the building, but in large buildings there must be a pick-up point located at the loading dock.

Consumer Recycling Facilities
Though office paper makes up the majority of the solid waste stream in offices, consumer recyclables such as glass and metal containers are also an important factor, and they become increasingly prominent when effective paper recycling is practiced. In large buildings with cafeterias and lunchrooms, organic waste can also be a considerable item.

Providing recyclable waste collection for glass, metals, newsprint and plastic, as well as organic waste where appropriate, is an important supplement to an office recycling program.

Recyclables Compacting
Most recyclables are bulky and are stored in a low density form. This is particularly problematic when they are picked up by a vehicle without compacting equipment because it makes transport inefficient.

Reducing the bulk of recyclables will make their handling and transport more efficient:

- Office paper which has been sorted can be compressed and baled as can cardboard and newsprint.
- Glass and metals can be sorted and crushed and shipped in returnable bins.

Waste management and recycling efforts can be encouraged by:

- Considering all current and potential water flows within the building;
- Providing adequate, dedicated storage for paper, cardboard and other consumer recyclables, but with at least 75% of its area designed for paper;
- Providing for recyclable waste collection of glass, metals, newsprint and plastic, as well as organic waste;
- Reducing the bulk of recyclables by on-site compacting;
- Providing a pick-up point located at the loading dock in large buildings.

7.3 REFERENCES

1. Property Management Services, Public Works and General Services Canada, Sustainable Development Strategy: Solid Waste Management Reduction Strategy for Property Management Services, Draft #3, Environmental Services Directorate, A&ES HQ, Ottawa, February 1996.

SUMMARY OF DESIGN STRATEGIES

Section	
2	**HEALTH & WELL-BEING**
2.1	**IMPROVING THERMAL QUALITY** - Providing heating and cooling supply devices close to occupants - Assessing effects of partitioning and space planning on heating and cooling control - Providing flexibility or ability to control local thermal conditions - Designing small thermal zones - Providing controls which correspond to interior partitioning - Providing readily accessible and easily comprehensible controls - Planning for the careful admission of direct sunlight - Using thermal mass to regulate temperature variations
2.3	**CONTROLLING SOURCES OF POLLUTION**
2.3.1	**Finishing Materials** - Evaluating materials as potential sources of contamination - Sealing of exposed surfaces of materials containing contaminants - Requesting written recommendations from manufacturers - Repairing any moisture damage
2.3.2	**Paints** - Specifying water based paints - Specifying paints containing no mercury, lead, hexavelant chromium or cadmium compounds
2.3.3	**Adhesives** - Specifying construction adhesives with low emissions during curing
2.3.4	**Floor Coverings** - Selecting resilient flooring in common areas - Keeping carpets away from entrances - Specifying low emission carpets - Testing of the carpet systems - Off-site airing-out of carpets
2.3.6	**Building Flush-out** - Sustaining a period of full ventilation prior to occupancy
2.4	**ISOLATING POLLUTANT SOURCES** - Making provision to prevent transfer of contaminants - Providing air locks and pressurization to reduce entry of outside contaminants
2.5	**MINIMIZING CONTAMINATION WITHIN THE HVAC SYSTEM**

2.5.1	**Mineral Fibre Problems** - Using only small amounts of fibrous liners inside HVAC ducts - Avoiding suspended ceilings as return air plenums and using ducted returns - Specifying effective filter systems - Avoiding quantities of uncontained mineral fibre materials
2.5.2	**Water Related Problems in Mechanical System** - Designing in compliance with MD 15000 and ASHRAE recommendations - Minimizing moisture in ducts and moisture contamination of duct liners - Locating and designing cooling towers to prevent release of spray containing microbes
2.5.3	**Access for Maintenance** - Providing sufficient space and access to all relevant parts of the mechanical and ventilation system
2.6	**REASSESSING THE LOCATION OF AIR INTAKES** - Isolating intakes from sources of hazardous air contaminants - Isolating intakes from sources of nuisance air contaminants - Locations intakes to avoid "re-entrainment" of exhaust air
2.7	**PROVIDING EFFECTIVE VENTILATION** - Meeting or preferably exceeding MD 15000 standards
2.7.1	**Ventilation Effectiveness** - Eliminating short circuiting and dead air zones - Using most appropriate diffusers and velocities - Locating return air opening > 3m from any typical copy machine
2.7.2	**Outdoor Air Economizer Capacity** - Specifying 100% outdoor air capacity
2.8	**IMPROVING LIGHTING QUALITY** - Using IES Recommendations as general guide for maximum luminance ratios
2.8.1	**Lighting Distribution** - Providing appropriate illuminance, distribution and avoidance of glare - Providing ability to control the amount and direction of light - Enhancing the visual definition of the space - Providing appropriate and relevant distribution of lighting within the space - Providing a variety of lighting strategies - Developing a strategy employing both ambient light and task lighting
2.8.2	**Lighting Equipment** - Specifying lamps with colour rendering index > 75 - Specifying electronic ballasts

2.8.3	**Direct Lighting and Indirect Lighting Systems** - Selecting fixtures which minimize direct glare - Avoiding monotonous or disturbing arrangements - Minimizing brightness differences - Specifying systems with advanced optical systems and efficient reflector materials - Reducing the potentially overall bland appearance of indirect systems - Minimizing "hot spots" on the ceiling plane with indirect systems
2.8.4	**Natural Lighting** - Planning interior for daylighting - Organizing internal planning of partitions to maximize daylighting - Selecting internal reflectances which maximize daylight reflection - Avoiding adverse impacts of admiring sunlight into the workplace - Providing visual access to the exterior
2.9	**IMPROVING ACOUSTIC QUALITY** - Controlling of noise at source - Using appropriate acoustic separation
2.9.1	**Flanking and Isolation** - Extending partitions above the suspended ceiling - Eliminating holes for ducts, pipes, conduits, cables, etc. - Providing appropriate acoustical treatment on doors, sidelights, etc. - Minimizing break-in and break-out sound transmission
2.9.2	**Low Equipment and Equipment Room Noise** - Blocking flanking sound paths and isolation of plumbing noise - Designing of HVAC systems and equipment rooms for NC 40 or beaker
3	**SITE & LANDSCAPING**
3.1	**USING SITE RESOURCES** - Examining potential access to solar energy and daylight - Examining potential rainfall on the complete site - Examining seasonal sun path and prevailing wind potential
3.2	**RESTORING NATURAL ECOLOGY** - Examining existing water courses and drainage patterns across the site - Understanding natural behaviour of the ecosystem embracing the site - Considering ecological aspects of the site affected by building - Creating critical connections to any adjacent habitats - Establishing biodiversity - Supplementing existing natural vegetation - Retaining and filtering storm water on site - Clustering plants - Considering plant root systems

3.3	**ENHANCING SITE MICROCLIMATE** - Planning landscape integral with energy strategy - Planning shade walls and paved areas adjacent to the building - Using deciduous trees for summer shading - Using coniferous trees for wind shielding - Planting shrubs to reduce heat build up - Consolidating or relocating paved areas - Using ponds and water fountains
3.4	**RE-EXAMINING SURFACE PARKING** - Developing alternative transportation strategies - Providing covered personnel loading and unloading at building - Varying paving materlals in parking lots based on traffic use - Considering oil grid separators at paved areas
3.5	**USING EFFICIENT IRRIGATION**
3.5.1	**Using Site Rainwater** - Using materials which allow rainwater to percolate for walkways and parking - Focusing the flow of water by grading the site - Storing water on the site - Handling rainwater in visible surface channels
3.5.2	**Redesigning the Landscape** - Landscaping with trees, hardy shrubs and indigenous plants requiring little or no watering - Grouping plants of similar water needs together into hydrozones - Increasing the organic content of the soil - Reducing the amount of turf to small areas/using drought resistant native grass types - Using mulch material to control weeds and reduce evaporation loss - Employing water conserving irrigation system - Selecting native plants or plants from areas with similar soils and climates - Retaining natural drainage patterns
3.5.3	**Applying Water to the Landscape more Precisely** - Employing drip irrigation systems
3.5.4	**New Sources of Irrigation Water** - Considering constructed wetlands for grey-water treatment

3.6	**CONTROLLING STORM WATER** - Designing landscape to retain and filter storm water on site to protect ecosystems - Using large semi-porous areas capable of absorbing water and releasing it slowly - Preserving natural slopes and existing water flows - Constructing detention and retention ponds for on-site storm water management - Engineering land forms to catch, hold and absorb water - Using roof spaces and terraces for vegetation - Preserving natural areas to detain and filter storm water
3.7	**ENSURING SOUND CONSTRUCTION PRACTICES** - Limiting topsoil removal and stockpiling existing topsoil on site - Exposing smallest area of soil at any one time during development - Requiring a waste management plan from the contractor - Establishing staging areas and travel routes for construction vehicles - Protecting from construction activity and debris - Enforcing specified parking for construction worker's vehicles - Scheduling of features capable of carrying storm run-off - Removing heavy sediment loads from runoff waters
4	**ENERGY USE**
4.2	**SELECTING EFFICIENT LIGHTING EQUIPMENT** - Specifying smaller T-5, T-8 or T-10 lamps - Specifying high frequency ballasts - Specifying Low Total Harmonic Distortion ballasts
4.2.1	**Lighting Control** - Using a mixed approach to lighting control - Providing manual switching to users - Providing separate switching in all daylight zones - Using a controlled stepped lighting strategy - Using photocell controlled dimming ballasts in response to daylight - Scheduling each area, with override - Specifying time switches and other systems
4.3	**SELECTING HVAC CONTROLS** Using energy management strategies which are: - Capable of being operated and maintained simply, efficiently and effectively - Have a greater number of HVAC zones - Provide for setback of temperature during unoccupied hours - Designed for optimal heat-up and cool-down strategies - Accompanied by individual meters or sub-meters - Provide feedback to users and management on building energy use

4.4	**SELECTING PRIMARY HVAC EQUIPMENT** - Examining potential for ground source/geothermal, solar and other renewable sources - Carefully considering conversion efficiency of the equipment - Considering "part-load" efficiencies in plant selection - Making provision for staged or variable output primary equipment - Using heat pumps to transfer thermal energy - Reclaiming "waste" heat from building exhaust or condensate fluids - Employing air and water-side cooling economizers - Providing durable and reliable equipment - Providing easy access to equipment
4.5	**SELECTING SECONDARY HVAC EQUIPMENT** - Designing a decentralized approach to secondary system design - Sizing systems appropriately - Eliminating reheating and re-cooling of distribution fluids as a control strategy - Minimizing volumes and parasitic losses - Reducing fan and pump energy - Variable speed fan and pump controls - Designing for 100% free air cooling - Specifying new electric motors efficiencies meet ASHRAE/IES 90.11989 Standard
4.5.1	**Service Hot Water** - Using conservation device on hot water supply - Meeting or exceeding ASHRAE/IES 90.1-1989 Standard - Placing water heaters as close to point of use - Specifying point-of-use heaters - Specifying recirculating systems be insulated throughout entire length - Examining feasibility of solar hot water heating systems
4.6	**COMMISSIONING GUIDELINES** - Commissioning according to ASHRAE Guideline 1-1989
4.7	**UTILIZING THERMAL MASS** - Using improved solar control devices - Using building mass as a cooling sink and combine with night-time flushing - Using operable windows - Considering sensors linked to the HVAC system

4.8	**UPGRADING WINDOWS** - Specifying high performance glazings - Evaluating the overall U-Value of the window system - Specifying window frames which enhance the overall thermal resistance - Controlling excess solar gain - Matching high performance glazings to the orientation - Carefully considering the use of tinted or reflective glasses
5	**MATERIALS USE**
5.1	**REDUCTION**
5.1.1	**Planning for the Efficient Use of Space** - Reviewing all space allocations programming - Carefully designing to optimize size and configuration of interior spaces - Considering multi-functional spaces and space-sharing - Eliminating non-inhabited spaces - Open planning of interiors - Carefully integrating services, structure and interior partitioning
5.1.2	**Eliminating Finishing Materials** - Reducing in amount or eliminating finishing materials
5.1.3	**Longevity** - Making building longevity an explicit issue - Designing spaces which are not overly specialized - Considering adaptation for alternative future uses
5.2	**RETAINING AND REUSING MATERIALS** - Carefully removing materials for future reuse - Extensive sourcing of possible salvaged components
5.2.3	**Designing for Materials Recovery** - Separating of structural and space enclosure elements - Detailing to avoid damaged - Keeping components and elements distinct - Reducing mixture of material types used - Considering greater modularity - Designing and detailing for ease of disassembly
5.3	**SELECTING LOW ENVIRONMENTAL IMPACT MATERIALS** Selection based on: - Recycled content of current and emerging materials - Recoverable and reused materials - Low embodied energy - Local materials - Longer service life before replacement - Low maintenance and refinishing requirements

5.3.1	**Wood Products** - Specification of tropical woods labelled by a recognized authority - Considering alternative wood products - Selecting laminates on cores of engineered wood or domestic softwood - Selecting less utilized domestic wood species
6	**BUILDING WATER USE**
6.1	**SPECIFYING WATER EFFICIENT APPLIANCES** - Deploying water efficient appliances - Specifying water conserving flush toilets - Specifying spring loaded lavatory fixtures - Specifying urinals with maximum flow rate of 0.06 L/s - Considering electronic proximity devices - Collecting, retaining and using rainwater
6.2	**WATER CONSERVATION MANAGEMENT** - Providing appropriate signage in rest-rooms - Installing water metering in buildings
7	**WASTE REDUCTION**
7.1	**REDUCING CONSTRUCTION & DEMOLITION WASTE** - Careful dimensioning and modular design - Considering extended material maintenance and replacement cycles - Using highly efficient, engineered use of materials
7.1.1	**Construction Process** - Drafting specifications based on the Code of Practice set out by the *Canadian Construction Association* - Incorporating contract clauses dealing with these issues - Discussing on site waste and recycling issues with contractor
7.2	**PROVIDING DEDICATED STORAGE SPACE** - Considering all waste flows within the building - Providing adequate, dedicated storage for consumer recyclables - Providing for recyclable waste collection - Reducing the bulk of recyclables by on-site compacting - Providing a pick-up point located at the loading dock