PLANNING, DESIGN AND CONSTRUCTION STRATEGIES FOR GREEN BUILDINGS

Green Buildings BC—New Buildings Program
Agencies Responsible:
British Columbia Buildings Corporation
Ministry of Finance and Corporate Relations

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The Lui Centre at UBC utilizes a comprehensive set of green strategies. It uses ultra-low flush toilets, minimizes impervious landscaped areas, preserves all existing trees, makes extensive use of recycled and salvaged materials, maximizes daylight, and uses at least 25% less energy than the Model National Energy Code for Buildings.

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Disclaimer

The following set of Planning, Design And Construction Strategies For Green Buildings has been developed under the Green Buildings BC—New Buildings Program. This first draft of this document will be subject to changes during the Green Buildings BC Pilot Project Initiative (1999 – 2002) and the monitoring period thereafter. The Province of British Columbia cannot be held liable for any possible errors in the following document and is not liable for any building processes or products used to meet the targets. All parties using these strategies and resources are expected to adhere to all other applicable standards, laws, and codes.

List of Acronyms

Concepts:

CFC:	Chlorofluorocarbons
CFM:	Cubic feet per minute
ECM:	Energy conservation measure
IAQ:	Indoor Air Quality
IEQ:	Indoor Environmental Quality
IDP:	Integrated Design Process
IPM:	Integrated Pest Management
PV:	Photovoltaic Solar Panels
PVC:	Polyvinyl chloride
VAV:	Variable air volume
VOC:	Volatile Organic Compound

Organizations and Programs:

AIA:	American Institute of Architects
AIBC:	Architectural Institute of British Columbia
ASHRAE:	The American Society of Heating, Refrigeration and Air Conditioning Engineers
ASMI:	Athena Sustainable Materials Institute
CHBA:	Canadian Home Builders' Association
CMHC:	Canada Mortgage and Housing Corporation
CSA:	Canadian Standards Association
CSI:	Construction Specifications Institute
EBN:	Environmental Building News
FCM:	Federation of Canadian Municipalities
GBBC:	Green Buildings BC
GVRD:	Greater Vancouver Regional District
IES:	Illuminating Engineering Society of North America
ISO:	International Standards Organization
LEED:	Leadership in Energy and Environmental Design Green Building Rating System (developed by USGBC, below)
MNECB:	Model National Energy Code for Buildings
NRCan:	National Resources Canada
UBC:	University of British Columbia
UN:	United Nations
USDOE:	United States Department of Energy
USEPA:	United States Environmental Protection Agency
USGBC:	United States Green Building Council

Introduction: **How to Use This Document**

Audience

This document is offered as a resource for those interested in exploring a variety of strategies to build more environmentally responsible buildings. It is intended to be useful for the design team of a green building project, including the owner, project managers, engineers, architects, landscape architects, value analysis consultants, green consultants, cost consultants, energy engineers, construction managers, government agencies and any other person or group involved in the design.

Document structure

The strategies in this document are organized around the following stages in the design process:

1. Program Planning and Site Selection
2. Selection of Design Team
3. Site Design
4. Building Orientation and Configuration
5. Building Systems Design
   - 5.1. Energy Design
   - 5.2. Structure Design
   - 5.3. Envelope Design
   - 5.4. Ventilation Design
   - 5.5. Water Systems Design
   - 5.6. Lighting Design
   - 5.7. Mechanical Design
   - 5.8. Finalize Building Systems Design
6. Interior Finishes
7. Specifications / Construction Drawings
8. Construction and Commissioning
9. Operations and Maintenance

Within each of these stages, “strategies” are presented that can reduce the environmental impact of the building. The strategies will offer practical suggestions to assist in the planning, design and construction of green buildings.

Structure of the individual strategies

The strategies are organized into the following way:

Many of the strategies listed relate to more than one green building issue. Therefore the "Key and related issues" are listed on the left-hand column.

The "Goal" is a statement of the intent of this particular strategy.

The "Strategy" is a practical suggestion concerning how to achieve a particular environmental objective in a specific stage of the design process.

Goals:

1.1. Research funding opportunities

⇒ *Key issue: Energy reduction*

Strategies:

- **There are many financial and supporting resources to support green buildings.** The application to these programs should be made as soon as possible.

The "Resources" section summarizes available resources. On the internet, it is linked (by clicking) to further information. The resources are listed in order of relevance and usefulness. More resources can be found in the "Guide to Green Building Resources."

funding and other resources

Resources for researching funding opportunities:

1.0. Financial and Supporting Resources:

- Commercial Building Incentive Program (CBIP)

***Case Studies** for researching funding opportunities:*

find out about the buildings that met funding requirements

3.4.1. Energy Use Case Studies

- Commercial Building Incentive Program (CBIP) Case Studies

These numbers refer to the "Guide to Green Building Resources" Document.

Many strategies have a selection of case studies that show how other buildings have used this strategy or met the broader environmental goal of the strategy. On the internet, you can access the case study by linking (clicking).

How the strategies should be used

The strategies offered here are presented as design options, or ideas to consider. They are voluntary. The strategies do not necessarily support each other, and the use of one strategy may preclude the use of others. Designers, owners and others will need to weight the benefits of using any particular set of strategies. There may be tradeoffs needed to achieve the diverse design goals of any particular project.

The field of green building design is evolving quickly. The list of strategies presented here should not preclude the design team from exploring other strategies not covered in this document.

What is not included?

This “Strategies” document does not specifically address the issues of programming, even though we recognize the uppermost importance of these issues and goals. It also does not focus on the Integrated Design Process (IDP), which assists in the development of a green building. Information on the IDP can be found in a document entitled:

⇒ “Guide to Value Analysis and the Integrated Design Process”

The other documents that are referred to in this document include the following:

⇒ “Guide to Green Building Resources”
⇒ “Case Studies”

These are available from:
Green Buildings BC—New Buildings Program
British Columbia Building Corporation
3350 Douglas Street, Victoria
British Columbia, V8Z 3L1
http://www.greenbuildingsbc.com/

Program Planning and Site Selection

Pictures of brook and underwater fish reproduced with permission from Fisheries and Oceans Canada. Picture of the Galloping Goose

Site selection and design has an impact on issues as diverse as surrounding wildlife habitat and transportation options for building users. All kinds of wildlife habitat are impacted by site selection, including the fish in the picture above. The Galloping Goose bike / walk / horse trail runs through Victoria BC, and enables many people to use alternate forms of transportation to travel to the areas close to the trail.

1 *First Stage in the Process:* **Program Planning and Site Selection**

Goals:	Strategies:
1.1 Set preliminary environmental performance targets (owner) ⇒ *Related issues: All*	**The building owner sets preliminary performance targets** at the outset of the project. These should be appropriate to the site and program, and should cover the following areas: ◦ **Energy** (Energy Use, Energy Source, Clean Energy Transport) ◦ **Water** (Water Use, Water Filtration, Ground Water Recharge, Human Waste) ◦ **Landscape** (Integrated Pest Management, Green Space, Native Plantings and Wildlife Habitat) ◦ **Materials** (Recycled Materials, Efficient Materials, Salvaged Materials, Local Materials, Durable and Low Maintenance) ◦ **Waste** (Recycling and Composting Facilities) ◦ **Construction Practices** (Construction Waste, Reuse Topsoil, Vegetation and Watercourse Protection) ◦ **Indoor Environmental Quality** (Air Pollutant Emissions, Ventilation Effectiveness and Air Filtration, System Commissioning and Cleaning, Daylighting) ◦ **Economic Performance** (Life-Cycle Assessment, Capital Cost Accounting) These environmental performance targets will be further developed when the design team is hired, and finalised as the design team enters the building systems design phase. Green building guidelines, rating systems or checklists (listed in the "Resources" section below) can be used to set targets. In addition to all of the environmental targets, the owner should have the targets that are required in every building, such as programming and functional targets.

Resources for setting environmental performance targets:

guidelines and checklists can be used by the owner to set appropriate and challenging targets

2.0. General Resources

2.1. Guidelines

- Leadership in Energy and Environmental Design (LEED)
- BC MFCR Green Buildings Checklist
- GBBC Performance Targets for Pilot Projects
- New York City High Performance Building Guidelines
- Santa Monica's Green Building Guidelines

general green building information

2.2. Whole Building Resources

- Green Building Information Council (GBIC)
- NRCan's Office of Energy Efficiency
- AIBC's Resources
- Environmental Building News
- Center of Excellence for Sustainable Development

case studies can give you examples of what is possible

Case Studies for setting environmental performance targets:

2.2.1. Whole Building Case Studies

- British Columbia Green Building Case Study Series
- Green Building Challenge 2000
- Advanced Buildings, Technologies and Practices
- Visions, Tools and Targets
- MEI Case Studies of Green Buildings
- Committee on the Environment (COTE)'s Home Page

Goals:

1.2 Research funding opportunities

⇒ *Key issue: Energy reduction*

Strategies:

- **There are many financial and supporting resources to support green buildings.** The application to these programs should be made as soon as possible.

funding and other resources

Resources for researching funding opportunities:

1.0. Financial and Supporting Resources:

- Commercial Building Incentive Program (CBIP)
- PowerSense, West Kootenay Power
- NRCan C-2000 Program
- REDI

find out about the buildings that met funding requirements

***Case Studies** for researching funding opportunities:*

3.4.1. Energy Use Case Studies

- Commercial Building Incentive Program (CBIP) Case Studies
- Renewable Energy Deployment Initiative (REDI)Case Studies

Goals:

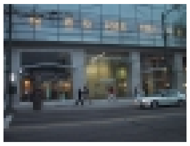
1.3 Reuse existing buildings

⇒ *Materials Issue*

⇒ *Related issues: Energy, Construction Waste, All*

Strategies:

- **Reuse an existing building** as much as possible through renovation or redevelopment. Roughly 80% of an average building's environmental impact is from its operations and maintenance over its lifetime, and only 20% from the embodied energy of materials. Therefore, the trade-offs and life-cycle costs of building new must be done carefully.



Case Studies for reusing existing buildings:

6.8.1. Materials Case Studies

- Telus Office Building

Goals:	Strategies:
1.4 Start early to source salvaged materials ⇒ *Key Issue: Materials*	◦ **Early on, look for appropriate salvageable materials** from demolition contractors, specialty suppliers, salvaged building material suppliers, or buildings that are being deconstructed. All consultants should be ready to specify salvaged materials. When a source has been identified, the availability, quality of material, timing and storage should be confirmed.

Resources for planning for salvaged materials:

6.3. Salvaged Materials

- GVRD's Construction/Demolition Recycling Program
- Design Guide—Salvaged Building Materials in New Construction
- EcoSmart Concrete Project

Case Studies for planning for salvaged materials:

6.8.1. Materials Case Studies

- Materials Testing Facility
- The Liu Centre
- Telus Office Building
- EcoSmart Concrete Project
- The Energy Resource Center

Goals:	Strategies:
1.5 Select appropriate land ⇒ *Key Issue: Transportation Energy* ⇒ *Related issues: Site Ecology, All*	**Select land** that: ◦ is a short walk from public transit, pedestrian and bicycle routes ◦ exists in an already-urbanized area ◦ is walking distance from amenities ◦ is already serviced by the requisite urban infrastructure (roads, utilities, etc.) ◦ is a brownfields site and remediate it ◦ allows infill development ◦ allows mixed-use development
⇒ *Key issue: Site Ecology* ⇒ *Related issue: Water*	**Avoid selecting sites** that are: ◦ designated as part of the BC Agricultural Land Reserve or the BC Forest Land Reserve ◦ flood land (find designation) ◦ ecologically sensitive land, defined according to the Sensitive Ecosystems Inventories BC ◦ habitat for rare or endangered species as defined by the BC Conservation Data Centre ◦ used as wildlife corridor ◦ within the 15- to 30-metre-wide streamside protection areas on fish-bearing streams in urban areas that are designated by the BC Fish Protection Act ◦ greenfield areas ◦ wetlands (as defined by The Canadian Federal Policy on Wetland Conservation)

Picture of bicycle light

Reprinted with permission of Vancouver Greenways

Resources for selecting environmentally appropriate land:

find a site that connects with public transit, greenways, and bike routes

3.3. Clean Energy Transport
- North America Greenways Information Page
- Environment Canada's Green Lane Success Stories
- National Center for Bicycling and Walking

these resources help you learn more about the ecology of your site

5.3. Native Plantings and Wildlife Habitat
- BC Conservation Data Centre
- Sensitive Ecosystems Inventories in British Columbia
- BC Land Reserve Commission
- Naturescape British Columbia
- The Evergreen Foundation
- NPSBC Native Plant Society of BC

Case Studies for selecting environmentally appropriate land:

see how others select appropriate land

3.4.3. Clean Energy Transport Case Studies
- Austin Green Building Program Case Studies
- Conservation Coop

Selection of Design Team

Photograph reprinted with permission of Martine Desbois.

The 16,000 square foot intensive green roof at the Zoo Atlanta's Conservation Action Resources Center (ARC) is flush with the original grade on the west and rises to the east. The roof acts as a tool to educate the public about conservation biology. The roof's earth-berm provides thermal mass that reduces heat gain. The plant life on the roof creates wildlife habitat, reduces stormwater runoff and reduces roof temperatures.

2 *Second Stage in the Process:* Selection of Design Team

Goals:	Strategies:
2.1 Select a design team with experience or interest in green and integrated design ⇒ *Related issues: All*	° **Ensure that knowledge, skills and experience with green design are criteria** for the selection of architects, landscape architects, engineers and other members of the design team. All applicants should be asked to provide proof of their knowledge of and / or previous experience with green design principles and practices.

Resources for selecting the design team:

2.2. Whole Building Resources

- BC Green Buildings Directory
- NAVFAC Policy: Procurement of Sustainable Facilities and Infrastructure Through Architect-Engineer (A-E) and Related Contracts

Goals:	Strategies:
2.2 Select appropriate professionals for the expanded design team ⇒ *Related issues: All*	**Ensure that the following skills are available** among team members: ° **Facilitation**: Having someone with experience in both green and integrated design can help the team make the best use of time at the first few design meetings. An experience facilitator can also help to steer the team in the right direction, and provide information on green design issues. ° **Energy Simulation**: This is indispensable for significant building energy conservation. Energy engineers specialize in analysis, research and engineering of energy conservation and renewable energy methods. They are best involved early during schematic and early design development and later at or near completion to verify the actual energy performance. ° **Green Expertise**: A professional with expertise in green design practices will stimulate the group to go beyond current practice. In addition, they will provide some reassurance to an inexperienced team about the best strategies to investigate given the specifics of the project. ° **Value /Cost Analysis**: The role of this person (or people) is vital to the success of the project. The cost consultant must be involved very early in the process and must understand the process and the objectives / targets of the project. They must have the tools to respond quickly as to the cost impacts of various design concepts and variations to these concepts. They will need to be able to provide appropriate cost information at various stages of the process.

Goals:	Strategies:
2.3 Set environmental performance targets (design team) ⇒ *Related issues: All*	**The integrated design team sets performance targets.** The team, including the owner, further develops the performance targets set by the owner. These targets should be appropriate to the site and program, and should deal with the following issues: ° **Energy** (Energy Use, Energy Source, Clean Energy Transport) ° **Water** (Water Use, Water Filtration, Human Waste, Ground Water Recharge) ° **Landscape** (Integrated Pest Management, Green Space, Native Plantings and Wildlife Habitat) ° **Materials** (Recycled Materials, Efficient Materials, Salvaged Materials, Local Materials, Durable and Low Maintenance) ° **Waste** (Recycling and Composting Facilities) ° **Construction Practices** (Construction Waste, Reuse Topsoil, Vegetation and Watercourse Protection) ° **Indoor Environmental Quality** (Air Pollutant Emissions, Ventilation Effectiveness and Air Filtration, System Commissioning and Cleaning, Daylighting) ° **Economic Performance** (Life-Cycle Assessment, Capital Cost Accounting)

guidelines and checklists can be used by the owner to set appropriate and challenging targets →

2.0. General Resources

2.1. Guidelines
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- BC MFCR Green Buildings Checklist
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- New York City High Performance Building Guidelines
- Santa Monica’s Green Building Guidelines

general green building information →

2.2. Whole Building Resources
- Green Building Information Council (GBIC)
- NRCan’s Office of Energy Efficiency
- AIBC’s Resources
- Environmental Building News
- Center of Excellence for Sustainable Development

Case Studies for setting environmental performance targets:

case studies can give you examples of what is possible

2.2.1. Whole Building Case Studies
- British Columbia Green Building Case Study Series
- Green Building Challenge 2000
- Advanced Buildings, Technologies and Practices

Site Design

The above Day Care Centre in Heddernhein, Frankfurt am Main, and the below Hundertwasser House apartments in Vienna, have extensive green roofs that are visible in the pictures.

3 *Third Stage in the Process:* **Site Design**

Goals:	Strategies
3.1 Protect or enhance site's ecological integrity and biodiversity ⇒ *Key issue: Site Ecology* ⇒ *Related issues: Water, Construction Waste, Energy, Transportation*	◦ **Minimize the development footprint.** This includes parking, building, roads. Cluster buildings together. ◦ **Locate building to preserve the site's natural areas**. Do an inventory of the site's ecology. If there are concerns, send in a map of the site to the Conservation Data Centre to have it assessed for rare or endangered species. Avoid making major changes to sensitive landscapes, wildlife habitat, or topography. ◦ **Re-establish** damaged native ecosystems. Plant native species and take out ecologically harmful non-native or invasive species. Plant native species along streams to act as buffers. Use landscaping to control erosion. ◦ **Preserve**, establish, or re-establish native biodiversity (diversity of native plant and animal species). During construction, salvage native plants to be replanted on the site or elsewhere. ◦ **Preserve**, establish, or re-establish wildlife habitat by providing shade, shelter, food and water to sustain the desired wildlife. ◦ **Make connections** between the natural ecology of the site and natural systems both within and beyond the site. ◦ **Build support for urban greenways** that can be used by wildlife, pedestrians, cyclists, and others. This can be done by working with the relevant local or regional government agencies to help you establish, connect with or further develop a greenway.

Resources for protecting the site's integrity and biodiversity:

these resources can supply information about the ecology of your site →

5.3. Native Plantings And Wildlife Habitat
- BC Conservation Data Centre
- Sensitive Ecosystems Inventories in British Columbia
- BC Land Reserve Commission
- Naturescape British Columbia
- The Evergreen Foundation
- NPSBC Native Plant Society of BC

Case Studies for protecting the site's integrity and biodiversity:

see how others protect site ecology →

5.4.1. Green Space Case Studies
- GBBC Case Study: Burnaby Mountain Secondary School
- GBBC Case Study: The Liu Centre
- GBBC Case Study: Beausoleil Solar Aquatics
- GBBC Case Study: Center for Environmental Studies
- Austin Green Building Program Case Studies

5.4.2. Native Plantings And Wildlife Habitat Case Studies
- Research Triangle Park Case Study

Goals:	Strategies:
3.2 Reduce or eliminate disturbance to water system ⇒ *Key Issues: Water, Site Ecology* ⇒ *Related Issue: Transportation*	◦ **Minimize storm water runoff**. Increase site infiltration where soil conditions allow by maintaining the natural pervious landscape or designing a pervious landscape. Use pervious surfaces (e.g. ones which allow water to penetrate) for as much as possible of the surfaces that are usually paved (e.g.: roads, parking, courtyards and pathways), where soil conditions permit. ◦ **Use organic stormwater management** features like vegetative swales, filter strips, vegetative buffers, infiltration basins, or drywells instead of subsurface storm drains to treat stormwater runoff from fields, roofs and roads, where soil conditions permit. ◦ **Celebrate these natural water management techniques** by making them into attractive landscape elements. Examples can be seen in many of the case studies. ◦ **Install oil / water separators** to treat run-off from parking lots (do not use them for run-off from fields or roofs). On impervious areas that do exist, capture rainwater for site or building use. ◦ **Design roads and parking lots without curbs** or with curb cuts or openings that drain to stormwater treatment & infiltration measures.

Resources to reduce or eliminate water system disturbance:

4.0 Ecological Performance Resources: Water

4.2. Water Filtration (including storm water management)

- BC Urban Fish Habitat Protected by New Streamside Regulation
- Environment Canada Regulations
- USEPA Publications
- USEPA Technology Fact Sheets
- Start at the Source
- Controlling Urban Runoff

Case Studies to reduce or eliminate water system disturbance:

4.4. Water Case Studies

4.4.1. Water Use Case Studies

- CK Choi Building
- Lui Centre
- Crestwood
- Canadian Water and Wastewater Association

4.4.2. Water Filtration and Ground Water Recharge Case Studies

- Lui Centre
- Burnaby Mountain Secondary School
- CK Choi Building
- Materials Testing Facility
- Crestwood Corporate Centre Building 2
- Lewis Center for Environmental Studies
- Miller SQA Building
- Research Triangle Park Case Study

Goals:	Strategies:
3.3 Prevent or reduce the use of potable water for irrigation ⇒ *Key Issue: Water* ⇒ *Related Issues: Site Ecology, Energy*	° **Harvest rainwater** or use recycled storm water, or site-treated grey or waste water for irrigation ° **Use water-efficient plants**. These are often native species, or species that have adapted. ° **Use water-efficient irrigation**, including: ⇒ micro irrigation ⇒ moisture sensors ⇒ weather data based controllers.

The picture above shows a Rain Barrel on Display at the Vancouver Demonstration Garden at 2150 Maple Street. Picture courtesy of the City of Vancouver, Engineering Services.

Resources for preventing or reducing water use in irrigation:

4.1. Water Use
- Canadian Water & Wastewater Assoc.
- Water Conservation Landscaping
- Native Plant Information Lists
- Rain Barrel Program

4.2. Water Filtration
- Urban Fish Habitat Protected by New Streamside Regulation
- Environment Canada Regulations

Case Studies for preventing or reducing water use in irrigation:

4.4. Water Case Studies
4.4.1. Water Use Case Studies
4.4.2. Water Filtration and Ground Water Recharge Case Studies[1]

[1] These case studies cover storm water management issues.

Goals:	Strategies:
3.4 Reduce urban heat islands ⇒ *Key issue: Site Ecology* ⇒ *Related issues: All Energy, Transportation, Water*	◦ **Maximize green space** through use of native gardens, trellises, roof gardens, etc. ◦ **Maximize pervious surfaces** for parking areas, paths, courtyards, etc. ◦ **Use light coloured, high-albedo materials for all non-pervious surfaces**. Drawings and specifications must record expected albedo requirements. ◦ **Provide shade** on impervious surfaces where high-albedo materials cannot be used.

Resources for reducing urban heat islands:

5.0. Ecological Performance Resources: Landscape
5.2. Green Space

- Landscape and Grounds Management Guidelines
- Nature Rules the Roof
- Learning About Urban Heat Islands
- Urban Heat Island Initiative
- Further resources

Case Studies for reducing urban heat islands:

5.4.1. Green Space Case Studies

- Burnaby Mountain Secondary School
- The Liu Centre
- Beausoleil Solar Aquatics
- Lewis Center for Environmental Studies
- Gardener on the Roof
- Greenroofs.com
- Austin Green Building Program Case Studies

Goals:

3.5 **Design infrastructure to support alternative transportation**

⇒ *Key Issues: Transportation, Energy*

⇒ *Related issues: Site Ecology, Water, Health and Safety*

Strategies:

- **Locate building** to have access to public transit, bike routes, and pedestrian routes.
- **Encourage walking and bicycling** by designing attractive, safe pedestrian and cycling infrastructure. These features can be centrally located and grouped with landscape features. Site features such as walking and cycling paths, public squares, and outdoor seating can be located to optimise the solar access and access to attractive landscape features. Internal infrastructure can also be important to encourage walking and cycling. Central, attractive staircases can encourage the use of stairs over elevators.
- **Maximize bicycle-parking** spaces and minimize car-parking spaces. Internal covered bike parking may be appropriate in some cases, and can be designed to be an attractive feature of the building. At other times, external bike parking, or a combination of both, will be more appropriate. Whether inside or out, bike parking can be made more desirable by being covered from the rain and located centrally.
- **Build changing facilities** and showers for cyclists and joggers.
- **Give preferred parking to** carpool cars.

The picture left shows traffic calming along the Ontario Greenway. Picture courtesy of the City of Vancouver Greenways Program.

Resources for supporting alternative transportation:

3.3. Clean Energy Transport

- North America Greenways Information Page
- Environment Canada's Green Lane Success Stories
- National Center for Bicycling and Walking

Case Studies for supporting alternative transportation:

3.4.3. Clean Energy Transport Case Studies

- Austin Green Building Program Case Studies
- Conservation Coop

Building Orientation and Configuration

Many of the homes in Civano, Tucson (shown left and below) are built using straw bale, which is made from the waste of wheat harvesting. The thermal mass of the walls moderates extreme temperatures, allowing significant energy savings.

The homes in Civano use 50% less energy than is standard for this area through a variety of measures, including: efficient windows; siting to optimise passive solar design, shading, and wind; solar PV (photovoltaic) panels and solar hot water systems; and cooling towers to cool air.

Photographs reprinted with permission of Civano.

Civano has reduces its water consumption by 65% compared to standard developments in the area through measures that include:

- Water harvesting, where roof-water is collected in cisterns underground and used for cooling and xeriscaping.
- The use of two sets of water systems: one potable and the other distributing reclaimed water for non-edible plant irrigation.

Civano has also made extensive use of recycled materials. The following materials used at Civano have recycled content: cementitious foam block, tile, carpeting, window frames.

4 Fourth Stage in the Process: **Building Orientation & Configuration**

Goals:	Strategies:
4.1 Use site resources to reduce building loads and enhance indoor environmental quality ⇒ *Key Issue: Energy* ⇒ *Related issues: Site Ecology, Water, Health, Comfort and Safety*	◦ **Use existing and proposed trees & plantings** to reduce heating, cooling and lighting loads. Plantings can reduce summer solar gain, channel summer breezes, and block winter winds, while still allowing daylighting. Deciduous trees, for example, let winter sun through while shading summer sun, and therefore are useful in front of south- and west-facing windows. Evergreen trees are particularly useful for blocking winter wind on the North of the building. ◦ **Orient the building to optimize prevailing winds and solar opportunities**. Prevailing winds should be used to create appropriate air pressures in the building if natural ventilation is being used. However thermal loses due to infiltration of prevailing winds should be minimized. The building should be sited and oriented to optimize the site's solar resources. Winter solar gain and summer shading are often important, but sun studies and energy computer simulations will need to be done to develop strategies appropriate for each building and site. ◦ **Use existing and proposed topography to create thermal mass around the building**. Earth berms and other topographical features can be used to enhance the building's energy performance. ◦ **Assess the feasibility of using on-site renewable or alternate energy**. Consider geothermal or ground source energy, co-generation, passive and active solar energy, passive and active wind energy, and other energy sources.

Resources for using site resources for energy and IEQ:

3.0. Ecological Performance Resources: Energy
3.1. Energy Use
3.2. Energy Source
9.0. Human Health and Comfort Resources: Indoor Environmental Quality

Case Studies for using site resources for energy and IEQ:

3.4. Energy Case Studies
3.4.1. Energy Use Case Studies

- British Columbia Green Building Case Study Series
- CBIP Case Studies
- CMHCs "Building Innovation" Case Studies
- MIT's Natural Ventilation Case Studies
- BRE's Environmental Building, UK

3.4.2. Energy Source Case Studies

- Renewable Energy Deployment Initiative Case Studies
- Canadian REN Case Studies

Goals:	**Strategies:**
4.2 Develop a project-specific building form and massing ⇒ *Key Issues: energy* ⇒ *Related Issues: Site Ecology, transportation*	◦ **Narrow floor plates can be used to give greater access to daylight, views, and natural ventilation.** Windows in rooms with 8 or 9 foot ceilings typically bring light 15 to 25 feet into the building. Lightshelves and other reflective glazing can extend natural light to depths of 30 to 35 feet if narrow floor plates are not possible. Narrow floor plates allow effective cross-ventilation. The benefits of greater views, natural light and natural ventilation need to be balanced with the potential for heat loss through the greater wall area. Various design strategies can be tested in energy simulations (see below). ◦ **Interior temperature fluctuations can be moderated by thermal mass**. Materials like concrete and masonry store and release heat slowly. ◦ **Computer simulations of thermal massing and natural ventilation strategies can help** to assess which strategies save energy and work as designed. Although a simulation is not necessarily needed at the building orientation and configuration stage, it can be useful. At this point, the form, massing, orientation and configuration can be modelled and optimized. Doing a simulation at this stage is particularly useful if the building's HVAC loads are dominated by outdoor conditions and it is an "envelope dominated" building. These are usually smaller buildings with higher envelope area to volume ratios, or low internal loads. However, if a simulation is not done at this stage, the form, massing, orientation and configuration can be simulated at the time of the first energy simulation, which will be at the building systems design stage.

Resources for form and massing:

3.0. Ecological Performance Resources: Energy
3.1. Energy Use
3.2. Energy Source
9.0. Human Health and Comfort Resources: Indoor Environmental Quality

Case Studies for form and massing:

3.4. Energy Case Studies
3.4.1. Energy Use Case Studies
3.4.2. Energy Source Case Studies

Goals:	Strategies:
4.3 Configure internal layout to reduce loads and enhance IEQ ⇒ *Key Issues: energy* ⇒ *Related Issues: Site Ecology, indoor environmental quality, materials*	◦ **Reduce heating, cooling, lighting and ventilation loads through careful placing of internal uses.** This can be done in a number of ways. ◦ **Locate internal spaces to optimize natural ventilation, daylighting, and site resources** like trees or topography for shading. Create operable windows where air quality is good and where prevailing winds will create desired internal pressures. Locate highly occupied spaces close to exterior windows. ◦ **Uses that do not need windows can be located on the north side.** Locating gyms, theatres or other uses that do not require windows on the north face is useful as this wall usually has the least potential for daylighting and passive solar gain. In addition, the north exterior wall has the greatest heat loss from any windows located there, so avoiding this is beneficial to the overall energy performance of the building. The energy simulation should act as a check of whether this is the appropriate strategy for your building. ◦ **Create zones:** Spaces with similar functions should be grouped together so that heating and cooling demands can be combined into HVAC zones. The building's orientation and relationship to the outdoors should be taken into consideration when selecting zones. ◦ **Use circulation areas as buffers**: public areas and circulation areas can be design to experience wider temperature ranges, because they are occupied less, and are occupied when people are moving. ◦ **Be as space efficient as possible**. Building less space means using fewer materials and maintaining and operating less space over time.

Resources for energy-efficient internal layout:

3.0. Ecological Performance Resources: Energy
3.1. Energy Use
3.2. Energy Source
9.0. Human Health and Comfort Resources: Indoor Environmental Quality

Case Studies for energy efficient internal layout:

3.4. Energy Case Studies
3.4.1. Energy Use Case Studies
3.4.2. Energy Source Case Studies

Goals:	Strategies:
4.4 Select best concept design ⇒ *Key Issues: all*	° **The integrated design team should at this point select the best concept design, including the orientation, configuration, massing and siting.** There may be some changes as the design progresses, but the basic concept should be chosen at this stage.

Goals:	Strategies:
4.5 Finalize all non-energy performance targets ⇒ *Key Issues: all*	° **As the design team enters the building systems design phase,** they need to come to consensus on all of the project's performance targets except energy, which will be confirmed after the building systems design. Finalizing non-energy targets can be done at the same meeting in which the design team meets to begin the energy design (see 5.1.1.). The initial performance targets should be modified in light of what is possible on this site and within the project budget. The final targets should then be printed up and given to each design team member to refer to throughout the design.

Building Systems Design

Rendering of a Mountain Equipment Coop store in Ottawa. The building has an innovative envelope with insulation values four times the MNECB requirements and includes a demonstration straw bale infill wall. It uses 50% less energy than the Model National Energy Code for Buildings (MNECB), has a lighting load less than 50% of MNECB, and reduced its construction waste by 75%. Wind turbine supplies 10% of the building's electrical energy usage.

Photograph reprinted with permission from the Advanced Building website.

5 *Fifth Stage in the Process:* **Building Systems Design**

5.1 Energy Design[2]

Goals:	Strategies:
5.1.1 Design and select all building systems to meet energy targets ⇒ *Key Issue: energy* ⇒ *Related Issues: Site Ecology, IEQ*	◦ **Conduct an energy simulation.[3]** The energy simulation provides the energy and cost information required to make the "best" selection of building systems. The "best" selection will be the one that provides the lowest life-cycle cost within approved cost budget. This is the most iterative phase of the overall design process. The goal is to investigate energy and cost savings resulting from the synergies between the various building systems and their components. ◦ Once energy loads are optimized through the selection of the best combination of structural, envelope, ventilation, water, and lighting systems (see sections 5.2 to 5.6), the design team will select the most appropriate mechanical system to meet this load (see section 5.7). This process will generally lead to the selection of a smaller mechanical system than would normally be the case.

Resources for designing building systems for energy targets:

2.2. Whole Building Resources
- Guide to Value Analysis and the Integrated Green Design Process

3.0. Ecological Performance Resources: Energy
3.1. Energy Use: Energy Modelling and Software Tools
3.2. Energy Source
9.0. Human Health and Comfort Resources: Indoor Environmental Quality

Case Studies for designing building systems for energy targets:

3.4. Energy Case Studies
3.4.1. Energy Use Case Studies
3.4.2. Energy Source Case Studies

[2] Energy design can include strategies taken in building orientation and configuration, structure, envelope, ventilation, water, lighting and mechanical design. Because the co-ordination of these building systems and professions is necessary to achieve significant energy savings, it is crucial to bring them together as the design team begins the systems design phase.
[3] See the glossary for a further definition of the building energy simulation.

5.2 Structure Design

Goals:	Strategies:
5.2.1 Choose environmentally sensitive structural materials ⇒ *Key Issues: materials, life-cycle costs*	◦ **Design with salvaged, recycled and efficient materials** as much as possible. See the Stage 7: "Specifications / Construction Drawings" for information on this strategy. ◦ **Use locally harvested or manufactured materials.** This will reduce the environmental impacts of transportation. ◦ **Use materials with low environmental impact over their life.** Selecting materials this way requires research, using software like BEES or ATHENA, or doing book research. ◦ **Use low-VOC materials.** Use structures that do not require finishes that emit VOCs.

Resources for environmentally sensitive structural materials:

6.0. Ecological Performance Resources: Materials
6.1. Recycled Materials
6.2. Efficient Materials
6.3. Salvaged Material

- GVRD's Construction/Demolition Recycling Program
- Design Guide—Salvaged Building Materials in New Construction
- EcoSmart Concrete Project

6.5. Durable, Low Maintenance And Healthy Materials
6.6. Low-Environmental Impact Materials
6.7. Overall Material Resources

Case Studies for environmentally sensitive structural materials:

6.8. Material Case Studies
6.8.1. Materials Case Studies

- Materials Testing Facility
- The Liu Centre
- Telus Office Building
- EcoSmart Concrete Project
- The Energy Resource Center

Goals:	Strategies:
5.2.2 Design for reuse ⇒ *Key Issues: life cycle costs*	◦ **Design for flexibility.** Design a structure that allows for changes in use over time. This may include modular building materials, or flexible floor plans, with column spacings and floor-to-floor heights that can be easily adapted to many uses, to ensure long structural life. ◦ **Design for disassembly.** Select building systems that can be deconstructed at the end of the building's useful life.

5.3 Envelope Design

Goals:

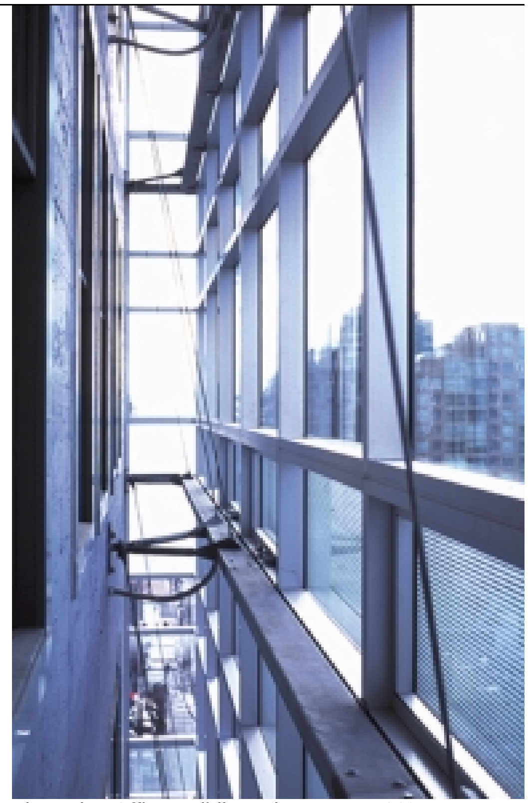
5.3.1 **Design envelope to reduce heating, cooling, lighting, and ventilation loads**

⇒ *Key Issues: Energy*

⇒ *Related Issues: Site Ecology, Light, Health, Comfort and Safety*

Strategies:

- **Design an energy-efficient envelope**: appropriate insulation, tight construction and high-performance, *low-e* windows (when this reduces life cycle costs).
- **Avoid thermal bridges** in walls (use continuous insulation, or eliminate metal studs in outside walls, or otherwise ensure thermal break).
- **Optimize solar heat gain and reduce glare.** The design options include: selecting glazing with appropriate ratio of visible light transmittance to solar heat gain coefficient; using trees & plantings to reduce summer solar gain; and ensuring windows have appropriate exterior shading.
- **Locate and size fenestration to capture the wind and fresh air** available on site. This can reduce the need to mechanically heat, cool, and move air.



The Telus Office Building, above, uses 30% Less Energy Than ASHRAE 90.1. The third skin creates an air gap which keeps heat in during the winter and provides shade in the summer. Reprinted with permission by Busby + Associates.

Resources for reducing energy use through envelope design:

3.0. Ecological Performance Resources: Energy
3.1. Energy Use
3.2. Energy Source

Case Studies for reducing energy through envelope design:

3.4. Energy Case Studies
3.4.1. Energy Use Case Studies
3.4.2. Energy Source Case Studies

Goals:	Strategies:
5.3.2 Use passive and active renewable energy ⇒ *Key Issue: Energy* ⇒ *Related Issues: Site Ecology, Light, Health, Comfort and Safety*	° **Design building for solar heat and light.** Optimize solar gains to offset heating and lighting needs. ° **Control solar heat gain and glare.** This can be done by selecting glazing with appropriate ratio of visible light transmittance to solar heat gain coefficient, and by ensuring windows have appropriate exterior and / or interior shading. Shading devices range from trees to solar electric (PV) panels (that double as shading devices) to blinds. Deciduous trees can provide excellent sunshading, allowing light through in the winter and blocking unwanted lighting the summer. ° **Design building to incorporate the site's wind and air resources.** Plan air openings where air is cleanest. Design with the wind speeds and directions in mind to optimize natural ventilation if feasible. ° **Assess the feasibility of incorporating renewable** energy into the envelope, using: ⇒ passive solar technologies like solarwall ⇒ active solar technologies like photovoltaic panels

Resources for designing the envelope for renewable energy:

3.0. Ecological Performance Resources: Energy
3.1. Energy Use
3.2. Energy Source

- The Canadian Renewable Energy Network
- RetScreen
- Renewable And Sustainable Energy Systems In Canada

Case Studies for designing the envelope for renewable energy:

3.4.1. Energy Use Case Studies
3.4.2. Energy Source Case Studies

- Renewable Energy Deployment Initiative (REDI) Case Studies
- Canadian REN Case Studies
- Beddington Zero (fossil) Energy Development (BedZED) Case Study
- BCIT Photovoltaic

Goals:	Strategies:
5.3.3 Optimize indoor environmental quality ⇒ *Key Issue: User Health and Safety* ⇒ *Related Issues: Energy, Site Ecology, Light*	° **Optimize daylighting and views.** Design the envelope to bring in daylight and views to as much of the inhabited floor area as possible. See below in this document 5.5. Lighting Design for daylight strategies, resources and case studies. ° **Design the envelope to provide adequate fresh air**. In addition, users should be provided with as much comfort and control as possible. See below in this document 5.3. Ventilation Design.

5.4 Ventilation Design

Goals:	Strategies
5.4.1 Assess ventilation requirements ⇒ *Key Issues: Health, Comfort and Safety*	° **Set ventilation targets.** The first step in the ventilation design is for the team to set optimum CFM targets.

Goals:	Strategies:
5.4.2 Reduce ventilation loads ⇒ *Key Issue: Energy* ⇒ *Related issues: Site Ecology, Health, Comfort and Safety*	° **Select an efficient mechanical or natural ventilation system.** Buildings with access to clean air and a quiet outdoor environment may benefit from use of natural ventilation systems at least in swing seasons. ° **Assess the potential for heat recovery systems.** Heat can be recovered from both sensible and latent heat. ° **Consider using zones** to group areas with similar occupancies and ventilation needs. ° **Weigh the benefits of VAV** (variable air volume) air distribution systems. When there is reduced demand, reduce the system load.

Resources for reducing annual energy use:

1.0. Financial and Supporting Resources
- Commercial Building Incentive Program (CBIP)
- PowerSense, West Kootenay Power
- NRCan C-2000 Program
- Renewable Energy Deployment Initiative (REDI)

2.0. General Resources
2.1. Guidelines
2.2. Whole Building Resources
3.0. Ecological Performance Resources: Energy
3.1. Energy Use
3.2. Energy Source

Case Studies for reducing annual energy use:

3.4.1. Energy Use Case Studies

- British Columbia Green Building Case Study Series
- CBIP Case Studies
- CMHCs "Building Innovation" Case Studies
- MIT's Natural Ventilation Case Studies
- BRE's Environmental Building, UK
- The Energy Resource Center
- Seattle City Light Case Studies

3.4.2. Energy Source Case Studies

- Canadian REN Case Studies
- Canadian Geothermal Case Studies
- Commonwealth of Pennsylvania, DEP Cambria Office
- Geoexchange: Geothermal Heat Pump Consortium
- Energie Cités Case Studies
- Beddington Zero (fossil) Energy Development (BedZED) Case Study
- BCIT Photovoltaic

Goals:	Strategies:
5.4.3 Provide users comfort and control ⇒ *Key Issue: Health, Comfort and Safety* ⇒ *Related Issues: Energy, Light*	° **Provide individual controls for ventilation**. Operable windows, in addition to individual controls for airflow, encourage users to turn off ventilation when needed, and also allow a high level of comfort and control. Individual controls should therefore be provided where feasible. See resources and case studies above.

Goals:	Strategies:
5.4.4 Provide adequate fresh air ⇒ *Key Issue: Health, Comfort and Safety* ⇒ *Related Issues: Materials, Energy, Light*	° **Separate air intakes from pollution.** Trees, waterways, forested areas, fields and other planting options can improve outside air quality. The intake must be far enough away to eliminate exposure to contaminated air. ° **Use carbon dioxide sensors** to monitor ventilation rates and to provide ongoing information concerning air quality. ° **With the help of building users and owner, reduce pollution sources.** For pollution generating sources that cannot be eliminated from the building, create isolated zones that are separately ventilated. ° **Ensure that indoor air is free of pollution.** See this goal in the "Interior Finishes" section below.

Resources for providing adequate fresh air:

9.0. Human Health and Comfort Resources: Indoor Environmental Quality
9.1. Air Pollutant Emissions
9.2. Mineral and Glass Fibre
9.3. Outdoor air Intake

- See ASHRAE proposed standard 62 R (1997) for recommended separation distances.
- See ASHRAE fundamentals (1997) Chapter 15 for description of separation analysis.
- See ASHRAE 62-1999, to find "Ventilation Standards for Acceptable Indoor Quality" for natural or mechanical ventilation systems. Here you will also find recommendations for the prevention of standing water to prevent microbial growth.
- See ASHRAE 52.2. entitled "Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size" for filter efficiency ratings

9.4. Ventilation Effectiveness and Air Filtration
9.7. Overall Indoor Environmental Quality Resources

Case Studies for providing adequate fresh air:

9.7.1. Air Pollutant Emission Case Studies

5.5 Water Systems Design

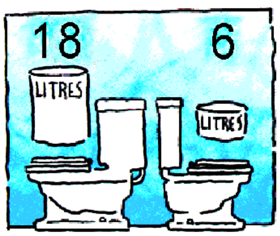
Goals:

5.5.1 Reduce or prevent the use of potable water to treat human waste

⇒ *Key Issue: Water*

⇒ *Related Issues: Site Ecology, Waste, Energy*

Water use per flush — conventional vs. ULV toilet



Source: *Environment Canada's Water Efficiency Website*, 2001. Reproduced with the permission of Environment Canada, 2001.

Strategies

Install water-efficient toilet fixtures. This could include:

- Water closets with a maximum of 6 litres per flush
- Wastewater piping with a generous pitch to account for smaller water flows
- Waterless urinals or urinals with a maximum of 3.6 litres per flush (use individual-flush urinals).

Install alternative wastewater technologies. Often these options allow the water to be treated on site to tertiary standards. This also meets the Site Design and Planning goal of reducing or eliminating disturbance to the natural water system, as it returns water to the ground in as good as or better condition than the water would have otherwise been treated.

Options include:

- constructed wetlands
- composting toilets
- biological waste water technologies
- aerobic treatment.

Grey water and black water systems can treat water to be reused for toilet flushing and irrigation. Once treated, the water can recharge groundwater if conditions are appropriate.

Resources for reducing or preventing the use of potable water to treat human waste:

these resources give information concerning site ecology

4.0 Ecological Performance Resources: Water

4.1. Water Use

- Canadian Water and Wastewater Association
- Directory of Water-conserving Plumbing Products

→ 4.2. Water Filtration

- Urban Fish Habitat Protected by New Streamside Regulation
- Environment Canada Regulations

4.3. Human Waste

- USEPA Technology Fact Sheets
- CMHC's Biological Toilets and Greywater Systems

Case Studies for reducing or preventing the use of potable water to treat human waste:

4.4. Water Case Studies
4.4.1. Water Use Case Studies
- Canadian Water and Wastewater Association

4.4.2. Water Filtration and Ground Water Recharge Case Studies
- Miller SQA Building
- Research Triangle Park Case Study

4.4.3. Human Waste Case Studies

these building have reduced or prevented the use of potable water to treat human waste →

- CK Choi Building
- Lewis Center for Environmental Studies
- Beausoleil Solar Aquatics
- USEPA Constructed Wetlands Case Studies
- The Body Shop Headquarters
- Hennepin County Public Works Facility
- YMCA Environmental Learning Centre

Goals:	Strategies:
5.5.2 Select water-efficient fixtures ⇒ *Key Issue: Water* ⇒ *Related Issues: Site Ecology, Energy*	**Install the following where appropriate**: ◦ Lavatory and kitchen faucets with max 9.5 litres per minute. ◦ Public lavatory faucets with 2 litres per minute or less. ◦ Self-closing, time-activated (5 second shut off) or motion-detecting public faucets. ◦ Showers with a maximum of 9.5 litres per minute ◦ Public showers self-closing time-activated (1 minute shut off). ◦ Dishwashers with a maximum of 27 litres on normal cycle (for non-industrial use). ◦ Clothes washers that are energy and water efficient (e.g. horizontal axis). ◦ HVAC water that is made up of recycled or storm water.

Goals:	Strategies:
5.5.3 Monitor water use ⇒ *Key Issue: Water*	◦ **Install water meters** to allow measurement of potable water consumption.

Goals:	Strategies:
5.5.4 Reduce water-related energy use ⇒ *Key Issue: Energy* ⇒ *Related Issues: Water*	° **Minimize energy use in water systems**. Insulating water pipes, reducing pipe lengths, reclaiming heat from water, choosing efficient dishwashers and washing machines and other techniques and features can save energy.

Resources for reducing annual energy use:

2.2. Whole Building Resources

- Environmental Building News

3.1. Energy Use

- EnerGuide

Case Studies for reducing annual energy use:

4.4. Water Case Studies

4.4.1. Water Use Case Studies

- Canadian Water and Wastewater Association

5.6 Lighting Design

Goals:	Strategies
5.6.1 Reduce lighting load ⇒ *Key Issue: Energy* ⇒ *Related: IEQ*	◦ **Install high-efficacy lamps & fixtures** (e.g.: compact fluorescents and T-8 lamps). ◦ **Maximize daylight** to reduce the need for electric lighting. (See below 5.6.2 Maximize daylight and views. See also 5.3.3 Optimizing indoor environmental quality).

Goals:	Strategies:
5.6.2 Maximize daylight and views ⇒ *Key Issues: Indoor Environmental Quality (IEQ)* ⇒ *Related Issue: Site Ecology, Energy, Health Safety and Comfort*	◦ **Ensure occupied spaces have direct access to outdoor views**. The use of interior atriums, courtyards, clerestory windows, etc., can bring outdoor views and light into the building. ◦ **Ensure all occupied spaces have access to daylight**. Using a smaller footprint and narrower building depth allows light to penetrate better throughout the building. If the building is broad, lightshelves can be used to allow light deep into the interior. ◦ **Reduce glare and unwanted heat gain** by using sun shading, interior or exterior window treatments and or light shelves. Deciduous trees can provide excellent sunshading, allowing light through in the winter and blocking unwanted lighting the summer. ◦ **Consider consulting professionals like those at the Seattle Lighting Design Lab.** The Lab provides assistance to residential and to commercial lighting designers seeking the most efficient lighting technologies and strategies, and it uses a 1,200 square foot mock-up facility and a daylighting lab.

Daylight and occupancy sensors in the CK Choi Building, UBC reduce the use of artificial lighting. The lighting load is 0.9 w / sq. ft.

Picture reprinted with permission from Michael Sherman Photography.

Resources for maximizing daylight and views:

2.1. Guidelines
- Santa Monica's Green Buildings Guidelines

2.2. Whole Building Resources
- Advanced Technologies For Commercial Buildings
- Vital Signs Project
- Sustainable Building Technical Manual

3.1. Energy Use
- Seattle Lighting Design Lab
- Daylighting Performance and Design
- Daylighting in Architecture, A European Reference Book

9.6. Daylighting

Case Studies for maximizing daylight and views:

3.4.1. Energy Use Case Studies
3.4.2. Energy Source Case Studies
9.7.2. Daylighting Case Studies

Goals:	Strategies:
5.6.3 Provide user comfort and control ⇒ *Key Issue: IEQ*	° **Provide individual controls for lighting where feasible**. This encourages users to turns lights off, and it also allows a high level of comfort and control. ° **Minimize glare and visual discomfort from electric lighting sources**. The design of the room form, surfaces, and lightshelves, and the choice of finishes can assist in providing comfortable light distribution.

5.7 Mechanical Design

Goals: **Strategies**

5.7.1 Optimize mechanical system to meet reduced loads

⇒ *Key Issue: Energy*

⇒ *Related Issues: Indoor Environmental Quality, Light*

- **Avoid over-sizing equipment.** At this point in the design, the mechanical engineer has worked with the architect, electrical engineer and design team to reduce heating and cooling loads so that the mechanical system can be reduced. The next step is to ensure that the mechanical equipment is appropriately sized down as well.
- **Install high-efficiency heating and cooling equipment**. Explore feasibility and life cycle cost of heat recovery equipment. Determine the feasibility and life-cycle cost of using demand control ventilation and motion- or CO_2-detecting occupancy sensors for lights and HVAC systems. These measures are most appropriate for spaces with intermittent or short-duration occupancy loads.

The YMCA Environmental Learning Centre in Paradise Lake, Ontario (pictured above and below) is completely off the energy grid. It gets energy from a wind turbine and photovoltaic arrays, and uses solar water heating. Natural ventilation, night sky evaporative cooling, extensive use of daylighting and earth covered roofs keep the energy use down. The greenhouse provides passive solar heating and also hosts a “living machine” that filters and cleanses the wastewater. The building uses recycled materials and has composting toilets. Pictures courtesy of the Advanced Building website.

- **Maximize the use of passive heating and cooling**, using such methods as solar heat gain and natural ventilation.
- **Explore the life-cycle costs renewable and alternate energy sources.** Consider, for example, solar water pre-heating, photovoltaic panels, wind power, geothermal heat exchange, local microhydro, fuel cells, or other benign energy sources.
- **Do a computer-simulated energy modelling** of the building, to minimize energy use by optimizing the site, envelope, ventilation, water, lighting, and mechanical systems design.

Resources for optimising the mechanical system**:**

3.0. Ecological Performance Resources: Energy

3.1. Energy Use

- Commercial Building Incentive Program (CBIP)
- EnerGuide
- Energy Modelling and Software Tools

3.2. Energy Source

- The Canadian Renewable Energy Network
- RetScreen
- Renewable Energy and Sustainable Energy Systems in Canada

Case Studies for optimising the mechanical system**:**

3.4.1. Energy Use Case Studies

- British Columbia Green Building Case Study Series
- CBIP Case Studies
- CMHCs “Building Innovation” Case Studies
- MIT’s Natural Ventilation Case Studies
- BRE’s Environmental Building, UK
- The Energy Resource Center
- Seattle City Light Case Studies

3.4.2. Energy Source Case Studies

- Canadian REN Case Studies
- Canadian Geothermal Case Studies
- Commonwealth of Pennsylvania, DEP Cambria Office
- Geoexchange: Geothermal Heat Pump Consortium
- Energie Cités Case Studies
- Beddington Zero (fossil) Energy Development (BedZED) Case Study
- BCIT Photovoltaic

Goals:	Strategies:
5.7.2 Reduce ozone depletion ⇒ *Key Issue: Other Ecological Issues*	◦ **Use HVAC systems, refrigerants and fire-suppressant equipment that do not contain CFCs, HCFCs or Halons**. If HVAC systems are inherited that contain CFCs or HCFCs, perform a phaseout conversion.

Goals:	Strategies:
5.7.3 Document designs for commissioning ⇒ *Key Issue: Energy* ⇒ *Related Issues: All*	◦ **All major building system designs should be documented for commissioning**. This is so that they are installed and calibrated to operate as they the design indented. An independent commissioning authority should be hired to verify the installation, performance, training and documentation. Consider making contractor payments dependent on the commissioning agents' verification of system performance that complies with design and construction documents.

although energy systems have historically been the focus of commissioning, all major systems should be commissioned

→

Resources

4.3. Human Waste
- CMHCs Commissioning Guide For The Toronto Healthy Houses Water Systems

9.0. Human Health And Comfort Resources: Indoor Environmental Quality
- Commissioning Specifications, C-2000 Program
- ASHRAE (1996) Guideline 1: The HVAC Commissioning Process
- USDOE Buildings For the 21st Century Program
- Sustainable Building Technical Manual
- Santa Monica's Green Buildings Design & Construction Guidelines
- NYC High Performance Building Guidelines
- PECI Commissioning Resources
- USDOE / PECI Model Commissioning Plan and Guide Commissioning Specifications

Goals:	Strategies:
5.7.4 Monitor carbon dioxide ⇒ *Key Issue: IEQ*	◦ **Monitor carbon dioxide to ensure indoor air quality**. A permanent CO_2 monitor will ensure that space ventilation is performing to design. It could be independent or part of the building controls. This system should be part of the commissioning verification process.

Goals:	Strategies:
5.7.5 Ensure indoor air is free of pollution ⇒ *Key Issue: IEQ*	◦ **Perform ventilation effectiveness**. This may require the owner paying the consultant extra for this service. It is extra work, and not included in standard contracts. ◦ **Ensure adequate air filtration.** Filter air to top standards.

Resources

9.4. Ventilation Effectiveness And Air Filtration

- ASHRAE Fundamentals Handbook: Mechanically ventilated buildings can be designed to perform air change effectiveness (E) of at least 0.9 using ASHRAE 129-1997.
- ASHRAE Standard 52.1-1992: Gravimetric and Dust Spot Procedures: Supply air filters can be specified as a minimum of 40% efficient according to ASHRAE Dust Spot method.
- Practical Control of Indoor Air Problems

5.8 Finalize building systems design

Goals:	Strategies
5.8.1 Finalize energy performance targets ⇒ *Key Issues: energy*	◦ **As the design team finishes the building systems design phase,** they need to come to consensus on the project's energy performance targets. The initial energy performance targets should be modified in light of what is possible on this site and within the project budget.

Goals:	Strategies
5.8.2 Update all environmental performance targets ⇒ *Key Issues: energy*	◦ **As the design team finishes the building systems design phase,** all environmental performance targets should be updated. The final energy targets and updated performance targets should be circulated to each design team member (including the owner) to refer to throughout the design.

Interior Finishes and Appliances Selection

Picture reprinted with permission by Architectura.

The Liu Centre for the Study of Global Issues at the University of British Columbia minimized concrete and cement through an efficient structural system that combines precast hollow core planks and cast-in-place frames using 50% high volume fly ash (HVFA) content concrete. Fly ash is a waste material that displaces cement in the concrete mix. In the GVRD, cement manufacturing produces 80% as much greenhouse gas emissions as automobiles. In the picture above, concrete forms the flooring and acts as both as structure and as finish. In addition, many salvaged materials were used throughout the building, including courtyard pavers. Salvaged glulam beams and structural decking form the seminar wing's exposed structure.

6 Sixth Stage in the Process: **Interior Finishes and Appliances**

Goals:	Strategies:
6.1 Reduce internal loads ⇒ *Key Issue: Energy* ⇒ *Related Issues: Water, IEQ*	° **Install high-efficiency appliances**. Select energy efficient equipment, including: copy machines, computers, printers etc. in offices; washing machines, dishwashers, refrigerators, microwaves, ovens, etc, for domestic uses; and other energy efficient equipment for other uses. Often the appliances are selected once the building is cmplete.

Resources

3.0. Ecological Performance Resources: Energy
3.1. Energy Use

- Commercial Building Incentive Program (CBIP)
- EnerGuide
- CBIP Screening Tool
- Further resources

Goals:	Strategies:
6.2 Reduce disposal of waste materials to landfills ⇒ *Key Issue: Waste*	° **Provide built-in recycling amenities** that make it easier for occupants to recycle than throw away. Create accessible areas for separating, collecting, and storing paper, glass, plastics and metals. ° **Provide built-in composting amenities**, including storage and use areas for composting. ° **Select indoor finishes that are recycled or salvaged.** Refer to the glossary for examples of commonly salvaged and recycled materials.

Picture of the CK Choi Building reprinted with permission from Michael Sherman Photography.

"The main structure for the building is re-used heavy timbers from the demolition of the old UBC Armouries. The brick façade is from a street in Gastown. The doors, washroom accessories, stair rails and other finishings are also reused. Most other building materials used have the maximum possible recycled content."
Freda Pagani, Director, Sustainability, Land and Building Services UBC, talking about the CK Choi building. 1988

Resources

7.0. Ecological Performance Resources: Waste
7.1. Solid Waste

- B.C. Recycling Hotline
- Recycling Council of British Columbia
- GVRD's Solid Waste Site
- City of Vancouver's Garbage and Recycling Site

7.2. Composting Facilities

- GVRD's Composting Site
- City of Vancouver's Composting Programs
- Landscape Planning: Environmental Applications
- Landscape Ecology Principles

Case Studies

7.3.1. Composting Facilities Case Studies

- GVRD Information on Compost Demonstration Gardens
- UBC Compost Project
- Organics Composting System at BCIT

Goals:	Strategies:
6.3 Ensure indoor air is free of pollution ⇒ *Key Issue: IEQ*	◦ **Select indoor finish materials for minimal indoor air pollutant emissions.** Strive to make indoor finishes (paint, adhesives, surface coatings, and surface areas) "Ecologo" Certified, "Zero VOC" certified, "Green Seal" certified (for paints and coatings) or Carpet and Rug Institute Certified (for carpeting) or equivalent. ◦ **Surfaces exposed to inhabited spaces, supply or return air should not trap or release dust, mineral or glass fibre**. The building design should ensure that acoustic duct linings are protected, fibrous finishes are avoided and that ceiling plenums that expose the airstream to artificial mineral or glass fibres are avoided. ◦ **Locate air intakes distant from sources of outdoor pollution**. Review site conditions carefully to ensure that the air intake is placed to bring in fresh air. The proposed ASHRAE standard 62 r (1997) is a good source for recommended separation distances.

Resources

6.0. Ecological Performance Resources: Materials
6.5. Durable, Low Maintenance and Healthy Materials
6.6. Low-Environmental Impact Materials
6.7. Overall Material Resources
9.0. Human Health and Comfort Resources: Indoor Environmental Quality
9.1. Air Pollutant Emissions
9.2. Mineral and Glass Fibre
9.3. Outdoor Air Intake
9.4. Ventilation Effectiveness and Air Filtration
9.5. System Commissioning and Cleaning
9.7. Overall Indoor Environmental Quality Resources

the following case studies have a variety of ways of ensuring that indoor air is free of pollution →

Case Studies

9.7.1. Air Pollutant Emission Case Studies

- Crestwood Corporate Centre Building 2
- CK Choi Building
- Lewis Center for Environmental Studies
- Pennsylvania's Department of Environmental Protection
- Probe (Post-Occupancy Review of Buildings and their Engineering)

Specifications / Construction Drawings

The solarwall system in place at Charlie Lake School gymnasium, Peace River School District #60, Fort Saint John, BC. Photograph above, solarwall on building exterior; photograph below, interior detail in gym.

Photographs reprinted with permission from Ivan Lewis.

7 *Seventh Stage in the Process:* **Specifications / Construction Drawings**[4]

Goals:	Strategies:
7.1 Specify the overall environmental intent of the project ⇒ *Key Issues: All*	◦ **Summarize the project's environmental requirements** in Division 1 - General Requirements construction contract specification sections. This will help to ensure that the detailed specifications throughout are understood in the context of the overall environmental performance targets.

Resources

2.2.1. Whole Building Case Studies

- Research Triangle Park Case Study and Specs: The Division 1 environmental specs are available on the internet.

Goals:	Strategies:
7.2 Specify environmental site design features ⇒ *Key Issue: Site Ecology* ⇒ *Related Issues: water, energy*	◦ **Provide detailed spec and drawing information for the preservation of site ecology.** Site disturbances can be limited by delineating recycling and disposal areas, and by establishing clear construction boundaries. Natural areas can be rehabilitated and appropriate wildlife (butterflies, birds, etc) can be encouraged using native species and ecosystems. A horticulturalist, landscape architect or native plant society can assist in selecting the necessary plants and landscape features to be specified in the construction contract. ◦ **Provide detailed spec and drawing information for all site water features.** Features like the ones that follow will need drawings and specifications to describe them: vegetative swales, filter strips, vegetative buffers, infiltration basins, drywells, pervious paving, oil / water separators, curb-less roads, and roof gardens. Any systems that are intended to be used to harvest rainwater, use recycled stormwater or site-treated grey or waste water for irrigation should be specified and drawn. All water-efficient plantings and irrigation systems need to be specified. See the "3rd Stage in The Process: Site Design" for resources and case studies for the above strategies. See the "8th Stage in The Process: Construction and Commissioning" for strategies to prevent erosion and preserve site ecology during construction that can be used in the specs. Particularly important to the spec writing is the "Site Sediment and Erosion Control Plan."

[4] Every design decision that is made in each stage of the process needs to be translated into specifications. This section simply highlights some of the areas that are of particular concern, and provides some specifications that are freely available.

Goals:	Strategies:
7.3 Specify energy-efficient systems and products ⇒ *Key Issue: Energy* ⇒ *Related Issues: All*	◦ **Specify the package of energy conservations measures and other systems that were selected through the use of energy computer simulation software.** This will include specifying the selected envelope, ventilation, water, lighting, and mechanical systems. ◦ **Specify energy efficient equipment**, including: copy machines, computers, printers etc. in offices; washing machines, dishwashers, refrigerators, microwaves, ovens, etc, for domestic uses; and other energy efficient equipment for other uses.

Goals:	Strategies:
7.4 Specify acceptable indoor air quality ⇒ *Key Issue: Air Quality*	◦ **Specify that all mechanical systems and all ventilation systems meet current best standards.** Also, specify that all air cleaning and air filtration systems meet current best standards. ◦ **Specify space around ventilation equipment**. All ventilation equipment should be installed with enough space around it so that it can be maintained and inspected on a regular basis. Design space around equipment to allow for replacement and adjustment of filters, fan equipment, and other items.

Resources for specifying acceptable indoor air quality:

9.0. Human Health and Comfort Resources: Indoor Environmental Quality
9.3. Outdoor Air Intake

- ASHRAE Publications
- Ventilation systems can be specified to meet or exceed ASHRAE 62-1999.
- All mechanical systems can be specified to comply with ASHRAEs recommendations for prevention of standing water, found in ASHRAE 62-1999.
- Air cleaning and filtration systems can be specified to meet or exceed ASHRAE 52.2.

Goals:	Strategies:
7.5 Specify water-efficient fixtures and systems ⇒ *Key Issue: Water*	◦ **Specify products and systems that use water efficiently.** This includes all fixtures, features and systems intended to reduce or prevent the use of potable water to treat human waste. See 5.4. Water Systems Design for examples of products to be specified, for resources and case studies.

Goals:	Strategies:
7.6 Specify green products and materials ⇒ *Key Issue: Materials*	◦ **Specify salvaged, recycled and efficient materials** as much as possible. The GVRD's Directory of Resource and Efficient Building Products can be used to find appropriate materials. See the glossary for definitions and standard examples of these materials. ◦ **Specify local materials.** Avoid the environmental and economic costs of transportation by specifying local materials, products, services and systems as much as possible. ◦ **Specify rapidly renewable materials.** See the glossary for definition and examples of standard products to specify. ◦ **Specify minimally processed products.** Use materials that have not been highly processed, as they will have less embodied energy, and there will be little risk of chemical emissions from the manufacturing process. Examples include natural stone and slate shingles, wood products and plant products (agricultural or non-agricultural). ◦ **Specify low-emissions products**. This includes zero- and low-VOC paints, caulks, and adhesives. It also includes other reduced-emissions materials or products, like non-formaldehyde manufactured wood. ◦ **Specify alternatives to ozone-depleting substances**. Many building materials still utilize HCFCs, including rigid and blown foam insulations, some carpet pad and compression-cycle HVAC equipment. Alternatives should be specified. ◦ **Specify alternatives to PVC, polycarbonates, and other hazardous components.** There are many alternatives available to vinyl, PVC cabling and PVC pipes. Other alternatives to hazardous materials include low mercury fluorescent lamps and chromium-free solar collectors. ◦ **Specify durable and low maintenance materials and products**. These include products such as fiberglass windows, fibercement siding, slate shingles, and vitrified clay waste pipe.

Resources for specifying green products and materials:

6.0. Ecological Performance Resources: Materials
6.1. Recycled Materials
6.2. Efficient Materials
6.3. Salvaged Materials
6.5. Durable, Low Maintenance And Healthy Materials
6.6. Low-Environmental Impact Materials
6.7. Overall Material Resources

- Environmental Building News: One of the best resources for specifying green materials and products is the Environmental Building News GreenSpec™ Directory.

Case Studies for specifying green products and materials:

2.2.1. Whole Building Case Studies

- Sydney Olympic Village: See this case study for examples of PVC alternatives.

6.8.1. Materials Case Studies

Goals:	Strategies:
7.7 Specify construction waste reduction ⇒ *Key Issue: Waste*	See the 8th Stage in the Process: Construction and Commissioning, “Minimize the disposal of construction waste” for strategies, resources and case studies for writing specs. Particularly see the GVRDs master spec.

Goals:	Strategies:
7.8 Specify commissioning process ⇒ *Key Issue: Energy*	See the 8th Stage in the Process: Construction and Commissioning, “Commission all major systems” for strategies, resources and case studies for writing specs.

Goals:	Strategies:
7.9 Verify that all building systems meet energy targets ⇒ *Key Issue: Energy*	**Conduct the final energy simulation to verify performance.** This final computer energy simulation should be conducted when working drawings and specifications are 95% complete. The purpose of this is to verify that the final design meets the design intent.

Construction and Commissioning

Photograph courtesy of the Advanced Building website and Enermodal Engineering.

Reducing the number of car parking spaces can not only save $C0_2$ as people choose other transportation choices, but it can reduce construction costs significantly. Ottawa's Conservation Coop, above, is located downtown close to transit and within walking distance from many services. In this apartment building housing over 200 people, there are only 8 car-parking spots, but storage space for 240 bicycles. Some of the bike storage is seen above.

"When commissioning is done correctly, cost savings can be substantial. The Oregon Office of Energy documented direct energy savings of 279,000 kW/year or $12,276 per year for a 110,000 square foot office building. In a 22,000 square foot office building, energy savings equalled 130,800 kWh/year or $7,630 per year, equivalent to $0.35 per square foot."
LEED Reference Guide Version 2.0

8 *Eighth Stage in the Process:* **Construction and Commissioning**

Goals:	Strategies:
8.1 Prevent erosion during construction ⇒ *Key Issues: Site Ecology, Water, Waste*	**Minimize site disturbance**. There are a number of strategies that include: ° maintaining or providing vegetated ground cover ° controlling erosion with mulch or grass ° controlling sedimentation by building silt fences, stabilized slopes, or sediment traps. The prevention of erosion is important because properly done, it will also prevent the accompanying air pollution, and sedimentation of streams and storm sewers.

Resources to prevent erosion during construction:

4.2. Water Filtration
- USEPA Publications: See "Storm Water Management for Construction Activities"

8.2. Reuse Topsoil
- CMHC Waste Management Action Plan

Goals:	Strategies:
8.2 Ensure protection of site ecosystem ⇒ *Key Issues: Site Ecology, Water*	° **Rare vegetation, large trees, and watercourses are protected during construction**. Requirements for landscape and watercourse protection should be written into contract documents, and there should be follow-up during construction. For this to be done properly, an inventory should have been completed at the initial design stage, which can be referred to now. A wide area around the trees and other features to be protected can be fenced off, and construction can be scheduled to minimize damage to these protected areas. An area can be designated for washing down concrete trucks etc., to ensure there is no erosion of site soils. ° **Use a formal Site Sediment and Erosion Control Plan** to ensure that stormwater does not erode site soil and contaminate local water bodies. This may mean maintaining site landscape throughout construction or providing ground cover, or it might mean phasing construction, stabilizing soils, or using other measures. Creating and following a plan should prevent loss of site soil as well as the sedimentation of storm sewers, streams and the local air.

Resources to ensure protection of site ecosystem:

4.2. Water Filtration
- USEPA Publications

Resources to ensure the protection of site ecosystem:

4.2. Water Filtration
- BC Urban Fish Habitat Protected by New Streamside Regulation
- USEPA Technology Fact Sheets

8.2. Reuse Topsoil
- CMHC Waste Management Action Plan

Picture of fish reprinted with permission of Fisheries and Oceans Canada

8.3. Vegetation And Watercourse Protection
- Landscape Ecology Principles in Landscape Architecture and Land-Use Planning
- Manual for Stormwater Quality Protection
- Erosion and Sediment Control Field Manual

Case Studies to ensure the protection of site ecosystem:

these cases show the preservation of rare and large trees and watercourses

5.4.1. Green Space Case Studies
- Burnaby Mountain Secondary School
- Lewis Center for Environmental Studies
- Austin Green Building Program Case Studies

5.4.2. Native Plantings And Wildlife Habitat Case Studies
- Research Triangle Park Case Study

8.4.1. Construction Waste Case Studies
- The Liu Centre
- CK Choi Building
- GVRD's Construction/Demolition Recycling Case Studies

Goals:	Strategies:
8.3 Minimize the disposal of construction waste ⇒ *Key Issue: Construction Waste*	◦ **Construction and demolition waste is reused, recycled or salvaged for later reuse**. This can be achieved through using a project waste management specification. ◦ **Ensure that the contractor follows a formal Waste Management Plan.** This WMP shall ensure construction-site recycling of: corrugated cardboard, clean dimensional wood, palette wood, concrete, brick, concrete block, asphalt, metal, drywall, land clearing debris, paint. For demolition projects, this WMP shall encourage the salvaging of: dimensioned lumber; heavy timbers; wood siding; structural steel; wood panelling; moulding; trim and wainscoting; heritage architectural elements; cabinets and casework; brick and block; electric equipment and light fixtures; plumbing fixtures and brass; windows, doors and frames and hardwood flooring.

Resources to minimize the disposal of construction waste:

8.0. Ecological Performance Resources: Construction Practices

8.1. Construction Waste

- GVRD's Construction/Demolition Recycling Program: The Greater Vancouver Regional District's Project Waste Management Master Specification (or equivalent) saves the owner money, and ensures that all possible construction and demolition waste is recycled, reused or salvaged.
- Metropolitan Portland Construction and Demolition Waste Information Program
- City of Los Angeles Solid Resources Citywide Recycling Division

Picture of CK Choi Centre courtesy of Matsuzaki Wright Architects

Case Studies to minimize the disposal of construction waste:

these practices save money

8.4.1. Construction Waste Case Studies

- The Liu Centre
- CK Choi Building
- GVRD's Construction/Demolition Recycling Case Studies

Goals:

8.4 Protect and conserve topsoil

⇒ *Key Issue: Construction*

Strategies:

- **All topsoil removed during construction is saved and reused**. Even if it not used on the same site, it can be sold for use on another site.

Resources to protect and conserve topsoil:

8.2. Reuse Topsoil

- CMHC Waste Management Action Plan

Goals:

8.5 Ensure indoor air quality

⇒ *Key Issue: IEQ*

Strategies:

- **Develop and implement an Indoor Air Quality Construction Plan**. This should include the below features:
- **Plan and implement construction sequencing** that requires absorptive materials (like insulation, carpeting, ceiling tiles, gypsum, textile materials) to be installed after drying or curing of materials that may emit chemicals detrimental to IAQ.
- **Ensure absorptive materials are safe from moisture damage**. Ensure condensation and moisture in HVAC is drained safely and reliably.
- **Ensure supply and return air duct systems are clean and verified before occupancy**. This can be done by sealing the air ducts during construction, or by flushing them out before occupancy.
- **Conduct a complete building flushout** using new filters and 100% outdoor air for a minimum of one week before occupancy.

Resources to ensure indoor air quality:

9.0. Human Health and Comfort Resources: Indoor Environmental Quality

9.1. Air Pollutant Emissions

- Canada Mortgage and Housing Corporation
- Eco Logo Program
- USEPA Indoor Air Quality Division

9.2. Mineral And Glass Fibre

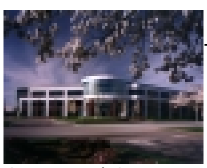
- Indoor Pollutants
- Guidelines for Reducing Occupant Exposure to Volatile Organic Compounds (VOCs) from Office Building Construction Materials
- Indoor Air Quality Info Sheet
- Indoor Air Bulletin
- IEQ Strategies & Energy Design Update

9.3. Outdoor Air Intake

- ASHRAE Fundamentals Handbook
- ASHRAE Systems and Equipment Handbook
- ASHRAE Standard 62-1989: Ventilation for Acceptable Indoor Air Quality

9.4. Ventilation Effectiveness And Air Filtration

- Gravimetric and Dust Spot Procedures
- Practical Control of Indoor Air Problems


Crestwood Centre courtesy of Bunting Coady Architects

Case Studies for ensuring indoor air quality:

9.7.1. Air Pollutant Emission Case Studies

- Crestwood Corporate Centre Building 2
- CK Choi Building
- The Liu Centre
- Lewis Center for Environmental Studies

Goals:	Strategies:
8.6 Commission all major systems ⇒ *Key Issue: Energy* ⇒ *Related Issues: All*	◦ **All major building systems are commissioned**. This is so that they are installed and calibrated to operate as the design indented. An independent commissioning authority should be hired to verify the installation, performance, training and documentation. Consider making contractor payments dependent on the commissioning agents' verification of system performance that complies with design and construction documents.

although energy systems have historically been the focus of commissioning, all major systems should be commissioned

Resources

4.3. Human Waste
- CMHCs Commissioning Guide For The Toronto Healthy Houses Water Systems

9.0. Human Health And Comfort Resources: Indoor Environmental Quality
- Commissioning Specifications, C-2000 Program
- ASHRAE (1996) Guideline 1: HVAC Commissioning
- → PECI Commissioning Resources
- Building Commissioning Guidelines

these case studies have information on commissioning

Case Studies

9.7.1. Air Pollutant Emission Case Studies
- Probe (Post-Occupancy Review of Buildings and their Engineering)

9 *Ninth Stage in the Process:* **Operations and Maintenance**

This section will be developed in future drafts of this document.

GLOSSARY

Albedo: The proportion of reflected radiation to the total radiation falling on a surface. A highly reflective surface has a high albedo (see *urban heat island effect*[5]). Roofs and other surfaces such as playgrounds, courtyards and paths should be designed with a high albedo (e.g. an albedo reflectance of 0.5). This can be accomplished either through the use of a light-coloured surface or vegetation.

Alternate energy: Alternate energy may include *geothermal heat exchangers*, *fuel cells*, and other relatively benign energy sources.

ASHRAE: The American Society of Heating, Refrigeration and Air Conditioning Engineers

ASHRAE Dust Spot Method: Dust spot efficiency is measured by testing a filter's ability to efficiently collect fine particles of a mix specified by the ASHRAE filter test procedure.

Biodiversity: The complete range of biological organisms that exist in an undisturbed ecosystem.

Brownfield sites: Previously-used, under-used, or abandoned industrial and commercial facilities that are ecologically degraded or environmentally contaminated.

Building energy simulation: This is a computerized modelling of a building and its systems that forecasts the expected energy consumption performance. It is usually based on hourly weather data for the area and the predicted schedule of the building's occupants and loads. It is a useful tool to select ECMs (energy conservation measures).
The energy simulation can take place at three stages—the first one is optional and the last two have been found to be crucial to ensuring the utility of the energy simulation:

[5] Words in Italics can also be found in the glossary.

Building energy simulation (cont.):

1. The first (optional) energy simulation can take place in the building orientation and configuration stage. At this point, the form, massing, orientation and configuration are optimized. Doing a simulation at this stage is particularly useful if the building's HVAC loads are dominated by outdoor conditions and it is an "envelope dominated" building. These are usually smaller buildings with higher envelope area to volume ratios, or low internal loads.
2. Energy simulation can be crucial at the Building System design stage. The kinds of energy conservation measures tested by the simulation might include:
   - design and selection of HVAC systems, including natural or mechanical heating and ventilation
   - use of renewable or alternate energy
   - envelope design
   - shading provided by landscape, building form, or other devices
   - lighting system design including fixture selection, daylighting and control of glare
   - selection of energy efficient water systems
   - control strategies for lighting and HVAC systems

If an energy simulation was not required at the Building Orientation and Configuration stage, then the energy model at this stage will also include orientation, configuration, massing and siting elements of the building.

3. A final computer energy simulation should be conducted when working drawings and specifications are 95% complete. The purpose of this is to verify that the final design meets the design intent.

Building commissioning: A comprehensive plan and process that ensures all building systems perform according to the documented design intent and the owner's operational needs.

Chlorofluorocarbons (CFCs): These chemicals are used as coolant in mechanical equipment (refrigeration, air conditioning, packaging, insulation, or as solvents and aerosol propellants) and are now phased out due to their damaging effects. CFCs should be reclaimed whenever servicing or disposing of old equipment. Building materials that use CFCs or HCFCs should be avoided (or they will off-gas over the life of the material). (See *HCFC*s)

Commercial Building Incentive Program (CBIP):	A program from Natural Resources Canada--Office of Energy Efficiency. Financial incentives of up to $60,000 are given for commercial / institutional buildings that are 25% more energy efficient than the *MNECB*. Code and CBIP compliance software is available. Contact Jim Clark (613) 947-1948 or Terri Scott (613) 943-9227 or visit: http://cbip.nrcan.gc.ca/cbip.htm
Compost:	A process by which organic wastes break down into soil.
Daylighting:	Lighting spaces within a building with natural light.
Demand control ventilation:	Fresh air is supplied in response to actual number of occupants and occupant activity. This can be through occupancy sensors or user control.
Energy conservation measure (ECM):	A specific device, action, or strategy that reduces energy consumption in a building.
Filter strip:	A landscaping feature that treats run-off by diverting it across a grassy area.
Fuel cell:	An electrochemical technology that converts energy into electrical power. Depending on what it is fuelled by it can generate less pollution than grid-connected power.
Geothermal heat exchange:	A technology that uses electricity to exchange heat with the ground. In colder times, it uses heat from below the ground to heat buildings. In warmer times, heat is extracted from the building and put into the ground.
Greywater:	The wastewater from faucets, showers, and clothes washing that does not contain sewage or faecal contamination. Kitchen sink and toilet water is called blackwater. Greywater can be reused for irrigation after it is filtered.
Greater Vancouver Regional District (GVRD):	A regional district that offers resources and information in the following areas: composting, recycling, salvaging, and job-site recycling.
Greenfield sites:	Sites that have never been previously developed.
Heat recovery systems:	These are mechanical systems that are designed to capture waste heat from one system for use in another, avoiding having to generate heat from a primary energy source.
HVAC:	Heating Ventilating and Air Conditioning

Hydro-chlorofluorocarbons (HCFCs):	HCFCs deplete ozone slower than *CFCs*, however, they still pose an environmental problem. A total ban on HCFCs is to be effective 2030. Many building materials still utilize HCFCs, including rigid and blown foam insulations, some carpet pad and compression-cycle HVAC equipment. Alternatives should be specified.
Indoor Air Quality (IAQ):	Acceptable IAQ is defined by ASHRAE standards. Defined as air that is not likely to pose a health risk and if a substantial majority of occupants do not express dissatisfaction.
Indoor finish materials:	Paints, coatings, adhesives, architectural sealants, filler and surface areas.
Infill:	Infill development "fills in" empty lots of land (or empty portions of already partly used lots) within an urban area, helping to reduce urban sprawl.
Integrated Pest Management (IPM):	A comprehensive method of pest management intended to minimize impacts on the environment and on human health. For more information, contact the Integrated Pest Management Division, Ministry of Environment, Lands and Parks. Contact Linda Gilkeson, IPM Coordinator: phone: (250) 387-9410.
Life cycle assessment:	An economic analysis that includes capital costs, transportation costs, installation costs, operating costs, maintenance costs, and disposal costs.
Low-e windows:	*Low-emissivity windows* are designed to reflect heat but admit light. This keeps buildings warmer in winter and cooler in summer, saving energy.
Micro hydro:	A small-scale, site-specific, renewable resource of electricity using small scale hydro generators.
Mineral fibres:	Minute insulation fibres made from glassy minerals. They are formed by melting and spinning glass fibre.
Mixed-use:	Development that combines many uses, like institutional and residential with retail or commercial.
MNECB:	Model National Energy Code for Buildings.
Off-gassing:	Any material that emits gaseous chemicals into the air. See *VOC*s.
Photovoltaic panels (PVs):	A technology that uses semiconductor material in photovoltaic (PV) solar panels to convert sunlight to electric power.

Pollutant sink: Some carpets, drywall and insulation can act like sponges or a trap for pollutants. They can absorb gases, vapour, moisture, mildew and other pollutants. They will then re-emit these pollutants later.

Polyvinyl chloride (PVC): PVC produces hazardous chlorinated hydrocarbons including dioxin, which is linked to birth defects, cancer and hormone disruption. Standard PVC products include water and waste pipes, vinyl flooring, PVC-sheathed cabling and furniture. There are PVC-free alternatives available for all of these products.

Rapidly renewable materials: Materials that have a harvest rotation of 10 years or less. These materials use the sun's energy efficiently, and are considered to have less embodied energy. Examples include linoleum, some products made with plant oils, natural paints, materials made with coir and jute, cork, and materials made with organic cotton, wool, and sisal. However, if a material meets these standards, but requires large transportation distances or emits VOCs or other chemicals, its use should be reconsidered.

Recyclables: Materials that are able to be collected and recycled.

Recycled materials: Materials that are bought new but have used some recycled content in the manufacturing process. There are several main categories:

- Post-consumer content is material that has been used as a consumer item and then recycled.
- Pre-consumer recycled content (also called post-industrial and secondary material) is material that has been part of an industrial process and is then recycled.

Post consumer recycled materials should be chosen over post-industrial recycled content.

Standard examples of materials with recycled content include: drywall, steel framing, insulation (cellulose, polystyrene, fiberglass, and mineral wool insulation are all available with recycled content), ceiling tiles, concrete aggregate, compost, carpet and pad, floor tile, paint, glass cullet, playground surfacing, roofing (shingle, tile, and panel roofs all are available with recycled content) and parking stops.

Renewable energy: Energy from sources that are continuously being renewed like wind energy, solar energy, *micro hydro*.

R-value: The thermal resistance of a material.

Salvaged materials: Materials that have been used before and have not been remanufactured, but may require some minor processing. Standard examples include: floors, landscaping materials, brick, masonry, sinks, bathtubs, windows, doors, hardware, tile, millwork, dimensional lumber, timbers, electrical fixtures, insulation. As the majority of the energy that is used in a building throughout its life is in operating energy, old windows and HVAC systems should only be used if they are reconstructed, or if they are up to very high energy standards.

Shoulder Seasons: Spring and autumn, when a building requires both heating and cooling in the course of daily operation.

Sick Building Syndrome (SBS): A condition that includes impacts on health and comfort experienced by occupants of some buildings.

Stack effect: Thermal buoyancy induced by a temperature difference between the outdoor air and the indoor air.

Thermal bridge: A pathway for heating energy flow through with little resistance. Any highly conductive element like a metal stud, spacer or channel in the building envelope that penetrates or bypasses the insulation will act as a bridge through which heat can escape.

Thermal flywheel: The cyclical pattern that is established when a building element like a solid masonry wall collects heat during one period and discharges it during another period.

Urban heat island effect: The replacement of vegetative cover with artificial surfaces has resulted in increased local temperatures. This phenomenon can increase urban air temperatures by up to 10 ^{o} F compared to air temperatures over adjacent rural areas. See also: *albedo.*

Variable air volume (VAV): A method used to deliver heating or cooling used in some *heating ventilating and air conditioning* (*HVAC*) systems. VAV systems vary the air flow to a space in proportion to its demand for cooling or heating. Other systems vary supply air temperatures, and keep airflow constant.

Vegetative buffer: A strip of heavily vegetated landscape that is designed to absorb, filter and treat runoff water.

Vegetative swale: Also known as a grassy swale or a bio-swale, this is an earthen depression that channels and treats stormwater, and promotes infiltration. This long, gently-sloped landscape feature is like a ditch except that it is planted with grasses or native wetland plants selected for stormwater treatment, and is sized for specific infiltration and detention capacities.

Volatile organic compounds (VOCs): Carbon-containing chemicals that evaporate from material surfaces into indoor air at normal room temperatures. This process is described as *off-gassing*. Symptoms of VOC exposure include dizziness, eye irritation, respiratory irritation, nasal congestion and headaches.

Workshop: A workshop, or workshops, in which all project team members come together in the early phase of the project's design to set goals and generate design ideas.

Xeriscaping: Landscaping with plants that require little or no water other than what is provided from rain.