BUILDING RESILIENCE:

PRACTICAL GUIDELINES FOR THE SUSTAINABLE REHABILITATION OF BUILDINGS IN CANADA

2016

FEDERAL PROVINCIAL TERRITORIAL HISTORIC PLACES COLLABORATION (FPTHPC)

Library and Archives Canada Cataloguing in Publication
ISBN 978-1-988314-00-6

MTBA Mark Thompson Brandt Architect & Associates Inc.
Building Resilience: Practical Guidelines to Sustainable Rehabilitation of Buildings in Canada
Includes bibliographic references

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• ARCHITECTURE • URBANISM • CONSERVATION •

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“Heritage conservation contributes to creating a sustainable built environment and resilient communities.”

Federal, Provincial, and Territorial Directors of Culture and Heritage in Canada have endorsed the above statement to underpin the development of this document.

PREFACE

Governments, organizations, and individuals across North America are seeking ways to better address climate change and the conservation of our natural environment. At the same time, there is growing understanding that conservation of our cultural heritage is important for healthy communities with strong economies and good quality of life.

Only in recent years has the link between heritage conservation and *sustainability* of communities gained credence and momentum.[1] For example, the United Nations Intergovernmental Panel on Climate Change Assessment Report explains the importance of *retrofitting* our existing building stock in fighting climate change, through reducing a building's energy consumption, carbon footprint and GHG emissions (refer to Appendix A). However, to date, there are few resources that a broad cross-section of individuals, organizations, and governments in Canada can refer to for best practices in *retrofitting* or *rehabilitating* our existing building stock, especially historic buildings, in ways that conserve energy and water, provide for healthy indoor air quality, and reduce the impact on materials consumption and the environment. This document attempts to do just that by demonstrating how heritage conservation contributes to creating sustainable built environments and resilient communities.

1 In North America, however, Donovan Rypkema has for almost two decades monitored the economics of heritage *rehabilitation* & *preservation* in general and against costs of new construction. For more information on Rypkema and his presentations, papers and reports, refer to his web site at: http://www.placeeconomics.com/

BACKGROUND

THE FEDERAL PROVINCIAL TERRITORIAL COLLABORATION ON HISTORIC PLACES IN CANADA (FPTCHPC)

The Federal Provincial Territorial Historic Places Collaboration (FPTCHPC) allows FPT governments to work together on matters of importance for historic places in Canada.

The FPTCHPC recognizes the importance of addressing *sustainability* through the conservation and retrofit of Canada's existing building stock and the simultaneous protection of *heritage value* in our historic buildings. Over the last decade, some initiatives world-wide, and here in Canada, have been undertaken in order to find commonality and best practices in addressing this challenging objective.

PAN-CANADIAN APPROACH

Building Resilience: Practical Guidelines for Sustainable Rehabilitation of Buildings in Canada is a document intended to establish a common pan-Canadian "how-to" approach for practitioners, professionals, building owners, and operators alike.

In 2013, the FPTCHPC retained the Cascadia Chapter of the Canada and US Green Building Councils to define both an outline of these issues and how a useful "how-to" document might address them. In 2014, the FPTCHPC retained an experienced professional consultant working in the fields of natural and heritage conservation (*sustainability*, adaptive reuse, *rehabilitation*, and *preservation* in the architectural and planning environments), MTBA & Associates Inc., to apply this framework and lead the creation of a working document that has broad applicability and usability.

Broad but focussed input and consultation across the nation, achieved through peer reviews, a survey of individuals across Canada involved and engaged in practices related to these issues, and a series of Case Studies submitted by practitioners, helped inform the document to represent best practices and guidelines for *sustainable rehabilitation* in Canada.

This input and these case studies are also intended to ensure that regional and multi-disciplinary specificities are reflected in what is intended to be a truly national document.

Building Resilience is intended to be a positive climate change action and a positive heritage conservation action for all jurisdictions in Canada.

ACKNOWLEDGEMENTS

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1. INTRODUCTION AND CONTEXT

The purpose of these illustrated guidelines is to identify best practices for the sustainable conservation and retrofit of existing buildings. Specifically, the primary focus is on environmental sustainability in historic buildings.

1.1. INTRODUCTION

Building Resilience: Practical Guidelines for the Retrofit and Rehabilitation of Buildings in Canada serves as a “sustainable building toolkit” that will enhance understanding of the environmental benefits of heritage conservation and of the strong interrelationship between natural and built *heritage conservation*. Intended as a useful set of best practices, the guidelines in *Building Resilience* can be applied to existing and traditionally constructed buildings as well as formally recognized heritage places.

These guidelines are primarily aimed at assisting designers, owners, and builders in providing existing buildings with increased levels of *sustainability* while protecting *character-defining elements* and, thus, their *heritage value*. The guidelines are also intended for a broader audience of architects, building developers, owners, custodians and managers, contractors, crafts and trades people, energy advisers and *sustainability* specialists, engineers, heritage professionals, and officials responsible for built heritage and the existing built environment at all jurisdictional levels.

Building Resilience is not meant to provide case-specific advice. It is intended to provide guidance with some measure of flexibility, acknowledging the difficulty of evaluating the impact of every scenario and the realities of projects where buildings may contain inherently *sustainable* elements but limited or no *heritage value*. All interventions must be evaluated based on their unique context, on a case-by-case basis, by experts equipped with the necessary knowledge and experience to ensure a balanced consideration of *heritage value* and *sustainable rehabilitation* measures.

Building Resilience can be read as a stand-alone document, but it may also further illustrate and build on the *sustainability* considerations in the *Standards and Guidelines for the Conservation of Historic Places in Canada* (Federal Provincial Territorial Historic Places Collaboration (FPTHPC), Second Edition, 2010). Refer to Section 1.4 below.

GUIDELINES AT A GLANCE

PART ONE provides background and context around issues related to the *sustainable retrofit* and *rehabilitation* of buildings. It defines the terms and helps us understand why *sustainable retrofit* and *rehabilitation* is useful and important, how it relates to the wider world, who should be involved in *building conservation*, and how *Building Resilience* can be used as a companion to the *Standards and Guidelines for the Conservation of Historic Places in Canada.*

PART TWO delves more deeply into issues surrounding *sustainable retrofit* and r*ehabilitation***,** placing emphasis on the fundamental need to properly and thoroughly understand the existing building prior to undertaking *retrofit* or *rehabilitation* work, particularly the building’s history, cultural heritage value, fabric, changes of form, and use over time. Part Two also provides information on some broader related issues such as the building site’s wider context and the *retrofit* or *rehabilitation* of buildings from the Modern period.

PART THREE provides practical tested guidance, broken out by building components to simplify the approach to building *retrofit* and *rehabilitation*. It also looks at building materials and maintenance as they relate to *sustainable retrofit* and *rehabilitation*. Use Part Three for direct assistance in planning, designing, and executing a *retrofit* or *rehabilitation* project.

PART FOUR offers further information, including a bibliography and resource list, information on web-based design tools, a glossary, and Appendices, including case studies.

CASE STUDIES in Appendix C provide illustrative examples of building *retrofits* and *rehabilitations* across Canada where sustainable principles are effectively incorporated to help significantly improve the building's overall *sustainability* while protecting *heritage value*.

Figure 1 Reviewing *sustainability* upgrade opportunities and inherently sustainable elements on site. Source: Judith Cook

1.2. THE RELATIONSHIP BETWEEN BUILDING CONSERVATION, SUSTAINABILITY, AND CLIMATE CHANGE

BUILDING CONSERVATION

Building conservation can be defined as the wise use and management of a building to prevent unwanted change, which can include unsympathetic or incompatible alteration, decay, destruction, misuse, or neglect. The objective is "safe-guarding the character-defining elements of a cultural resource so as to retain its heritage value and extend its physical life."

In Canada, the *Standards and Guidelines for the Conservation of Historic Places in Canada* is a useful reference tool that provides advice on heritage conservation treatments.

SUSTAINABILITY FOR BUILDING RETROFIT AND REHABILITATION

The organizing principle of *sustainability*[1] in the built environment is often considered to be sustainable development, or, "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[2]

Building conservation is a crucial contributor to sustainability because it fulfills the interrelated economic, cultural, social and environmental principals of *sustainable development*.[3] Potential gains achieved through a conservation approach are listed below:

Environmental

- Conserving embodied energy and benefitting from existing construction;
- Reusing and recycling existing sites, buildings and materials with high service lives and repairability;
- Using appropriate technologies or time-tested regionally/climate adapted materials and models;
- Reducing urban sprawl while protecting forests, wildlife, farms, and other natural environments;
- Reducing the waste and landfill use associated with demolition.

Socio-cultural

- Conserving diverse cultural memories;
- Conserving and building community and identity;

1 In ecology, sustainability is how natural systems endure and remain diverse and productive for life on a finite planet. In more general terms, sustainability refers to the endurance of systems and processes.

2 The term "sustainable development" and its definition rose to significance after it was used by the Brundtland Commission in its 1987 international report *Our Common Future*

3 The 2005 UN Convention on the Protection and Promotion of the Diversity of Cultural Expressions states that "The economic, cultural, social and environmental aspects of sustainable development are complementary". Further, it offers this principle of sustainable development: "Cultural diversity is a rich asset for individuals and societies. The protection, promotion and maintenance of cultural diversity are an essential requirement for sustainable development for the benefit of present and future generations." Further, it states that "The econo mic, cultural, social and environmental aspects of sustainable development are complementary." See: http://www.unesco.org/new/en/culture/themes/cultural-diversity/cultural-expressions/the-convention/convention-text/.

- Conserving community spaces and amenities;
- Providing more affordable housing;
- Providing smaller-scale commercial space for local starting initiatives;
- Providing educational opportunities.

Economic

- Reducing development costs by using already developed sites;
- Increasing property value through redevelopment;
- Promoting the use of a lifecycle costing model that embodies a long-term view;
- Developing skilled jobs that lead to durable and equitable employment;
- Supporting regional economies, including local materials suppliers.

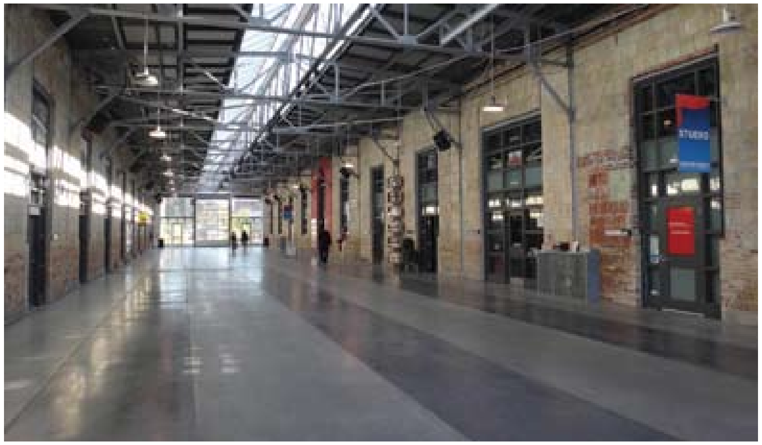

Figure 2 Covered street in Barn 2, Wychwood Barns, Toronto, ON. Source: Places to Grow, Province of Ontario

CLIMATE CHANGE AND SUSTAINABLE RETROFIT AND REHABILITATION

Today, a key component of environmental degradation is climate change. It is now commonly recognized that climate change must be addressed on as many fronts as possible to counteract and mitigate its harmful effects on our environment.

It is also now common knowledge that buildings are the largest single source of energy use, waste, and emissions into the atmosphere. For example, nearly half of the greenhouse gases produced in Canada come from buildings.[4] Improving the performance of our existing building stock, then, is singularly important in mitigating climate change.

Buildings in Canada consume[5]:

33% of energy produced

50% of natural resources

12% of water usage
(excluding process water for industry)

4 Royal Architectural Institute of Canada, 2030 Challenge: Climate Change and Architecture, 12 December 2014, http://www.raic.org/architecture_architects/green_architecture/2030/2030factsheet_e.pdf.

5 CAGBC, CaGBC Municipal Green Building Toolkit, 2007, 12 December 2014, http://s3.amazonaws.com/zanran_storage/ www.cagbc.org/ContentPages/24130512.pdf.

And they generate[6]:

25% of landfill waste

10% of airborne particulates

35% of greenhouse gases

In fact, according to the *Intergovernmental Panel on Climate Change (IPCC)*, "...over the whole building stock, the largest portion of carbon savings by 2030 is in retrofitting existing buildings and replacing energy using equipment..." and energy savings of 50-75% can be achieved in commercial buildings that make smart use of energy efficiency measures.[7]

"Improving energy efficiency in existing buildings encompasses the most diverse, largest and most cost-effective mitigation opportunities in buildings to combat climate change."
-IPCC

Therefore, as an effective way of combatting climate change, authorities and communities should sustainably *retrofit* and *rehabilitate* their existing buildings, which includes not only buildings of heritage value but other older buildings up to and including those of the Modern era.

But it's also important to keep in mind that existing buildings account for character and identity in our towns and cities. For example, respondents of a survey conducted in Vancouver, B.C. overwhelmingly support the preservation of heritage buildings, reporting that these contribute to citizens' *sense of place,* i.e. the special meaning, character, unique identity, and geographic location gives a community. The same survey found that 50% of respondents would prefer living in a historic building sensitively retrofitted for energy efficiency and thermal comfort as compared to the 11% of respondents preferring a new building.[8]

Best practices for building *retrofit* and *rehabilitation*, then, should take into account a building's contribution to the community's sense of place. Technologies, practices, and durable and healthy materials should be incorporated in ways not adversely affecting the building's character or *heritage value*.

CLIMATE CHANGE AND AVOIDED IMPACT

Older buildings often contain many features that provide a built-in measure of *inherent sustainability*. These characteristics can be ascribed largely to the *avoided impact* they have on the environment. This includes such holistic and long-term factors as the *embodied energy* and *embodied carbon* older buildings represent. *Inherent sustainability* also often refers to the *sustainability* of traditional building design

6 Ibid.

7 For more information refer to : http://sustainabilityworkshop.autodesk.com/buildings/new-vs-existing-buildings#sthash.NEVtS2sk.dpuf

8 Vancouver Heritage Foundation, "Conserving Heritage Buildings in a Green and Growing Vancouver", http://www.vancouverheritagefoundation.org/wp-content/uploads/2013/01/Conserving-Heritage-Report-FINAL.pdf, (accessed 25 May 2014).

and construction techniques, durable and/or local materials, repairable assemblies, and longer-term life planning.

One way to measure the *sustainability* of a design, *retrofit,* or *rehabilitation* project is to conduct a *Life Cycle Assessment* (LCA). Life cycle thinking is applied to building components, assemblies, and products by asking these questions:

- What is involved in making a product/assembly, transporting it to a site, and installing it?
- What inputs and waste will occur related to using the product over its life?
- What will happen to the product when it is no longer needed?

The answers to these questions most often reveal that older buildings have much higher *sustainability* due to their use of natural and durable materials, repairable assemblies, and replaceable small components.

It's also important to factor in the consequences of new construction. It takes decades for a new, energy-efficient building to overcome the negative environmental impacts created during its construction process. Moreover, manufactured components are used with high frequency in new construction, which can limit repair opportunities, lead to replacement, and heighten the negative impacts of manufacturing and of building waste. In other words, adapting and reusing existing buildings rather than demolishing and/or building new ones is usually the better strategy to make the built environment more immediately sustainable.[9]

There is, however, room to improve the synergies between heritage conservation and environmental *sustainability*, and the illustrated guidelines footnoted below are intended to address that opportunity.[10,11,12] Section 2.5 also offers more discussion on this point.

Finally, *building conservation* is also about "green building" in the sense that, for properties that are not formally recognized heritage properties, upgrading the building's operating environmental efficiency is still desirable. However, *sustainability* in Canada and around the world is recognized as being so much more than adding "green gadgets." We must focus on the bigger picture to be successful in addressing environmental degradation and climate change. Technology is only part of the answer.

Figure 3 Aerial photograph showing a range of sustainability upgrades including fresh air preheating, geothermal well and solar panels integrated into a community energy system, green roofs on select buildings and grey water reservoirs, Benny Farm, Montreal, QC. Source: L'Oeuf Architectes

9 The National Trust for Historic Preservation, "The Greenest Building: Quantifying the Environmental Value of Building Reuse," http://www.preservationnation.org/information-center/sustainable-communities/green-lab/lca/The_Greenest_Building_lowres.pdf, (accessed 25 May 2014).

10 Nancy Pollock-Ellwand, "Common Ground and Shared Frontiers in Heritage Conservation and Sustainable Development: Partnerships, Policies and Perspectives," International Journal of Sustainable Development and World Ecology. 18:3. 1992.

11 U.S. Department of the Interior National Park Service Technical Preservation Services, "The Illustrated Guidelines on Sustainability for Rehabilitating Historic Buildings, http://www.nps.gov/tps/standards/rehabilitation/sustainability-guidelines.pdf, (accessed 25 May 2014).

12 Robert A Young, Stewardship of the Built Environment: Sustainability, Preservation, Reuse. Washington: Island Press. 2012.

SOCIAL AND LOCAL ECONOMIC VALUE

Because maintaining, repairing, and conserving "pre-Modern", "pre-WWII", and vernacular buildings may be more labour-intensive activities than they would be in newer buildings, these buildings often add value to their surrounding communities through local job creation. Approaching older buildings through a sustainability lens also adds broader economic and societal benefits and cultural diversification through cultural and heritage tourism and stronger social connections.[13,14,15]

Figure 4 Aerial rendering showing the rehabilitated and expanded Evergreen Brick Works complex (Don Valley Brick Works complex). The complex includes a range of sustainability strategies including retention of existing industrial buildings, extensive planting and vegetated greenways, sustainably constructed infill and site water management, industry and community uses. Toronto, ON. Source: Holcim Foundation

Figure 5 A skating path within one of the rehabilitated reused industrial structures at the Evergreen Brick Works complex, Toronto, ON. Source: DTAH

13 British Columbia Heritage Branch, Ministry of Forests, Lands and Natural Resource Operations, "Fact Sheet: Heritage Sites are an asset to communities", https://www.for.gov.bc.ca/ftp/heritage/external/!publish/web/Heritage%20Branch%20BC%20Dashboard%20-%20final.pdf, (accessed 25 May 2014).

14 Bruce Whyte, Terry Hood, and Brian P. White (eds.), "Cultural and Heritage Tourism: A Handbook for Community Champions" The Federal-Provincial-Territorial Ministers' Table on Culture and Heritage, http://linkbc.ca/siteFiles/85/files/CHT_WEB.pdf, (accessed 25 May 2014).

15 Jean Carroon, Sustainable Preservation: Greening Existing Buildings Hoboken: John Wiley & Sons Inc. 2011.

"Because it necessarily involves the conservation of energy and natural resources, historic preservation has always been the greenest of the building arts."
– Richard Moe, United States National Trust, 2008

"The functional adaptability of historic buildings is one their great under-recognized attributes. You cannot have sustainable development without a major role of historic preservation, period.
– Donovan Rypkema, "Sustainability, Smart Growth and Historic Preservation" Historic Districts Council Annual Conference, New York City, 2007

"The accumulated building stock is the elephant in the room: Ignoring it, we risk being trampled by it. We cannot build our way to sustainability; we must conserve our way to it."
-Carl Elefante, Forum Journal: The Journal of the National Trust for Historic Preservation, Summer 2007

1.3. WHO SHOULD BE INVOLVED

GOVERNMENTS

Given the scope and importance of the task of incorporating *sustainability* considerations into the *retrofit*, *conservation* and *rehabilitation* of buildings, and the broad range of stakeholders affected by these efforts, it is appropriate for governments to define strategies and areas of focus for sustainable conservation considerations.[16,17]

"Governments can provide policy, guidance and best practices to encourage good conservation and sustainability focused upgrades to existing and heritage buildings, as long as these directives work with market imperatives, building codes and other regimes in place. It is important that government inputs have the flexibility to apply widely through differing unique situations, and that they promote best practices from all perspectives."

-Cascadia Chapter, US/CaGBC, 2013

INDUSTRY

However, these efforts are not the sole responsibility of government decision-makers. Building officials, architects, engineers, owners, developers, and others in the real estate and construction industry are stakeholders and have a responsibility in this opportunity. It is equally important for all stakeholders to do their part capitalizing on building *retrofit* and *rehabilitation* as sound environmental actions and in applying best practices to that work. In return, these practices will improve cost-benefit through reduced operating costs (and potentially higher rents).

ALL EXISTING BUILDINGS

Furthermore, it is important to understand that the best practices associated with the *rehabilitation* of buildings with heritage value are directly transferrable as best practices for the *retrofit* of all existing buildings and for the design of new buildings. In fact, the green building community in North America believes the movement will have been a success when "green" building is simply considered "good" building.

SIMPLIFYING THE PROCESS

Although the task of moving the building and design communities towards *sustainable development* practices may appear to be complex and with many apparently competing considerations, there are strategies available to help all stakeholders achieve their objectives. Energy modelling and lifecycle costing, for example, can help guide decisions

16 Advisory Council on Historic Preservation, "Sustainability and Historic Federal Buildings," http://www.achp.gov/docs/SustainabilityAndHP.pdf, (accessed 25 May 2014).

17 British Columbia Heritage Branch, Ministry of Forests, Lands and Natural Resource Operations, "Our Heritage – Historic Places: Heritage Strategy for British Columbia," http://www.for.gov.bc.ca/ftp/heritage/external/!publish/web/Heritage_Historic_Places2013_final.pdf, (accessed 25 May 2014).

regarding appropriate, cost-effective, and energy efficient measures that are also sensitive to *heritage value*.[18] Web-based and other digital design tools can also help designers make decisions around complex issues. These tools include the Athena Institute's LCA Tool and the forthcoming APT Tool OSCAR (Online Sustainable Conservation Assistance Resource). Refer to Part Four for more information.

INTEGRATED DESIGN PROCESS FOR INTEGRATED SOLUTIONS

"Recognition of the interconnection and complexity of…natural systems and the need for corresponding holistic design has led to…integrated design, a process that gathers the entire (or most of the) project team together to create designs that benefit from the synergies of different areas of expertise."
-Jean Carroon, "Greening Existing Buildings", 2010

Heritage conservation architects and engineers have of necessity used *integrated design processes* (IDP) for many years in order to achieve optimum solutions for integrating needed contemporary interventions into buildings of heritage value. *Sustainability* consultants also understand the value and effectiveness of integrated design solutions.

Figure 6 *Integrated Design Process* for High Performance Buildings
Based on "Whole Building Design" (graphic) by Donald Prowler & Associates

Improving communications and avoiding "the silo effect" between the various design disciplines required for success in both heritage conservation work and sustainable design work have become necessary for best practice and long-term effectiveness in the building design process in general.

In fact, sustainable *rehabilitation* of any existing buildings requires IDP for success.

"Realizing these savings requires an *integrated design process* involving architects, engineers, contractors and clients, with full consideration of opportunities for passively reducing building energy demands."
- William Goodger, "Prophecies and Global Warming: How everything leads to the arrival of the Messiah", 2012

18 John H. Cluver and Brad Randall, "Saving Energy in Historic Buildings: Balancing Efficiency and Value," Planning for Higher Education 40:2. 2012.

1.4. STANDARDS AND GUIDELINES FOR THE CONSERVATION OF HISTORIC PLACES IN CANADA

*Standards and Guidelines for the Conservation of Historic Places in Canada (*Second *Edition, 2010)*, or *SGCHPC,* is a pan-Canadian benchmark for heritage conservation practice offering results-oriented guidance for sound decision-making when planning for, intervening on and using historic places. It establishes a consistent, pan-Canadian set of conservation principles and guidelines that will be useful to anyone with an interest in conserving Canada's historic places.

SGCHPP has become an important tool for the conservation community in Canada.

REHABILITATION

The *Standards and Guidelines* best practices on sustainable conservation and *rehabilitation* of historic places, which are incorporated into Part Three of *Building Resilience.* In fact, the *SGCHP* and *Building Resilience* can be read as companion pieces.

The *Standards and Guidelines* outline a cyclical and ongoing heritage conservation decision-making process that is particularly useful for sustainable *rehabilitation,* including the points below:

Developing a comprehensive understanding of the historic place's existing conditions, heritage significance and evolution, and the new use requirements by:

- Determining *heritage value*;
- Establishing *character-defining elements*;
- Investigating and documenting conditions and changes.

Planning in a comprehensive and integrated manner that balances natural and heritage conservation with other project goals and engages stakeholders early and throughout the process by:

- Ensuring the selected programme can be accommodated within the existing building or site while minimizing impact to heritage character;
- Ensuring new interventions are sustainable and appropriate;
- Thoroughly defining the new requirements and establishing priorities;
- Providing for a multi-disciplinary team approach.

Intervening carefully using a minimal intervention approach, including upgrades and ongoing maintenance by:

- Ensuring appropriate skills and experience are brought to the project;
- Ensuring an adequate and appropriate long-term maintenance plan is in place to protect value.

While these are best practices for buildings of *heritage value*, they are also applicable more broadly to existing buildings for which heritage value has not been determined. Building conservation, in other words, is inextricably linked with sustainability.

Note: *All direct quotes from the Standards and Guidelines for the Conservation of Historic Places in Canada integrated into this document are noted in tan coloured text boxes with italics. Quotes are referenced to the page number of the passage in the Second Edition.*

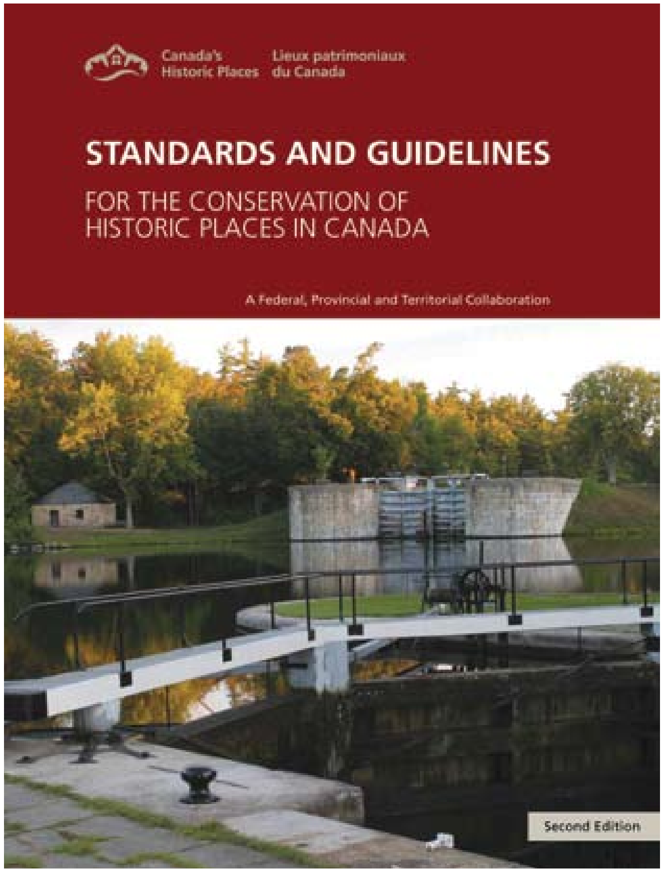

Figure 7 Cover of the SGCHPC, 2[nd] Edition, 2010.

2. UNDERSTANDING YOUR BUILDING

Prior to engaging in the retrofit, preservation, rehabilitation, or restoration of a building, it is crucial to gain a comprehensive understanding of both its heritage value (including its past and current importance to its community, along with its integrity and evolution over time) and its physical properties and relationships, including materials, assemblies, planning logistics, design intents and root causes of degradation.

2.1. CONTEXT

Part Two discusses the important first step in conducting sustainable *retrofits* or *rehabilitations*: acquiring a clear and comprehensive understanding of the existing building prior to commencing design. This understanding, crucial for any building in terms of *sustainability* regardless of its *heritage value* and/or *character-defining elements* and regardless of its intended use, can be gained by the following:

- Determining the *heritage value* and *character-defining elements* to be protected, if any;
- Thoroughly investigating and documenting all of the existing conditions;
- Assembling an integrated team that will harmonize disciplines for the planning, design, and construction of the *retrofit* or *rehabilitation* while sharing all pertinent understanding;
- Determining current energy, water, and overall resource consumption to establish a baseline measurement for evaluating proposed interventions;
- Determining the base impacts of new or adapted use;
- Determining the base spatial, material and performance impacts on the building of the proposed project requirements;
- Ascertaining and mapping out where conflicts occur and considering balancing the various project requirements;
- Prioritizing the sustainable measures that optimize performance improvement while maintaining *heritage value*.

2.2. MAINTAINING HERITAGE VALUE AND CHARACTER-DEFINING ELEMENTS

There are far too many past examples in Canada where *character-defining elements* were replaced in the name of energy efficiency or environmental requirements without adequate evaluation of potential impacts on heritage value. These replacements did not improve energy performance and were a poor return on investment. It's important to avoid replicating these mistakes by ensuring that a *heritage value* and *character-defining elements* have been identified and that its environmental characteristics and performance have been properly understood before beginning planning measures that will improve energy efficiency and overall *sustainability*.

Once *heritage value* and *character-defining elements* have been established, sustainability goals can be balanced with the broader project objectives. In order to determine the most appropriate solutions to meet energy efficiency requirements with the least impact on *character-defining elements*, the project team should work with specialists at this point.

The next step is to create a project-wide design and conservation approach to the *rehabilitation* intentions. Minimal intervention and reversibility are always foundational principles when rehabilitating heritage properties; the remaining elements of the approach establish criteria for making design decisions, and they help provide a definitive rationale for the interventions.

Usually, drafting a matrix of desired interventions, such as improvements that are sustainable, their prioritization, and their anticipated heritage character impact, will help the designer establish a systematic decision–making process that applies the rigour needed to most successfully execute the design and conservation approach.

Enlisting one of the on-line decision making tools, as listed at the end of the Resources Section of Part Four, can also help the designer work through challenging and often conflicting objectives.

Figure 8 Operable windows in a heritage building that currently functions well for contemporary use and demands. (Ontario Heritage Trust, 10 Adelaide Street, Toronto)

CONSIDERING HERITAGE AND NON-HERITAGE BUILDINGS

Building Resilience is intended to provide guidance for considering *sustainability* modifications to all sizes and types of buildings regardless of *heritage value*. All buildings contain inherent characteristics that should be respected to minimize material expended and unnecessary waste of usable materials.

Yet, as *heritage value* must be considered when deciding on the nature and degree of appropriate intervention, these guidelines also give specific direction for minimizing impacts on *character-defining elements* and intervening sensitively into non-*character-defining elements* in buildings with *heritage value* when considering upgrades that support sustainability.

In addition, completing the original design intent is not always a reasonable approach from a heritage conservation perspective and is rarely supported by the Standards and Guidelines for the Conservation of Historic Places in Canada. However, completion may be justified in the name of environmental goals to reduce urban sprawl or enhance the use and sustainability of an existing building.

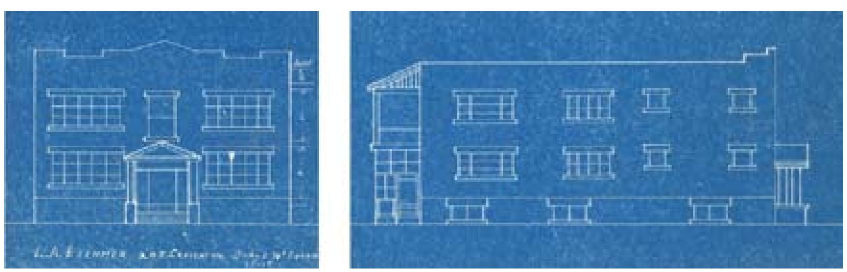

Figure 9 Plans depicting what was originally intended as a post-war duplex on an urban site in the New Edinburgh neighborhood, Ottawa, ON, 1945. Source: L.A. Boehmer

Figure 10 Actual building constructed after money to build second storey ran out, 2013 view. The surrounding neighbourhood of workers' housing and commercial structures, predominantly consisting of 2-storey, street-oriented design, became a designated Heritage Conservation District in 2002. This district, New Edinburgh, was originally a mill village at the Rideau River Falls and is adjacent to Rideau Hall, the Governor General's estate. The "suburban" look on this prominent corner does not harmonize with the neighbourhood. Source: VERTdesign.inc

Figure 11 Proposed "green" heritage-sensitive redevelopment of the property targeting LEED Platinum and Passivhaus certification. The original design intention is completed and includes an enlarged rear addition and many sustainable features. Source: VERTdesign.inc

2.3. UNDERSTANDING THE BUILDING AS AN ENVIRONMENTAL SYSTEM

When sustainable upgrades are being considered for an existing or traditionally-constructed building, the design approach must be based on a comprehensive understanding of the building's original materials and assemblies, including interrelated systems, materials sourcing, design language, and spatial organizations. This understanding, sometimes referred to as *"whole building ecology,"* will provide a clear picture of the building as an interconnected system in and of itself. Understanding these interrelationships will help identify the optimal changes and interventions that have the least impact upon resources and building character or *heritage value* and the most impact upon sustainable performance.

Any existing building will have these interrelated components inherent in its makeup:

- design and spatial relationships;
- systems and operating functions;
- built assemblies and components.

If the objective is to improve energy performance, the design team must first consider these inherent functions. The team should seek to understand, for example, how the building was originally designed to function with respect to energy (lighting, heating and cooling systems, building envelope, etc.) and to assess the current operation and condition of those energy assemblies and systems. There is also value in understanding the environmental impact and benefit of the *retrofit* or *rehabilitation* process itself (treatments, materials, waste management, etc.), to help determine repairs, materials replacement, and treatments.

To assist the design team with these considerations, each section in Part Three includes comments and suggestions on addressing interrelationships, *inherently sustainable elements*, and related challenges.

Figure 12 Waiting room of the 1912 Union Station, Ottawa. Image c.1950, showing HVAC systems integrated to furniture and design elements (i.e. benches and lighting pedestals) Source: Archive, National Capital Commission

Figure 13 The whole is greater than the sum of the parts. Source: Whole Building Design Guide www.wbdg.org

2.4. CALCULATION AND MODELLING

Many tools, as listed and explained below, can help assess a building's energy impact and performance. Each of these tools is important to the planning process; when appropriate analysis is not conducted before selecting materials and assemblies, the environmental benefits of building *retrofit* or *rehabilitation* can be reduced or even negated by the environmental cost of the materials themselves and by potential short and long term unintended consequences.

Furthermore, projects that require many new materials offer less significant environmental benefits than projects in which the footprint or use of a building remains unchanged.[1] With careful planning and leveraging of available tools, existing buildings can be upgraded in a *sustainable* manner, meeting and surpassing green building standards and *rating systems*.[2] Derived data can also be of long term benefit by providing a behavioural baseline and by identifying areas for monitoring.

EVALUATION TOOLS

Life Cycle Assessment

Lifecycle Assessment (*LCA*) can help achieve improved energy efficiency in a manner that is both cost-effective and sensitive to the character of the building.[3] Projects can benefit from the application of an *LCA* to determine the environmental impact of *rehabilitation* versus new construction and as a tool to analyze the environmental impact of materials/assemblies being considered.

For *retrofit* and *rehabilitation* projects involving energy upgrades, an *LCA* helps us understand past and current environmental characteristics and performance. One environmental metric for buildings is their *embodied carbon*; an *LCA* accounts for whole-life carbon costs in addition to energy performance, which can provide a more accurate sense of the environmental costs associated with a selected treatment approach.[4,5] In the past few years, both Canada's Historic Places Initiative and the US's National Trust for Historic Preservation conducted ground-breaking scientific research comparing the environmental impact of *retrofitting* or *rehabilitating* older buildings versus building new. The conclusion in both studies was that "building reuse almost always offers environmental savings over demolition and new construction."[6]

The University of BC used the same scientific analysis to determine the environmental impact of *rehabilitation* versus new construction as part of the UBC Renew process. This *LCA* provided scientific evidence to support the choice to *rehabilitate* the1960's Buchanan Building. As Cortese noted:

"The main outcomes of this *LCA* study are the establishment of a materials inventory and environmental impact references for the Buchanan building. An exemplary application of these references is in the assessment of potential future

1 NTHP, The Greenest Building.

2 Whole Building Design Guide Historic Preservation Subcommittee. "Sustainable Historic Preservation," National Institute of Building Sciences, http://www.wbdg.org/resources/sustainable_hp.php, (accessed 25 May 2014).

3 John H. Cluver and Brad Randall, APT Bulletin, 41:1, 2010.

4 Historic Scotland, "Embodied Energy Considerations For Existing Buildings," http://www.historic-scotland.gov.uk/technicalpaper13.pdf, (accessed 25 May 2014).

5 Alan M. Forster, Kate Carter, Phillip F.G. Banfill and Brit Kayan. "Green Maintenance for Historic Masonry Buildings: An Emerging Concept." Building Research & Information. 39:6. 2011.

6 NTHP, The Greenest Building.

performance upgrades to the structure and envelope of the Buchanan building." [7]

The study also provided a potential foundation for future sustainable UBC building projects:

"...this Buchanan building LCA can be seen as an essential part of the formation of a powerful tool to help inform the decision making process of policy makers in establishing quantified sustainable development guidelines for future UBC construction, renovation and demolition projects."[8]

Energy Modelling

Energy modelling is a tool used to analyze a building's energy consumption in a range of scenarios and is typically integrated into a parametric model of a building. The model contains data on the various building assemblies, design characteristics, environmental control systems, environmental and site characteristics and other items that may require energy. Using this data, software platforms are able to determine, in real time, a building's baseline energy performance and to provide dynamic results for potential performance-improving modifications.

Energy modelling can be challenging for existing buildings, especially for those with traditional assemblies that are not well documented or for which the selected software platform has limited or no performance data. However, as more research is undertaken into the performance of traditional assemblies and as this research is made available to the broader community, energy models will be more accurate and be that much more useful.

7 Andrew Cortese, "Life Cycle Analysis of UBC Buildings: The Buchanan Building," University of British Columbia, 2009, https://circle.ubc.ca/bitstream/handle/2429/20980/Buchanan_Cortese,A_2.pdf?sequence=1 , (accessed 25 May 2014).

8 Ibid.

Daylight Modelling

Daylight penetration into interior spaces can be modelled using several off-the-shelf simulation tools. These models calculate the hourly daylighting achievable from windows. They also inform the placement of other elements, such as light shelves, light tubes and other reflective elements, to enhance daylighting.

Thermal Comfort Simulations

Several energy modelling packages can incorporate thermal comfort modeling into building simulation. Here, thermal comfort (as defined in *ASHRAE* Standard 55 - Thermal Environmental Conditions for Human Occupancy) is evaluated based on the temperature, air velocity, and radiation in each space, which is helpful in determining when natural ventilation can be used for comfort cooling.

Air Pressurization Testing

This technique is used to identify the air tightness of a building and can be used in conjunction with smoke generation to areas with abnormally high air infiltration. Note that older buildings, particularly those designed to be heated using wood, coal, or oil-burning stoves, have been designed to allow higher ventilation/infiltration rates to supply these stoves with combustion air or to allow natural drying when a building is supersaturated.

Environmental Data Logging

This technique is of particular value for museums and art galleries housed in heritage buildings where relative humidity and temperature control are critical to preserve artifacts. Both indoor and outdoor conditions (temperature and relative humidity in key spaces) are monitored and recorded typically at 15-minute intervals to identify areas where temperature and relative humidity are varying too widely, or conversely, to identify areas where the control range is tighter than the zone requires and thus present an opportunity for energy savings through wider control bands.[9]

Thermal Modelling

Thermal modelling can be undertaken at a basic level to estimate energy losses through various elements or at a more detailed level using specialist software for higher accuracy results. As is the case with other computer simulations, the results are approximate and the degree of accuracy is commensurate with the expertise of the modeller and the quality of input information.

Energy Audits

Similar to energy modelling, an energy audit is an evaluative tool or process used to determine a building's energy performance and to identify measures to improve it. Generally, audits focus on the physical building itself, identifying opportunities for improvement, to reduce fuel consumption, and to improve building envelope performance. Energy audits are significantly less costly than energy modelling, making them accessible to more building owners, especially small building and home owners.

Utility Bill Analysis

Utility bill analysis is a low cost technique that can be used to identify atypical or unusual operation, including high fuel use, in a cooling season. Utility bill analysis can also contribute to establishing an energy, water, and resource consumption baseline for evaluating interventions.

Sub-metering

Whether used in temporary or permanent scenarios, sub-metering allows for resource use to be broken down by use type; it provides a better understanding of how, where, and when resources are consumed in buildings and by specific tenants. This information provides opportunities for more targeted measures that are most likely to achieve the greatest savings.

Thermography

Techniques such as energy modelling and energy audits may use thermography in their evaluations to provide visual information on building behaviour and areas that may require attention. Thermography helps to document the areas of the building envelope that are of concern, including:

- Poorly performing or non-continuous insulation;
- Areas with high thermal bridging;
- Water ingress, particularly in brick masonry walls;
- Evidence of drafts;[10]
- Damaged electrical insulation and short-circuiting.

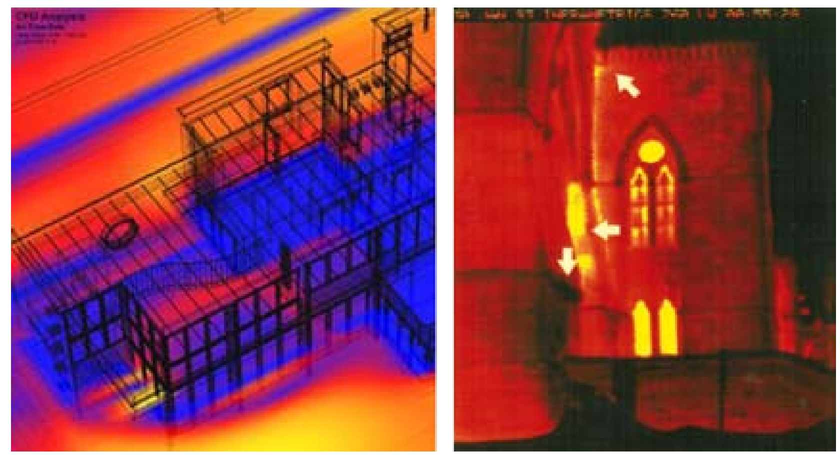

Figure 14 Thermography applied to analyze and improve building performance in 20th C. buildings (left) and 19th C. buildings (East Block of Parliament, right). Sources: http://logixicf.com/ecobuildtrends/eco-builds-trends-pics/large/150-buildingenergyperformance_clip_image008.jpg (left image) and Technology and Engineering Services, PWGSC, Ottawa (right image)

9 For more information refer to Arup, *Museum and Art Gallery Survival Strategies*, MLA Renaissance. 2010.

10 For more information, refer to Arup, Low Carbon Heritage Buildings: A User Guide, 2011.

2.5. UNDERSTANDING INHERENT SUSTAINABILITY

Project teams should find solutions that take advantage of durability, adaptability, and other passive *features that support sustainability* and that are often in existing buildings. Traditionally designed and constructed buildings, in addition to frequently using higher amounts of local and natural materials, typically take advantage of non-mechanical strategies adapted to the local climatic context to promote daylighting and thermal comfort throughout the year.[11]

The Online Sustainable Conservation Assistance Resource (OSCAR) tool outlines why using features that support sustainability is key:

> Buildings traditionally had sustainable/energy-efficient features out of necessity. Basic principles resulted in a wide diversity of responses, many of which became character-defining features of specific buildings and/or local building traditions. In the preservation of heritage buildings, it is important to recognize these features, not only as character-defining features, but also for their climatological significance. In doing so we can:
>
> 1. recognize the inherent energy-harnessing features and systems and how they function, to best work with, rather than against the historic intent
>
> 2. effectively prioritize work, including the reconstruction of non-extant original features to best meet the sustainability goals
>
> 3. learn from techniques from similar climates elsewhere in the world, foster awareness and stay attuned to opportunities to use such strategies where appropriate.[12]

Understanding the building as a holistic system should include evaluating the contribution of the inherent sustainability of the building and its site. Inherently sustainable characteristics, listed below, should be maintained and incorporated where possible into the *retrofit* or *rehabilitation* design:

- Building orientation;
- Building layout;
- Passive heating and cooling systems;
- *Embodied energy*;
- *Embodied carbon*;
- Materials: indigenous, durable, recyclable, natural;
- Long life and loose fit;
- Assemblies: breathable, repairable, compatible.

BUILDING ORIENTATION

Intentional building orientation takes into account form, siting, and landscape features that respond to sun and wind exposure. Examples include:

- A building entrance designed to protect from wind or rain and the region's uncomfortable weather;

11 Masonry and stone used for cladding of institutional buildings including limestones, sandstones, granites, and marbles may or may not be local. Nevertheless, they can provide thermal mass, depending on the thickness and density, and durable finishes.

12 http://oscar-apti.org/isf-tree/ (accessed 16 March 2015).

- Buildings that minimize exposure to the prevailing wind or cold north face by narrowing elevation or by including less door and window openings;
- Buildings set into slopes to take advantage of the greater temperature stability offered;
- Buildings built close to the ground, avoiding the need for their structures and envelopes to address extremes of weather.

BUILDING LAYOUT

Sustainable building layout occurs when plans take advantage of the group effects provided by shared heat and wind sheltering. Examples include:

- Plan forms that create enclosed areas with a cooler/warmer micro-climate for passive air conditioning systems;
- Plan forms designed with light wells or shallow depths from the exterior, reducing the need for artificial lighting;
- Spaces appropriately and efficiently sized that are applied against the building program requirements to minimize waste;
- Rooms grouped around a central chimney heat source, thereby sharing the heat;
- Zoned HVAC, such as bedrooms, that remain unheated during the day and are allowed to benefit from the downstairs heat rising at night;
- Larders with evaporative cooling systems on the roof or connected to the outside air and use convection to keep a building cooler.

PASSIVE HEATING AND COOLING SYSTEMS

Retrofit or *rehabilitation* projects should consider maintaining or heightening the building's passive heating and cooling systems through these measures:

- Maintaining or installing operable windows, skylights, and vents to provide natural ventilation and daylighting;
- Maintaining or installing storm windows, awnings, and shutters to provide seasonal or daily passive thermal controls;
- Installing two sets of storm windows in buildings in cold climates;
- Installing windows specifically sized to suit a space's function.

EMBODIED ENERGY

It is known that "even the most energy-efficient new building cannot offset its embodied energy for many years. The United Nations Energy Programme estimates that the embodied energy of a building is 20% [of the total building-life energy expenditure] if a building is operational for 100 years... the shorter the service life, the greater the ratio of embodied energy to operating energy is".[13] Existing buildings that reuse the energy expenditure of their original construction through *retrofit* and adaptation can lower the "environmental debt" that all new buildings acquire through the manufacturing and construction process.

EMBODIED CARBON

Carbon emitted through building construction, including the entire process of extraction, fabrication, transportation,

13 Carroon, Jean. 2010. Sustainable Preservation: Greening Existing Buildings.New Jersey: John Wiley & Sons Inc.: 7.

and assembly is called *embodied carbon*. When an existing building is demolished and a new building is erected, the carbon footprint is much larger than that of a *retrofitted* or *rehabilitated* building, in which its life-cycle carbon is largely already spent.

MATERIALS: INDIGENOUS, DURABLE AND RECYCLABLE

Vernacular buildings often used locally available materials – wood in forested regions, stone near local quarries, etc. Locally available materials reduce the transport footprint and encourage the longer life of a building through easy material replacement.

Natural, durable and recyclable materials also bring benefit to *retrofit* or *rehabilitation* work:

- Natural materials are non-toxic and provide variances for tolerances in replacements;
- Durable materials contribute to a building's long life and ease of *retrofit* or *rehabilitation*;
- Recyclable materials, when being switched during *retrofit* or *rehabilitation*, reduce the footprint of that action;
- Because lime-plaster is a carbon sequester, it uses much less energy than its modern equivalents.

LONG LIFE AND LOOSE FIT

- Allows for changing uses over time through design of layouts, structural spans, access to natural light, etc. This is why existing buildings built for a specific purpose can often be adapted and retrofitted for a variety of new uses

ASSEMBLIES: BREATHABLE, REPAIRABLE, COMPATIBLE

Traditional building assemblies often offer many sustainable features and characteristics such as those listed below:

- Traditional buildings respire, ensuring passive air changes ("breathability"). *Retrofits* and *rehabilitations* must respect and allow for this through envelope design and ventilation approach;
- Older buildings were constructed from repairable materials and assembled in ways that can often be repaired by local craftsmen or professionals or even occupants;
- Shingle-hanging provides the ultimate rainscreen with three levels of redundancy built-in.
-

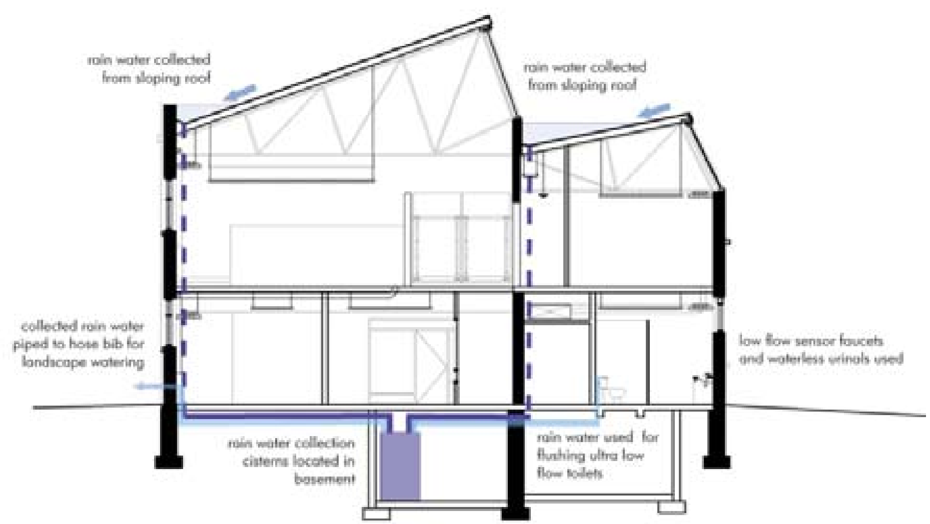

Figure 15 Integrating existing roof slopes into drainage and greywater retention system. Triffo Hall, University of Alberta. Edmonton, AB. Source: SAB Magazine

2.6. ENERGY PERFORMANCE

An energy performance upgrade must begin with an analysis of available actions and interventions. The planning strategies below provide a more targeted approach to heating, cooling, and lighting, resulting in greater energy-use awareness and, consequently, reduced energy use.

First and foremost, ongoing and good maintenance is key to the efficient energy operation of any building. In older buildings, maintenance can be neglected. Combined with inappropriate repairs or renovations, lack of maintenance can lead to original energy performing assemblies becoming compromised.

Second, it's important to study the existing building's original energy design as it may contain solutions to restore lost energy features. Original energy design or systems that are themselves part of a building's *heritage value* are especially worthy of further study. The original building design may also contain measures that were intended to enhance performance but, due to competing project objectives, were omitted during the construction process.

Third, the design team can consider the many passive strategies that use traditional designs and techniques to improve the energy performance of existing buildings without compromising *character-defining features*.[14,15] Prior to the availability of a stable electrical supply, these strategies were heavily relied on. As building technologies evolved and new resources became available, the reliance on passive strategies shifted to more managed and active strategies, which used mechanical and electrical systems to deliver air, heat, cooling, and lighting. Today's passive strategies make use of the natural airflow and lighting characteristics specific to a particular site and building design. A building may be only suited for certain passive strategies, requiring some level of mechanical augmentation.

Because it allows better tailoring of strategies to the building's idiosyncrasies, this mixed strategy (passive and active) offers the greatest potential for improving energy performance within existing buildings. For instance, as is the case with operable or vented skylights, a naturally occurring stack effect can be augmented using limited mechanical air movement to enhance performance.

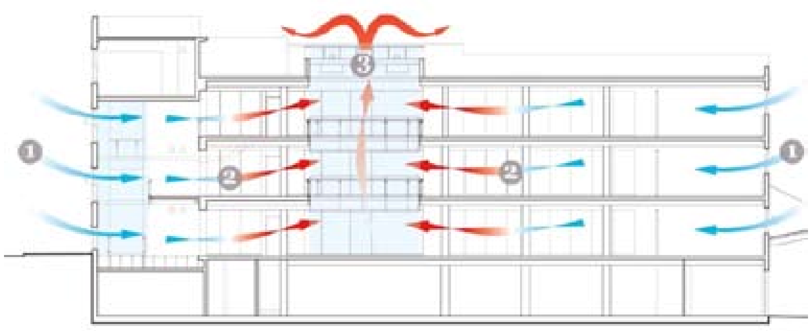

Figure 16 Stack effect in a cooling scenario: *1. Fresh air is drawn in from outside through operable exterior windows. 2. As the air passes through the office, it is naturally warmed. 3. The warmer air rises via the stack effect through the central atrium and is vented by the operable skylight.* 1220 Homer Street, Vancouver, BC. Source: Perkins + Will

14 British Columbia Heritage Branch, Ministry of Forests, Lands and Natural Resource Operations. Updated 2011. *Fact Sheet: Work With What You Have: Traditional Building Design.*

15 Hensley, Jo Ellen and Antonio Aguilar. 2011. *Improving Energy Efficiency in Historic Buildings.* US Dept of the Interior, National Park Service, Technical Preservation Services.

Figure 17 Localized control of sun-shading, heating, window operation, and air movement, Frontenac County Courthouse, Kingston, Ontario.
Source: MTBA Associates Inc.

Fourth, the design team should consider that energy may be wasted by delivering services to areas that do not require them.

Finally, the successful implementation of a targeted delivery strategy must include user awareness; operators and occupants must understand how to use the systems as intended. If, for example, an occupant opens the window and turns on the heat on a cold day, energy use is less efficient. To limit the impact of these occurrences, mixed systems should include an education program and a series of checks, balances, and centrally managed overrides.

2.7. UNDERSTANDING BEHAVIOURAL CHANGE TO IMPROVE PERFORMANCE

An integrated management approach is one of the most useful strategies that can be implemented to improve energy performance in an existing building. This approach includes:

- Regular condition and performance assessments;
- Regular cyclical maintenance of all components from HVAC to building envelope;
- Provision of training for building managers, operators and users in how their behaviour can address *sustainability* objectives;
- Establishment and implementation of building operation guidelines that take into account seasonal adjustments, building occupancy, day-night cycles, etc.

INTEGRATED MANAGEMENT STRATEGIES

Integrated management strategies focus on considering and coordinating a large range of systems that impact building longevity and efficiency, to arrive at a comprehensive approach that, ideally, balances the various competing needs.

Strategies affecting environmental performance include:

- Conducting periodic building condition assessments to identify potential maintenance projects needed in a timely manner;
- Carrying out capital projects and general maintenance to address system weaknesses and general wear in a timely manner;
- Providing the means to appropriately fund repair projects and general maintenance in order to prolong and effectively manage assembly life expectancies;
- Preparing training manuals, continuously updating maintenance logs and training personnel in treatments that incorporate *heritage conservation* and *sustainability*. Maintenance logs should include reference to necessary seasonal building adjustments that respond to non-mechanical system design aspects;

BEHAVIOUR-BASED MANAGEMENT STRATEGIES

Studies show that "positive occupant behaviour can reduce energy consumption by up to 20%."[16] Implementing a behaviour-based energy conservation plan through policies and education may well be the most effective energy efficiency strategy of all. User programs, if managed effectively, have been found to dramatically increase *sustainability* in general and energy savings in particular. These programs can improve protection of building fabric as well.

Some means and methods of behaviour-based building management include:

- Engaging users in controlling their environment with the appropriate education (i.e., operable windows, individually controlled radiator units). Control with

16 Hensley, Jo Ellen and Antonio Aguilar. 2011. *Improving Energy Efficiency in Historic Buildings*. US Dept of the Interior, National Park Service, Technical Preservation Services.

education creates awareness, which ideally leads to more targeted and reduced consumption;

- Maintaining regular two-way communication with occupants, celebrating successes and listening to why energy wasting behaviour exists so that the root causes can be addressed;
- Providing occupants with easy access to resource use information, including feedback on resources saved;
- Offering benefits to encourage users to create building efficiencies;
- Limiting materials and assemblies with unknown performance characteristics. This is especially important in existing or traditional buildings where any associated impact to building character or *heritage value* could be significant;
- Ensuring maintenance contracts contain specific references to *character-defining elements* and the associated maintenance expectations;
- Providing training in order to develop/maintain specialized maintenance knowledge and skills for historic materials and assemblies.

PROJECT CLOSE-OUT

Ensuring good document availability at the close of the *rehabilitation* project will go a long way in assisting owners and building managers keep up with these integrated and behaviour-based strategies. Accurate as-built drawings for all disciplines, information pertaining to building evolution, and summaries of building behaviour/intent statements (intended tenant and system behaviour) all need to be properly packaged and easily accessible in digital and binder (hard) copies. For heritage buildings, include information such as heritage evaluation and assessment reports and statements of significance into both hard and digital copies to assist management and users with understanding the interrelationships between their building's environmental and built heritage conservation.

Figure 18 Light fixture management system. National Printing Bureau, Gatineau, Quebec. Source: M. Loiselle

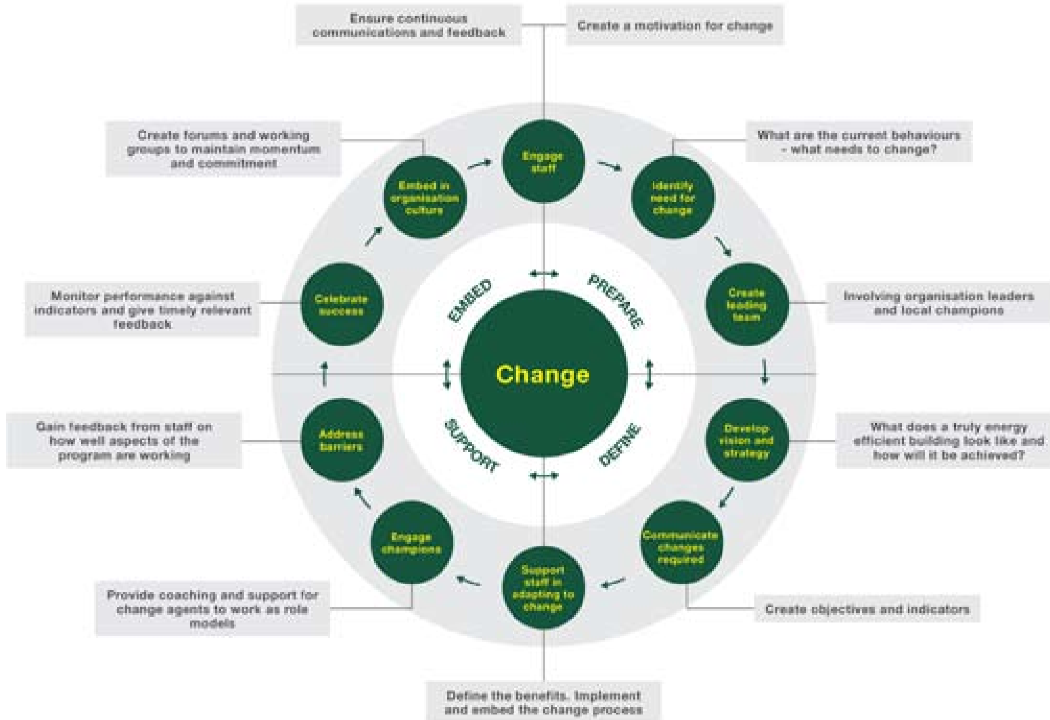

Figure 19 A change management process for energy efficiency behaviour. Source: Arup, Low Carbon Heritage Buildings

2.8. ACCOMMODATING HERITAGE VALUE IN BUILDING MAINTENANCE

Building performance and *sustainability* is partially and directly tied to the ongoing maintenance of the building components and systems. It is imperative to understand the processes causing deterioration and the processes, problems, and concerns inherent in preserving various historical building elements such as windows, metals, mortars and plasters, stone, and timber.[17,18]

Contemporary building maintenance regimes are often rarely suited to the unique realities of older buildings. Masonry walls, for example, are often thought to be "maintenance-free," which is an incorrect assumption that results in unnecessary damage to walls because of insufficient repointing and freeze-thaw action from water infiltration. Building maintenance regimes also frequently avoid using seasonal storm windows, citing them as a "recurring, potentially expensive activity." Often, very expensive replacement windows are purchased instead, which inverts the cost-value and shifts costs from operations to capital. However, although they may not be practical for tall buildings, seasonal storm windows could still be used in one and two storey buildings.

These kinds of less-informed and sometimes inappropriate maintenance regimes for older buildings can be an unintended by-product of programs not developed for older buildings, especially where large corporate or institutional organizations manage property portfolios containing a limited number of such buildings. Here, standardized systematic methods and processes targeted at newer buildings are in place, and maintenance personnel are more familiar with new buildings, simply by reason of their abundance. In addition, typical large-scale maintenance programs for older properties are often tied into revenue/expenditure projections, which are fed by annual building condition reviews and formulaic estimates for maintenance and replacement based on contemporary material and assembly life spans. The problem is then compounded by the fact that replacing traditional and/or original materials and components can be expensive and, when replacement is not executed properly, could compromise building character or heritage value.

For older buildings and portfolios of heritage properties, then, it is recommended that maintenance regimes and systems be augmented to better reflect the realities of working with historic fabric, traditional assemblies, potentially unique treatments and the potential presence of *heritage value*.

One example of such augmentation is Infrastructure Ontario's 2013-14 Pilot Project, which was intended to establish a heritage-sensitive maintenance regime by adapting its standard Annual Building Inspection Report (ABIR) process. The project aims to make the heritage maintenance program as user-friendly for property management personnel as

17 For more information refer to English Heritage's Practical Building Conservation Series published Ashgate Publishing.

18 For more information refer to Larry Kinney and Amy Ellsworth, "The Effects of Energy Efficiency Treatment on Historic Windows. The Center for Resource Conservation. http://conservationcenter.org/assets/EffectsEnergyonHistoricWindows.pdf, (accessed 25 May 2014).

possible to better ensure that heritage fabric is protected and maintained as efficiently as possible. After ABIR is completed by a property manager and used to plan maintenance and capital expenses, the property management team, which is already familiar with the maintenance approach, simply adapts it for properties identified as having *heritage value*.

The pilot project added the following adaptations to the standard ABIR system:

- Including the heritage character statement and visual information, which illustrate areas/assemblies with heritage value;
- Identifying and separately categorizing building components with or contributing to heritage value to ensure heritage fabric and assemblies are not simply treated as contemporary ones (i.e., creating a unique ABIR component for exterior stone walls, separate from other non-heritage exterior finishes). This allows for heritage repair and rehabilitation projects to be referenced and budgeted for more appropriately;
- Developing a cost multiplier to reflect the anticipated cost of carrying out maintenance projects on heritage assemblies.

Finally, to successfully improve the *sustainability* of heritage properties, funds for heritage-specific maintenance processes need to be budgeted for on an on-going basis rather than through major capital projects. This shift can benefit all building types and a range of ownership scales from large to small.

Figure 20 Leahurst Residence of the Kingston Psychiatric Hospital, one of the Infrastructure Ontario pilot project's subject buildings. It is part of the provincially-significant cultural landscape in Kingston, Ontario.
Source: MTBA Associates Inc.

2.9. CONSIDERING DISTRICT-WIDE INFRASTRUCTURE

In larger complexes, campuses, and large building groups, there is greater benefit and available resources to deliver services via a centralized source. Centralized or district-wide servicing provides greater efficiency and can serve significant areas depending on the size of the plant and distribution system. In Canada, district heating and cooling systems are typically found in downtowns where multiple buildings are connected via a supply network, or in large campuses such as universities, hospitals, and other multi-building institutional and residential complexes.

District servicing can satisfy the heating and cooling requirements of large building collectives by pooling individual resources and delivering from a single or a few sources. District heating plants contain boilers that provide steam to buildings connected to the plant via underground steam pipes. While in-building systems are constructed to include excess capacity to accommodate the seasonal variation in heating demands, district heating achieves greater efficiency as boiler loads are managed to suit the current demand. District heating may also take advantage of efficient fuel sources and waste sources not practical for individual systems. With the majority of the generating infrastructure located away from the outside of a connected building, greater spatial efficiency is achieved as the space is available for other uses.

Where building interiors have been identified as containing *character-defining elements*, existing district servicing becomes that much more important.

Interior building systems are designed to suit the nature of the supplied heating source. For instance, steam-supplied heating systems possess specialized distribution infrastructure and radiators that may not be suited to other sources like hot water or forced air.

When buildings are removed from a district system, new local systems must be installed to satisfy heating and/or cooling, requiring additional space for heat generating appliances, potentially new distribution systems (piping and ducts), and delivery appliances (radiators and vents), all of which may require significant modification to interior and sometimes exteriors. Modifications include new dropped ceilings, new vertical and horizontal chases, new window sill installations, new/enlarged service spaces, lost interior finishes sacrificed to install new distribution infrastructure within cavities, or surface-mounted conduits that may not be in keeping with a building's character or *heritage value*.

Figure 21 Cliff Street Heating Plant (on the right), district infrastructure for the Parliamentary Precinct, Ottawa, Ontario. Source: MTBA Associates Inc.

Where district heating and cooling exists, efforts should be made to maintain and enhance it by installing more efficient heat generating systems and exploring opportunities for capturing waste heat from buildings or processing it within the district. Historical campuses that once had district heating plants may have retained the associated infrastructure (boiler houses, tunnels, and piping). This infrastructure may accommodate reinstating district heating/cooling, thereby enhancing overall efficiency while revisiting original functionality and benefiting from current, more environmentally appropriate technologies.

There are a number of current technologies available for district heating and cooling, including fuel-fired, geo-exchange, bio-gas, co-generation (waste capture), and deep-water cooling.

2.10. THE UNIQUE CHALLENGE OF “MODERN HERITAGE”

Buildings constructed during the “Modern” period, which in Canada means from after WWII until the mid-1970s, present new and unique challenges for those with interest in conservation. Modern buildings responded to societal changes, new material access, and industrialization, resulting in the creation of a new way of building. Just like buildings from previous periods, over time, good quality Modern buildings have gained collective societal value. However, their materials and assemblies are often near or have exceeded their life expectancy. This makes these buildings subject to modification and/or demolition on a rapidly increasing basis.

Unique strategies are required to successfully undertake *sustainable retrofit* and *rehabilitation* projects of Modern buildings because they possess unique building systems, assemblies, materials, and building construction relationships. Below is a brief overview of *heritage value* in Modern buildings in Canada. The overview is followed by four ways of looking at approaches to Modern buildings that provide strategies or frameworks for their *sustainable retrofit* and *rehabilitation*.

DETERMINING VALUE

Evaluating the *heritage value* of Modern buildings places equal emphasis on design intent and material integrity. This comprehensive conservation mindset is used in many jurisdictions to evaluate Modern buildings. For example, a product or system in a Modern building may be valued as unique or cutting edge at the time of construction.

Another determinant in establishing *heritage value* is a building’s identification as representative of a type or style or as an example of a type or style of which few remain. Here, it’s important to keep in mind that the Modern period is characterized by the most significant volume of building construction in human history, which created a substantial quantity of buildings of lesser quality interspersed with higher quality examples. Furthermore, with evolving and pluralizing societal and technological advancements, Modern architecture responds in a wide range of styles from the minimal International Style to the flamboyant Expressionist Style. In other words, Modern-era buildings can be visually and stylistically diverse.

Figure 22

Figure 23

Left: Exterior curtain wall after *rehabilitation*. Source: MTBA Associates Inc.

Right: Upgrading exterior glazing system and perimeter heating. These combined *rehabilitation* treatments resulted in a 50% reduction in heat loss per linear metre (Numbering in image: *1. Reglazing 2. New induction units 3. Sun control 4. Heat loss)*. Source: B+H Architects

Figure 24 Full exterior envelope rehabilitated. Image shows rehabilitation progressing with granite panels temporarily removed to allow for the installation of new insulation and other envelope upgrades. For more information on the rehabilitation, refer to the Case Study found in the Case Study Appendix of this document. 333 Broadway, Winnipeg, MB. Source: Winnipeg Architecture Foundation.

USE OF EVOLVING MATERIALS AND ASSEMBLIES

Industrialized manufacturing yielded a range of new synthetic materials and assemblies that were eventually incorporated into buildings. These elements, seen as an embodiment of the period, responded to new building programs and scales never before attempted.

Unfortunately, new assemblies were often used with limited testing and a lack of long term performance knowledge, which could result in potentially challenging situations. Assemblies like curtain walls evolved so quickly (in building technology terms), systems were made obsolete often within less than a generation. The challenges created by the evolutionary arc of these wall assemblies are compounded by the proprietary nature of many systems, making conservation of the physical materials difficult. Additionally, over the life of a building, there are often a range of attempts to address assembly deficiencies with varying degrees of invasiveness, i.e., attempts will move from seal replacements to supplemental envelope components to full replacement. Each successive intervention potentially weakens both the legibility of the original design intent and the building’s character or its *heritage value,* which makes accurate conservation or *retrofit* and *rehabilitation* more difficult.

DEALING WITH DEFECTS

Any building can have unintentional design flaws that may cause failures sometimes years after the building is finished. However, with Modern-era buildings, there is the potential for construction defects to be present to a greater degree due to size, scale, or type of construction. The innovative structural solutions required to erect modern buildings may include minor design faults or assembly errors that can get repeated many times over. Assemblies may inadvertently combine materials that trigger galvanic action, or they use experimental materials that don’t perform well over time. In such cases, it is most important to identify and conserve the heritage value of the building as opposed to adhering to like-for-like replacement, particularly of manufactured materials. When technical improvements that do not affect heritage value are possible, defective assembly details or inappropriate material choices should not be replicated.

SEPARATION OF SKIN FROM STRUCTURE

One of the most significant changes from pre-modern to Modern construction was the separation of the exterior wall from the structure of the building. In pre-modern buildings the height and size of openings were dictated by the direction of structural forces and the capacity of the exterior and interior load bearing walls to transfer those forces into the ground. With new skeletal frame and thin shell structural systems made of concrete and steel, structural requirements are accommodated by a system freeing the exterior walls to perform as an envelope hung from the structure. The ultimate expression of this approach is the unitized curtain wall available in a range of finishes and styles, often made entirely of windows and spandrel panels within a grid.

The gradual development of thermal resistance and air and moisture awareness using a largely trial and error approach evolved as a result of this separation and the use of envelope systems with less thermal mass. This approach and ensuing lack of heating and cooling efficiency was supported by the availability of energy in low costs and high quantities never before available. Over time, successive upgrade deficiencies were identified and sometimes addressed using systems and components that require constant attention and monitoring. Components of particular concern include the thousands of seals and gaskets that have been installed at the intersection between other individual wall components; these seals and gaskets are prone to failure.

Such challenges associated with Modern era wall technology directly impact the building material and design integrity, *sustainability* performance, and *heritage value* of these buildings.

SEPARATION OF INTERIOR FROM EXTERIOR ENVIRONMENT

With the exterior wall freed from a structural function, greater exterior wall and form flexibility resulted, and interior conditions were often disconnected from the exterior environment. Interior conditions became controlled at an ever-increasing rate via mechanical and electrical systems. These new systems did not rely heavily on exterior or natural conditions (natural ventilation and lighting), resulting in less site-specificity for buildings and greater energy demands. For a deeper discourse on this subject refer to Appendix B.

ADAPTABILITY OF STRUCTURES

A building’s flexibility is enhanced by separating building skin from building structure and by using unitized and/or standardized assembly components. Exterior skins can often be addressed independently of the underlying structure, increasing the range of *sustainable rehabilitation* or *retrofit* and adaptive reuse options. The appropriate approach is selected based on a building’s heritage character value and material conditions and the degree of *sustainability* performance improvement desired. Poor material conditions in exterior walls does not necessitate full demolition.

Distinct structural systems provide further flexibility and adaptability. The structure provides a framework that can be used to guide *rehabilitation, retrofit* and adaptive reuse projects. For instance, the Friedman Building at the University of British Columbia (identified by the University as a heritage resource) was adapted and *retrofitted* in a way that took advantage of the inherent design characteristics of the existing building, including those removed in previous renovations. The result is a building that respects the original design intent, accommodates a new use that requires less severe modifications than retaining the current use, benefits from a clarified plan with enhanced access to natural light in the center of the floor plate, and utilizes a new exterior wall system. These upgrades clearly respect the spirit of the building.

Due to the vast quantity of Modern buildings, it is absolutely necessary that interested parties focus on *retrofitting* and adapting this building stock. Many buildings are at or past their intended life span and are in need of attention. Addressing the needs of Modern buildings could offer a substantial opportunity to reduce energy consumption in Canada. The appropriate level of intervention needs to be considered on a case-by-case basis to protect a building’s *heritage value* where it has been identified or, at a minimum, to accommodate the features that have design value or provide a sense of place.

Figure 25 Rehabilitated exterior assembly. Friedman Building, University of British Columbia Source: Acton Ostry

Figure 26 New corridor with glazed partitions. Friedman Building, University of British Columbia. Source: Acton Ostry

Figure 27 New seismic buttress connected to the existing building. Friedman Building, University of British Columbia. Source: Acton Ostry

3. BUILDING COMPONENT GUIDELINES

Regardless of project size or type, there are common considerations for retrofit and rehabilitation projects, particularly those including energy retrofits and environmental benefit objectives that can serve as guidelines for best practices.

3.1. CONTEXT

Building Resilience is intended to provide guidance for planning *sustainable retrofit* and *rehabilitation* interventions within all existing buildings, especially buildings of *heritage value*. It is also meant to provide component-focused interpretation of the Standards (refer to the *Standards and Guidelines for the Conservation of Historic Places in Canada, 2nd Edition*) within the scope of a *sustainable rehabilitation* project.

While Parts One and Two of *Building Resilience* provide an overall introduction, background, and context to the relationship between *sustainable* practices and building *retrofit* and *rehabilitation*, Part Three provides actionable guidelines for retrofitting or rehabilitating existing buildings. It presents general guidelines applicable to all *sustainable retrofit* and *rehabilitation* projects, which are followed by details on how to evaluate a project in context. Component and material-specific guidelines appear next. Part Three concludes with general guidelines for *sustainable* conservation that are applicable to all building projects.

These guidelines should be consulted throughout the project planning process by all stakeholders. This will ensure that all parties are aware of the building's *heritage value* (where identified), project goals, and the concerns of other stakeholders. Potential relevant stakeholders may include property owners, managers and developers, government authorities, agencies and departments, conservation/building professionals, and contractors/tradespeople.

Building Resilience is not meant to provide case-specific advice: all interventions must be evaluated by experts equipped with the necessary knowledge and experience to ensure a balanced consideration of building character or *heritage value* and *sustainable rehabilitation* measures.

While a variety of guidelines could be applied during a *sustainable rehabilitation* project, each solution needs to align the project goals with the building character or *heritage value*, *character-defining elements*, *material integrity*, and *inherently sustainable* elements both within the building and its site.

Figure 28 The interior partitions in this 1908 office building are glazed with patterned or frosted glass, providing light penetration without losing privacy. Use of electricity for artificial light is reduced. Ontario Heritage Trust, 10 Adelaide, Toronto, ON. Source: HCNT. Issue 1 2009

SUSTAINABLE REHABILITATION OR RETROFIT PROJECT GENERAL GUIDELINES

- **Understand the building and site:** At the outset, it is necessary for all project participants to understand the building and site, including their *character-defining elements* and overall *heritage value*.
- **Develop a clear project statement:** A clear statement of the project requirements that reflects an understanding of the building and site must be developed to make clear the interrelationship between the building and the proposed changes, including the sustainability improvements.
- **Document and assess:** The building and site characteristics are documented and assessed to determine inherently *sustainable* elements and material and design integrity.
- **Review project requirements and inherently sustainable features:** The project requirements and goals are once again reviewed, this time in relation to inherently *sustainable* elements and material and design integrity.
- **Balance all project goals:** Recommendations are then presented on the relationship between heritage character, inherently *sustainable* elements, building or site integrity, and project requirements to best balance project goals with the heritage character and realities of the building or site.
- **Ensure continuous evaluation:** Because the relationship between heritage character, building or site integrity, *sustainability*-related interventions, and project requirements is dynamic, evaluation should occur on an on-going basis throughout a project. Continuous evaluation provides opportunities to achieve greater efficiencies within the *rehabilitation* project, especially in buildings with *heritage value*.
- **Recommend interventions:** Recommendations on interventions are then presented in the context of undertaking a *sustainable retrofit* or *rehabilitation* project. *Rehabilitation*, by its nature, includes some level of intervention. Therefore, in order to minimize impact on heritage character and to optimize sustainability performance, all selected actions must be undertaken with a solid understanding of the building's and site's realities as developed prior to the start of design.

Relevant excerpts from the *Standards and Guidelines for the Conservation of Historic Places 2nd Edition* are presented and identifiable in this document by *tan-coloured italicized text.*

COMPONENT- AND MATERIAL-SPECIFIC GUIDELINES FOR SUSTAINABLE REHABILITATION

How to Use the Component- and Material-Specific Guidelines

Each of the component- and material-specific guidelines should be read in concert with the more general guidelines presented above (Section 3.1). Each guideline is written in the following format, which is meant to aid the user in their application:

- **Introduction:** An overall description of elements and materials that may be encountered within a building or site component. The introduction may include descriptions of common traditional and/or original and modern assemblies and common scenarios encountered in a *retrofit* or *rehabilitation*;

- ***Inherently Sustainable* Elements:** Existing characteristics that may be (or may have been) present within a building or site as applicable to the component. These features may limit the need for intervention and/or provide guidance for minimally-intervening within and augmenting a property;
- ***Sustainability* Challenges:** Common issues on potential conflicts that may limit the ability to undertake *sustainability*-focused interventions within the scope of a *rehabilitation* project;
- **Interrelationships:** Each building component exists in a dynamic relationship with other components. It is critical to the success of any *sustainable retrofit* or *rehabilitation* project that these relationships are considered on an on-going and as-applicable basis;
- **Component-specific Guidelines:** Charts laying out specific guidance for the building element under discussion. Where appropriate, reference is made to the relevant pages in excerpts from the *Standards and Guidelines for the Conservation of Historic Places 2nd Edition.*

SUSTAINABLE RETROFIT AND REHABILITATION PROJECT GENERAL GUIDELINES

	RECOMMENDED
1	**Executing** all *retrofits* and *rehabilitations* using a *minimum intervention* approach.
2	**Assembling** an integrated multidisciplinary design team, as appropriate, to holistically and effectively design and execute the project.
3	**Including** *heritage conservation* and *sustainability* specialists from pre-design through construction as part of an integrated multidisciplinary design team.
4	**Understanding** the *sustainability* goals specific to each project and their place in the overall project objectives.
5	**Understanding** the overall building and site character, *character-defining elements*, and interrelationship between each.
6	**Understanding** how a building's operating systems were designed to function and the modifications made over time, including potential deficiencies.
7	**Evaluating** previous interventions, their successes, failures, impact on building performance, and opportunities for sustainable upgrades.
8	**Evaluating** inherently sustainable design features to best integrate new interventions.
9	**Determining** the level of integrity present for interior and exterior elements.
10	**Conducting** an energy audit at the start of a *sustainable* conservation project to establish a "baseline" and determine energy consumption levels and associated sources. This will help ensure that energy interventions are targeted to minimally impact building fabric and maximize payback.
11	**Undertaking** energy modelling to better understand energy demands and to target areas where the greatest benefit can be achieved with minimum intervention.
12	**Considering** initial construction costs, operations and maintenance costs, and replacement costs when evaluating potential *sustainability* upgrades.
13	**Evaluating** the interrelationship between proposed interventions to determine their interaction and co-relation between each.
14	**Augmenting** existing operating systems to enhance system performance wherever possible.
15	**Aligning** and integrating new interventions with other new interventions to minimize disruption to the building fabric.
16	**Accommodating** future interventions by incorporating redundancy into the overall building design and design of individual components.
17	**Using** *sustainable* materials (renewable, recycled, local, durable low-VOC, etc.) that are compatible with the building fabric and *character-defining elements* when undertaking interventions.
18	**Re-using** materials while avoiding the creation of a "false sense of history".

3.2. EVALUATING PROJECT OBJECTIVES IN CONTEXT

Buildings and their assemblies, materials, and uses exist in complex and dynamic relationships, each impacting the other in ways that are unique to a building's location and construction. As such, it is critical to the success of any *sustainable rehabilitation* project that the project context is well understood by the entire project team prior to proceeding.

EVALUATING RELATIONSHIPS

Various Project Objectives

The project team needs to understand how each of the project objectives relates to the others and what and when each objective(s) takes precedence. Potential project objectives include conservation of *heritage value*, *sustainability* targets, budget, and assembly/material life span, among others. The goal of reviewing the relationship between objectives is to limit intervention impact by selecting approaches that satisfy multiple objectives with the least intervention. Often, a minimum intervention approach reduces immediate and long term material consumption, thereby satisfying heritage conservation objectives, *sustainability* objectives, and, potentially, budget and life span objectives.

Building and Programming

The building will directly impact the success of *sustainable rehabilitation*, especially when it includes adaptation for new use. When substantial intervention is required to accommodate a new use, it must carefully balance material input and loss to ensure the *sustainability* benefits do not outweigh or diminish heritage character.[1] In almost all *adaptive reuse* projects, there needs to be some modification of a typical new building program to accommodate the realities of an existing building. These accommodations will vary depending on the proposed use/programming and the building under consideration, ideally to the benefit of both.

Sustainability Goals and Existing Inherently Sustainable Elements

Inherently sustainable elements are pre-existing or previously existing building characteristics that make or can help make a building *sustainable*. These characteristics must be understood, documented, and evaluated by the integrated design and implementation team to maximize their effectiveness. By considering *inherently sustainable elements* in an integrated fashion, the project team will develop an improved understanding of how building materials, assemblies, and potential interventions and treatments impact other disciplines.

Building, Assemblies, and Materials

All decisions should consider the dynamic relationships between buildings, assemblies, and materials. For instance, re-introducing removed windows may offer opportunities for a hybrid HVAC system that includes localized natural ventilation delivery. An integrated project team structure that accommodates free exchange of information and design approaches between members can be an effective way to review these relationships and to improve understanding and execution of treatments and interventions. For more information on Integrated Team delivery, refer to Section 1.4: Who Should be Involved?

1 This issue is discussed at length in *The Greenest Building: Quantifying the Environmental Value of Building Reuse, Preservation Green Lab, 2011.*

Building, Programming, and User Expectations

End user performance expectations, including thermal comfort, drafts, and humidity level, influence the level of intervention required to accommodate a new/modified program within a building. These expectations may require various building envelope modifications, altering the building's intended behaviour and potentially endangering the building as a whole. These expectations need to be evaluated with the proposed program and the existing building characteristics in order to determine the appropriateness of an adaptive reuse program.

3.3. BUILDING SITE AND SURROUNDING CONTEXT

Building Resilience is intended to provide guidance for considering *sustainability* modifications when the building site and the surrounding context are identified as *character-defining elements* of a heritage property. They also give direction on how to minimize the impact of introducing new elements and intervening in the non-character-defining property and surrounding context associated with an older building.

Building siting refers to the placement of a building in its environment and may include solar and wind orientation, relative elevation, and landscape elements within its site. Each of these considerations influences how a building is exposed to sunlight, airflow, and precipitation. Siting characteristics can aid in *sustainability* efforts with ideal orientation.

Figure 29 Evergreen Brick Works (Sustainable Rehabilitation of a previous industrial site) in its Don Valley Context, north of downtown Toronto, ON. The site was formerly home to the Don Valley Brickworks (1880s-1980s) which extracted clay and shale from the site for their bricks. Currently the site is home to a range of community uses, sustainably-focused businesses and Evergreen (evergreen.ca). Refer to additional sustainability information in Part 2 caption. Source: SAB Magazine

Surrounding context refers to the placement of a site within a wider context. Context varies from site to site and is usually in a state of flux, which influences a building's behaviour. Potential contextual influences include building density, relative building heights, street widths, presence of public transit, and shared servicing (campus heating/cooling plants and localized water treatment). Dynamic relationships within a broader context are especially important when a building is located within a landscape of cultural *heritage value*, a well-established area, or Heritage Conservation District.

Figure 30 Benny Farm sustainable rehabilitation project in its urban context. Benny Farm is a sustainably redeveloped neighbourhood in the Notre-Dame-de-Grâce district in Montreal. It was originally constructed as a superblock development for returning veterans in the 1940s. Refer to additional sustainability information in Part 2 caption. Site plan, Montreal, QC. Source: L'Oeuf Architectes

Changes to the surrounding context can alter the way a building behaves. If taller buildings are constructed in the surrounding context so as to block sunlight entering windows, for example, new artificial lighting would need to be installed. If an adjacent building is demolished, side walls with limited insulation would be exposed. This would increase heating/cooling demands and require the replacement or upgrade of building systems. Changes like these, in other words, require a review of their impact on the dynamic balance between the building and its various systems (mechanical, electrical, building envelope, etc.). If such changes took place in a previous *retrofit* or *rehabilitation*, they can be studied to gain insight into a building's function over time and to provide guidance in subsequent modifications aimed at improving *sustainability*.

Existing buildings can be less efficient than new construction; however, it is often preferable to explore alternate approaches that mitigate lack of efficiency. For instance, inefficiency could be offset by introducing highly efficient infill structures. This should be done in a manner that respects an area's *morphology* and minimizes impact on existing building system behaviour. This strategy can be applied on multiple scales, including in established urban neighbourhoods via laneway housing (if this is a characteristic of an area's *morphology*) and in campus settings via new, sensitively inserted buildings.

INHERENTLY SUSTAINABLE ELEMENTS

Inherently sustainable elements associated with an existing building's site or context, particularly older buildings, include:

- Densely packed surrounding context with abutting buildings that limit exterior exposure;
- Centralized district servicing facilities that provide heating and cooling to a group of buildings;
- Limited parking combined with access to public transit.

SUSTAINABILITY CHALLENGES

Sustainability challenges for existing buildings, particularly older buildings, include:

- Significant changes in context that fundamentally changes a building's behaviour requiring substantial remedial interventions;
- Lack of control over surrounding context;
- Increasing density while responding to an area's heritage character or *heritage value*.

Figure 31 Compact urban forms such as this one, found in Halifax, is an efficient way to build since the proximity to neighbouring buildings allows for more efficient heating, increased density, and decreased automobile usage. Halifax, NS. Source: Shelley Bruce

Figure 32 An example of urban scarring where evidence of building evolution can be seen on an adjacent property. Changes to adjacent buildings can expose walls never intended to be exposed. Montreal, QC. Source: MTBA Associates Inc.

Figure 33 Adaptive reuse of a former gas station site to a community centre. Sustainability measures included: site remediation, geothermal heating/cooling, and efficient lighting. La Station, Nun's Island, Montreal, QC.
Source: Steve Montpetit

INTERRELATIONSHIPS

Select examples of interrelationships between building elements building site and surrounding context include:

Roofs

- Site and context modifications may increase or decrease weather exposure, potentially affecting roofing material life spans, required maintenance, and effectiveness of insulation.

Exterior Walls

- Site and context modifications may expose walls never intended to be exposed (e.g., removal of adjacent building).

Windows, Doors, and Storefronts

- Site and context changes may cause windows to receive more or less light. Door and storefronts may require modification to accommodate new traffic patterns and/or environmental flows.

Entrances, Porches, and Balconies

- Entrances, porches, and balconies mediate the relationship between a building and its surrounding context and lessen the severity of the weather on the building. Contextual changes may alter the effectiveness of these strategies in performing as intended.

Mechanical and Electrical

- Site and context may influence demands on mechanical and electrical systems through building exposure.

SUSTAINABLE CONSERVATION PROJECT GUIDELINES FOR BUILDING SITE AND SURROUNDING CONTEXT

	RECOMMENDED
1	**Understanding** the impact of adjacent buildings and context elements on building performance, including the influence of contextual change over time.
2	**Maintaining** large scale landscape elements, which moderate climate impact, including large scale vegetation and hardscape patterns**.**
3	**Maintaining** small scale site planting, including trees and other landscape features, which provide shading and windbreaks.
4	**Exploring** opportunities that retain historic buildings through site infill while respecting a context's character and development pattern.
5	**Maintaining** building-to-building relationships where there is abutting construction and where the buildings are in close proximity to each other.
6	**Installing** *sustainable* energy generating equipment only where compatible with the heritage character of the site and/or surrounding context.
7	**Locating** new campus buildings to minimize their impact on landscape character and on building-to-building relationships when increasing the overall density of the campus.
8	**Installing** new sustainable landscape features, such as bioswales, rain gardens, and large collection tanks, where they are compatible with the heritage character and functioning of the site and the surrounding context.
9	**Reusing** support structures to accommodate bicycle parking or other ancillary functions that support *sustainable* uses**.**

3.4. EXTERIOR FORM

This section is intended to provide guidance in considering *sustainability* modifications for exterior form, especially when these elements are identified as *character-defining elements* of a heritage property. It also gives direction on how to minimize the impact of introducing new elements and intervening in the non-character-defining exterior form of a traditional or heritage building.

Exterior form is a combined response to site and surrounding context, climatic concerns, interior functions, and available materials and construction technologies. This response manifests itself through building size, massing, orientation, proportional relationships, and use.

Exterior form may be affected by a range of *sustainability* modifications, from building systems modifications that affect exteriors to additions. For instance, removing a water tower from a roof where the water tower is a heritage character element may alter the roof line, affect the outward legibility of a building's function, and alter its *character-defining elements*.

INHERENTLY SUSTAINABLE ELEMENTS

Generally, *inherently sustainable elements* associated with an existing traditional or heritage building's exterior form, particularly historic buildings, include:

- Solid-to-void (solid wall to fenestration/opening) ratio that is appropriate to a building's location and climate;
- Ideal orientation with placement of windows, solids, and entries that suits the microclimate around the building;
- Projecting eaves and other elements that shield building faces and windows from harsh summer sunshine while permitting lower angled, winter sunlight to reach the building when feasible;
- Central courtyards that permit greater natural light penetration and improved passive ventilation into the center of a building.

SUSTAINABILITY CHALLENGES

Sustainability challenges for existing buildings, particularly heritage buildings, include:

- Exterior form that is often a critical element of a building's heritage character, leaving limited modification opportunities;
- Impracticality of re-orientating a building.

Figure 34 Features like a projecting cornice, bay windows, awnings over commercial ground floor frontage, and a unique wedge-shaped site give this building in Vancouver's Gastown historic area (and National Historic Site) its distinct character while contributing to the surrounding context with its form, massing, and scale. Vancouver, BC. Source: Shelley Bruce

INTERRELATIONSHIPS

Select examples of interrelationships between different building elements with respect to exterior form include:

Building Site and Surrounding Context

- Modifications to the site and surrounding context may lead to an exterior element not functioning as intended and degrading at a faster rate due to increased exposure.

Roofs

- Different *sustainability* strategies are available for flat, non-visible roofs versus sloped, visible roofs depending on the visibility, performance, and character of the roof.

Exterior Walls

- Along with the roof, exterior walls form the largest portion of a building's exterior form. Modifications to exterior walls affect a building's exterior form.

Windows, Doors, and Storefronts

- Fenestration contributes to exterior form, providing scale and rhythm. Even seasonal elements of windows, doors, and storefronts, including awnings, can influence a building's exterior form while improving a building's *sustainability*.

Entrances, Porches, and Balconies

- Entrances, porches, and balconies respond to and create a sense of orientation. These elements contribute to geometries, rhythm, and scale, but they also provide exterior shading, wind break protection, and air lock opportunities.

Figure 35 North elevation showing later chiller addition placed without regard for the strong axiality and Beaux-Arts planning, which is a character-defining element of the FHBRO "Classified" property. National Printing Bureau Central Heating Plant, Gatineau, QC. Source: MTBA Associates Inc.

Figure 36 Deep, low slung roofs over both interior and exterior space provide both shading and the home's distinctive form. Forest House, Ron Thom. Source: AZN Modern

SUSTAINABLE REHABILITATION PROJECT GUIDELINES FOR EXTERIOR FORM

	RECOMMENDED
1	**Integrating** existing interior courtyards into ventilation systems, taking advantage of natural ventilation and stack effect opportunities. Any modifications should maintain or provide the original building exterior's solid-to-void relationship and natural light sources associated with interior courtyards.
2	**Improving** access to natural light within the interior of a floor plate by adding discreet light wells or light tubes in secondary locations, which will have minimal impact on visible exterior form and limit required changes to a building's structural system.
3	**Avoiding** alteration of the exterior if it is a *character-defining element*, and instead seeking alternate means for increased *sustainability*.
4	**Adding** energy generating equipment only where compatible with heritage character.
5	**Upgrading** mechanical equipment, where part of a building's exterior form heritage character, limiting impact to that character.

STANDARDS AND GUIDELINES FOR THE CONSERVATION OF HISTORIC PLACES IN CANADA SUSTAINABILITY CONSIDERATIONS (PAGE 133)

	RECOMMENDED	NOT RECOMMENDED
20	**Adding** new features to meet sustainability requirements, such as solar panels or a green roof, in a manner that respects the exterior form and minimizes impact on *character-defining elements*.	Adding a new feature to meet sustainability requirements in a location that obscures damages or destroys *character-defining elements*.
21	**Working** with sustainability and conservation specialists to determine the most appropriate solution to sustainability requirements with the least impact on the *character-defining elements* and overall *heritage value* of the historic building.	Making changes to the exterior form, without first exploring alternative sustainability solutions that may be less damaging to the *character-defining elements* and overall *heritage value* of the historic building.
22	**Complying** with energy efficiency objectives in a manner that minimizes impact on the *character-defining elements* and overall *heritage value* of the historic building.	Damaging or destroying *character-defining elements* or undermining their *heritage value*, while making modifications to comply with energy efficiency objectives.
23	**Accommodating** functions requiring a controlled environment, such as artefact storage or exhibits in an addition, while using the historic building for functions that benefit from existing natural ventilation and/or daylight.	Introducing new mechanical systems based on airtight building envelope design in buildings that were designed to use natural ventilation.

3.5. STRUCTURAL SYSTEMS

This section is intended to provide guidance for considering sustainable modifications to structural components, particularly when the structural system is identified as a character-defining element of heritage building. *Sustainability* modifications when the structural system is identified as a *character-defining element* of an historic place. It also gives direction on how to minimize the impact of introducing new elements and intervening in non-character-defining structural systems in a traditional or heritage building.

Structural systems are the primary components that, by meeting user safety and other applicable codes and standards, provide the necessary strength and stiffness to prevent both collapse and unacceptable deformations.

Figure 37 Interior view of double-shelled dome, a character-defining element, allowing air stratification and access to natural light at the Bank of Montreal head office, Montreal, QC. Source: MTBA Associates Inc.

Structural systems can be an interior feature where structural elements are visible. Exposing the structural system can increase spatial volume, provide visual organization, add visual interest, and create material efficiencies (by limiting finish materials). Nevertheless, the visibility and legibility of the structural system should be based on the character of a building; it is not always appropriate to expose a building's structural system.

The *SGCHPC* provides structural advice that may be useful and applicable in older buildings regardless of heritage value. (Ref. pp 174 to 180).

INHERENTLY SUSTAINABLE ELEMENTS

Inherently sustainable elements associated with an existing building's structural system, particularly heritage buildings, include:

- Thermal mass in buildings with masonry walls integrated into their structural system;
- Modular structural systems that accommodate unitized components;
- Structural components that use reused/recycled/recyclable materials;
- Hollow core slabs that minimize material use and provide opportunities to integrate ventilation and electrical conduit chases;
- Bolted connections that allow for adaptability and easy repairs;
- Structural systems that provide maximum structural capacity using minimum materials (e.g., Guastavino vaults);

- Structural roof systems that provide voluminous spaces and opportunities for skylights to provide natural light deeper into a building.

SUSTAINABILITY CHALLENGES

Sustainability challenges for existing buildings, particularly heritage buildings, include:

- Heavy masonry walls may limit modification opportunities for windows, which could improve access to natural light;
- Structural capacity may not accommodate the weight of new mechanical equipment or green roofs over an entire building, but localized areas may possess the structural capacity;
- Structural spacing and arrangement may limit opportunities to modify/upgrade existing building systems.

INTERRELATIONSHIPS

Structural systems are rarely subject to *sustainability* upgrades; however, the structural system may impact the ability to intervene in other building components to satisfy a project's *sustainability* goals and/or accommodate an adapted use. While sustainability upgrades may not specifically target a building's structural system, the very sustainable move of rehabilitating a building for a proposed new use often requires work to be carried out on the structural system.

Roofs

- Roofs may act as structural diaphragms tying together and stabilizing building components.

Exterior Walls

- Load bearing, heavy masonry wall structural systems and hybrid heavy masonry with embedded iron/steel incorporate bearing capacity of exterior walls;

- Structural components may set the rhythm and framework for other elements and define exterior wall visual appearance.

Interior Arrangement

- Interior arrangement is often related to the structural system; modifying the interior arrangement may result in unintended visibility, concealment or loss of structural components.

Interior Features

- Structural components are often concealed by interior finishes and features.

Figure 38 (left) Rehabilitated long span wood trusses. The timber truss system was repaired by replacing defective or missing members and installing steel plates at connection points. Thus, this significant character-defining element was retained along with the old growth timber. As part of the rehabilitation process the building foundation was modified altering its relation to the ground plane. The new foundation system is clearly legible on the building exterior. For more information refer to the case study at the end of this document. Salt Building, Vancouver, BC. Source: Acton Ostry

Figure 39 (right) The raised structural system at the Gulf of Georgia Cannery National Historic Site keeps the complex of buildings cool and allows them to naturally dry out. Richmond, BC. Source: Shelley Bruce

SUSTAINABLE REHABILITATION PROJECT GUIDELINES FOR STRUCTURAL SYSTEMS

	RECOMMENDED
1	**Reviewing** structural capacity of separate building areas to determine localized structural capacity.
2	**Augmenting** existing structural systems rather than replacing them.
3	**Integrating** *sustainability* upgrades as part of structural upgrades required to meet contemporary code requirements.

STANDARDS AND GUIDELINES FOR THE CONSERVATION OF HISTORIC PLACES IN CANADA SUSTAINABILITY CONSIDERATIONS (PAGE 179)

	RECOMMENDED	NOT RECOMMENDED
31	**Working** with specialists to determine the most appropriate solution to energy efficiency and sustainability requirements with the least impact on the *character-defining elements* and overall *heritage value* of the historic place.	Making changes to character-defining structural systems, including foundations, without first exploring alternative sustainability solutions that may be less damaging to the *character-defining elements* and overall *heritage value* of the historic place.
32	**Repairing** the structural system from the *restoration* period by stabilizing, reinforcing or otherwise upgrading individual components in a manner that is consistent with the *restoration* period.	Replacing an entire structural system or its component from the *restoration* period when the repair or limited replacement of deteriorated or missing components is possible.
33	**Replacing** in kind an entire structural system or component from the *restoration* period that is too deteriorated to repair, using the physical evidence as a model to reproduce the system or component. The new work should be well documented and unobtrusively dated to guide future research and treatment.	Removing an irreparable structural system or component from the *restoration* period and not replacing it, or replacing it with an inappropriate new system or component.

3.6. ROOFS

This section is intended to provide guidance for considering *sustainability* modifications for roofs, especially when they are identified as *character-defining elements* of an historic place. It also gives direction on how to minimize the impact of introducing new elements and intervening on non-character-defining roofs in a heritage building.

Roofs include a range of finish assemblies with visible finishes such as copper, slate, thatch, cedar shake, asphalt shingle, and flat roof built-up membranes. These assemblies protect the underlying materials and interior spaces from external elements. Elements such as domes, cupolas, dormers, turrets, chimneys, and cresting may be architectural embellishments and/or functional elements that are integrated into a roof's composition and, as such, affect the roof's performance and exterior form. Another group of roof elements – eaves, fascias, soffits, gutters, and downspouts – protect and shield exterior walls. These protecting elements should be maintained and enhanced to limit exposure of exterior wall components that are not designed to accommodate increased exposure.

The SGCHPC offers the following advice regarding roofs that may be useful and applicable in older buildings regardless of heritage value:

As the most exposed architectural assembly, the roof is vital in protecting the rest of the building from the weather. A deteriorated roof can cause catastrophic damage to interiors and to the building structure. The roof is also an important architectural feature that contributes to a building's form and aesthetics. The profile and details of a roof may also be character-defining despite its more understated appearance compared to a large hip or gable roof. p.139, SGCHPC

INHERENTLY SUSTAINABLE ELEMENTS

Inherently sustainable elements associated with an existing building's roof, particularly heritage buildings, include:

- Large overhangs on orientations exposed to intense sunlight and weather to protect walls and shield openings;
- Roof elements such as cupolas, domes, chimneys, and dormers that aid in ventilating a building and/or improving access to natural light deep within a building;
- Gutters that direct water away from building envelope elements and offer opportunities to collect and reuse water for other uses;
- Roofing materials that reduce heat island effect;
- Roof forms that provide additional interior space, increasing occupancy density.

Figure 40 Modified fascia height to accommodate new insulation. Modifications achieve building envelope performance improvements with very limited visual impact. East Block, Parliament Hill, Ottawa, ON. Source: MTBA Associates Inc.

SUSTAINABILITY CHALLENGES

Sustainability challenges associated with an existing building's roof, particularly heritage buildings, include:

- Roof profiles that are important exterior form elements and may limit *sustainable* modification options where they are visible;
- Airflow through roof cavities and open attic spaces. Airflow must be well understood before modifying to limit unintended degradation from temperature, airflow, and moisture changes, which can affect roofing materials and underlying structures.

INTERRELATIONSHIPS

The interrelationships to consider between roofs and other existing building elements include:

Exterior Form

- Roof profile changes meant to accommodate increased insulation may change roof and/or eave profile, which must be carefully studied to minimize the impact on the heritage character associated with the exterior form.

Structural Systems

- Roof assembly modifications or installations of new *sustainability* appliances, including solar panels and solar hot water equipment, must consider a roof's form and its structural capacity to support these items.

Exterior Walls

- Roof modifications may affect exposure to the elements. (ie. reinstating/installing gutters directs water away from exterior walls and into cisterns or drainage systems.)

Mechanical and Electrical Systems

- Roof elements such as cupolas, domes, and dormers are often integrated into traditional ventilation systems, enhancing airflow within a building.

Operations and Maintenance

- Roof inspections allow minor issues to be addressed in a more proactive manner, limiting damage to adjacent materials, increasing/optimizing roof assembly life span, and reducing waste.

Figure 41 New Banking Pavilion green roof. The grid used for the green roof mirrors the lighting layout of the pavilion's ceiling below, harmonizing with character-defining design attributes. The green roof reduces heat island effect, provides insulation, reduces and/or slows water run-off, while having no negative impact on heritage value. This upgrade was completed as part of a comprehensive multi-building rehabilitation and upgrade to this icon of Modern architecture in Canada. Toronto Dominion Centre, Toronto, Ontario.
Source: Globe and Mail

Figure 42 Exterior walls, especially at interior corners, have been exposed to significantly increased amounts of water from the roof valley due to the loss of eaves troughing. As a result, the mortar is failing and the brick cladding is spalling. In addition, opportunities to collect rainwater for grounds maintenance are lost. Sagonaska School, Sir James Whitney School, Belleville, ON.
Source: MTBA Associates Inc.

SUSTAINABLE REHABILITATION PROJECT GUIDELINES FOR ROOFS

	RECOMMENDED
1	**Maintaining** roof elements such as cupolas, domes, chimneys, and dormers where they have a functional use and/or contribute to character-definition.
2	**Maintaining/reinstating** roof elements, including eaves, fascias, soffits, and downspouts that shield exterior walls and openings to limit material degradation.
3	**Exploring** opportunities for integrating water collection measures with downspouts in order to provide grey water for reuse.
4	**Replacing** roofing materials to high/low albedo roofs (as appropriate) where heritage character is not impacted.
5	**Evaluating** opportunities to increase roof insulation and/or ventilation in order to limit heritage character impact while improving performance.

STANDARDS AND GUIDELINES FOR THE CONSERVATION OF HISTORIC PLACES IN CANADA SUSTAINABILITY CONSIDERATIONS (PAGE 144)

	RECOMMENDED	NOT RECOMMENDED
25	**Complying** with energy efficiency objectives in upgrades to the roof assembly in a manner that respects the building's *character-defining elements*, and considers the energy efficiency of the building envelope and systems as a whole.	Damaging or destroying *character-defining elements* while making modifications to comply with energy efficiency requirements.
26	**Working** with energy efficiency and *sustainability* specialists to determine the most appropriate solution to energy efficiency and *sustainability* requirements with the least impact on the *character-defining elements* and overall *heritage value* of the historic building.	Making changes to the roof assembly, without first exploring alternative *sustainability* solutions that may be less damaging to the *character-defining elements* and overall *heritage value* of the historic building.
27	**Exercising** caution and foreseeing the potential effects of insulating the roof on the building envelope to avoid damaging changes, such as displacing the dew point and creating thermal bridges, or increasing the snow load.	Installing insulation without anticipating its potential impact on the building envelope. Inserting thermal insulation in roof assemblies, without providing appropriate vapour barriers or ventilation.
28	**Installing** thermal insulation in non-character-defining roof spaces, such as attics, without adversely affecting the building envelope.	Installing insulation in habitable attic spaces without considering its effect on character-defining interior features such as mouldings.
29	**Ensuring** that structural, drainage, and access requirements to improve the roof's energy efficiency can be met without damaging *character-defining elements*.	
30	**Assessing** the addition of vegetated roof systems (green roofs) or storm water cisterns to at-roof assemblies, and their impact on the building's *heritage value* and structural integrity, before work begins.	Adding a vegetated or reflective membrane roof system that might compromise the building's *heritage value* or its structural integrity.

3.7. EXTERIOR WALLS

This section is intended to provide guidance when considering *sustainability* modifications for exterior walls, especially when they are identified as *character-defining elements* of an historic place. It also gives direction on how to minimize the impact of introducing new elements to and intervening in the non-character-defining exterior walls of a heritage building.

Along with a building's roof, exterior walls are the most exposed elements to weather and exterior contaminants, making them critical to building performance. As is the case with many traditional load-bearing walls, exterior walls may function as integrated systems that perform structural, weatherproofing, and finish functions. As building assemblies have evolved, walls have gone from accommodating multiple functions to being composed of a series of layers that perform different barrier functions with the structural system often separated out as its own distinct system. Given the substantial difference in assembly approaches and that each performs differently, traditional and more contemporary walls must be evaluated individually.

Traditional load-bearing walls are typically constructed of masonry or timber, which provides opportunities for integrating thermal mass strategies into building heating and cooling strategies.

Modern period curtain wall systems were designed with sealed glazing units, which promoted air and moisture tightness and relied on mechanical systems to distribute, move, and cycle air within a building. Unfortunately, in practice, these curtain walls were often constructed using untested materials. In some instances, this lead to premature failure of components, requiring varying levels of replacement from localized to total depending on the assembly.

The SGCHPC provides the following advice on curtain wall systems that may be useful and applicable regardless of a building's heritage value:

Curtain wall systems present a range of new conservation challenges, because they were the result of an era of experimentation in structures and materials, and predate higher standards for energy efficiency. Their conservation should be examined on a case-by-case basis, taking into account the heritage value of the design and the actual conditions and causes of deterioration, while planning for extended or improved performance. p. 147, SGCHPC

Where exterior walls possess limited thermal resistance, one strategy for performance improvement is to introduce a second wall on the interior of the building with a controlled thermal zone between the two assemblies. The goals of this approach are to improve *sustainability*, improve occupant comfort, and minimize alterations to an existing wall's behaviour. While this approach may have merit, as determined on a case-by-case basis, the impact must be thoroughly reviewed given the level of impact on interiors and views from the exterior. Where a building's character is limited to the exterior, this approach may improve performance while protecting character; however, if the interior has design or character value, the level of intervention may not be acceptable.

Figure 43 Exterior glass curtain wall at the National Printing Bureau (c1950). The curtain wall is part of a double-wall assembly intended to help control interior conditions within the printing and production areas. Gatineau, Quebec. Source: MTBA Associates Inc.

INHERENTLY SUSTAINABLE ELEMENTS

Inherently *sustainable* elements associated with an existing building's exterior walls, particularly historic buildings, include:

- Heavy masonry exterior walls possessing thermal mass;
- Wall assemblies with built-in cavities aiding in moisture dispersion;
- Sun-shading devices such as horizontal projections screens, and others on curtain walls and at windows;
- Deeply set openings in exterior walls, providing shading;
- Wall assemblies with components possessing similar life expectancies or providing access to elements with shorter life expectancies;
- Unitized cladding permitting selective rather than total replacement, thereby reducing waste.

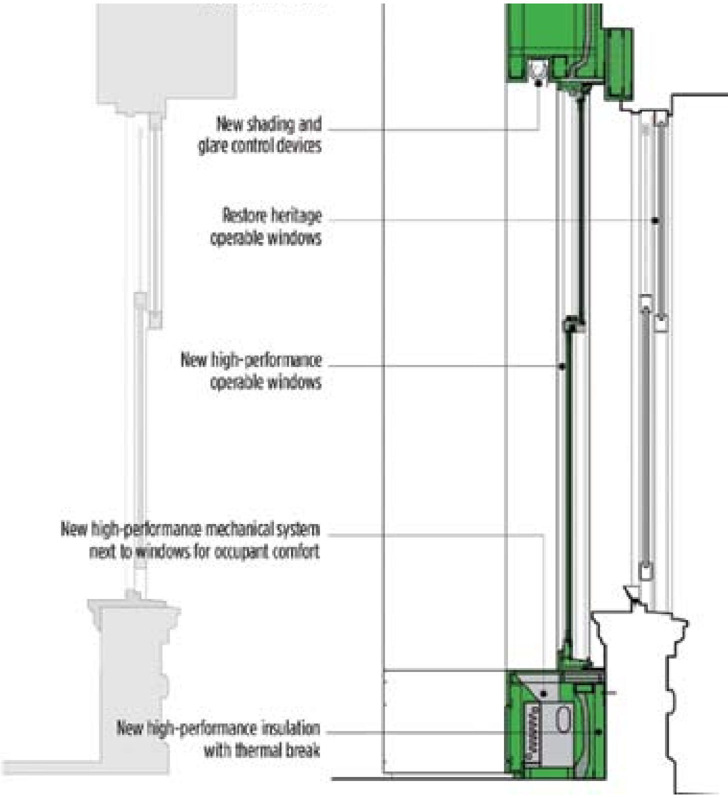

Figure 44 Exterior wall section before and after *rehabilitation*. *Sustainability* upgrades include new high performance window inside rehabilitated window, new insulation, new mechanical systems, and new shading devices. All new upgrades are integrated into a new wall added inside of the exterior wall. Calgary Public Building, Calgary, AB. Source: SAB Magazine

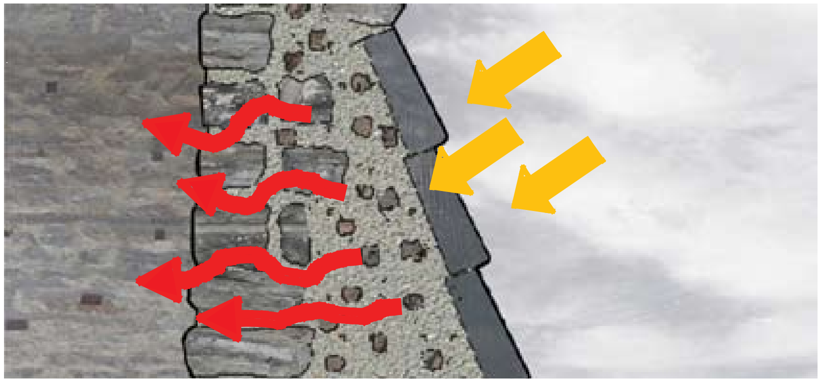

Figure 45 Dense masonry walls, a common thermal mass element on heritage buildings. Rubble wall study illustrating air and moisture movement through a heavy masonry wall. It is critical to maintain air and moisture behaviour characteristics to avoid creating unintended issues. East Block, Parliament Hill, Ottawa, ON. Source: MTBA Associates Inc.

SUSTAINABILITY CHALLENGES

Sustainability challenges for exterior walls in existing buildings, particularly heritage buildings, include:

- Wall assembly insulation moisture permeability, which must be well studied to avoid negatively affecting building envelope performance. Modifications should enhance performance, not fundamentally alter it;
- Exterior walls that are a significant part of a building's exterior form and heritage character. This limits options for visible modifications to walls.

INTERRELATIONSHIPS

Select examples of the interrelationships between exterior walls and other building elements include:

Exterior Form

Exterior wall modifications, such as cladding replacement, over-cladding on exterior insulation, new curtain wall systems, or new coating on exterior masonry surfaces, can change the scale, relationships, and legibility of exterior elements that compose exterior walls and affect exterior form.

Windows, Doors, and Storefronts

- Windows, doors, and storefronts provide access to exterior conditions (natural light, air, entrances) within an exterior wall. Therefore, modifications to fenestration affect exterior wall assemblies.

Entrances, Porches, and Balconies

- Entrances, porches, and balconies are may be directly engaged into exterior walls and are affected by changes to exterior walls.

Interior Arrangement

- Interior areas are reduced where new wall assemblies are added on the interior face of an exterior wall;
- Exterior curtain wall mullion spacing influences the placement of interior walls;
- Transparent exterior curtain walls result in mutually dependant interiors and exteriors.

Mechanical and Electrical

- Exterior wall air tightness and thermal performance directly impacts mechanical systems and can account for up to 40% of heat loss in older buildings,[2] significantly increasing the building's heating requirements. For instance, a tighter exterior envelope requires more mechanically-driven ventilation to achieve fresh air and air-change requirements.

2 Arup, Low Carbon Heritage Buildings: A User Guide. Kirklees Council and YoHr Space. 2011. http://www.yourclimate.org/pages/low-carbon-heritage-buildings. (accessed 24 November 2014).

Interior Features

- Exterior wall modifications may result in encasing or destroying interior features such as moulding, sills, casing, and other decorative finishes.

Operations and Maintenance

- Exterior wall modifications may impact operations and maintenance by adding additional materials and maintenance requirements. New materials may also restrict access to existing materials.

Figure 46 *Rehabilitation* of exterior envelope including full removal of all granite cladding panels to install new exterior insulation proud of the structural steel. The resulting 125mm shift is accommodated by a stainless steel channel added on the side elevations. Workers Compensation Board, Winnipeg, MB.
Source: 1x1 Architecture

SUSTAINABLE REHABILITATION PROJECT GUIDELINES FOR EXTERIOR WALLS

	RECOMMENDED
1	**Researching** original design intent to determine intended envelope performance and removed elements (for instance, shading devices) and installing or reinstating these items where they are integral to performance and/or beneficial.
2	**Researching** contemporaneous wall assemblies to determine vulnerabilities in an exterior wall assembly.
3	**Adding** wall assembly components that are compatible with heritage character and material assembly components (material and life span) and are appropriate to the local climate and building occupancy.

STANDARDS AND GUIDELINES FOR THE CONSERVATION OF HISTORIC PLACES IN CANADA SUSTAINABILITY CONSIDERATIONS (PAGE 151)

	RECOMMENDED	NOT RECOMMENDED
25	**Complying** with energy efficiency objectives in upgrades to exterior wall assemblies in a manner that respects the building's *character-defining elements*, and considers the energy efficiency of the building envelope and systems as a whole.	Changing the composition or materials of the exterior wall assembly in a manner that compromises the building's *character-defining elements* and the *durablility* of its materials. Replacing single pane glazing with sealed thermal units, without considering the impact on interrelated elements, such as curtain wall connections.
26	**Assessing** the potential impacts of adding insulation to the building envelope, such as displacing the dew point and creating thermal bridges.	Inserting thermal insulation in exterior wall cavities, in attics, and in unheated cellars and crawl spaces that might adversely affect the building's envelope and *character-defining elements*. Installing insulation on the inside of exterior walls without considering the effect on character-defining interior mouldings or detailing.
27	**Working** with energy efficiency specialists to determine the most appropriate solution to energy efficiency requirements with the least impact on the *character-defining elements* and overall *heritage value* of the historic building.	Making changes to the exterior walls without first exploring alternative energy efficiency solutions that may be less damaging to the *character-defining elements* and overall *heritage value* of the historic building.

3.8. WINDOWS, DOORS, AND STOREFRONTS

This section intends to provide guidance for considering *sustainability* modifications for windows, doors, and storefronts, especially when they are identified as *character-defining elements* of a heritage building. It also gives direction on how to minimize the impact of introducing new elements and intervening in non-character-defining windows, doors, and storefronts in a heritage building.

Figure 47 These large bronze-framed double-layered windows (storm and primary) were retained and rehabilitated, maintaining the primary source of light as when the building was constructed. Energy upgrades were limited to new gaskets on the interior operable windows which increased the lifespan of the windows Sir John A Macdonald Building, Ottawa, ON. Source: MTBA Associates Inc.

Traditionally, windows, doors, and storefronts were made using wood or steel/iron framing with plate glass while more contemporary windows are made using a range of composite materials including aluminum, stainless steel, vinyl, fibreglass, aluminum wrapped wood, and wood framing with float glass. Contemporary windows are sometimes assembled into larger units to create window walls or curtain walls that are suspended from the building structure.

Windows, doors, and storefronts are among the most important *character-defining elements* for both exterior form and interior arrangements. As they are the void to a wall's solid in the overall architectural composition, they often define a building's sense of rhythm, scale, and massing. On the inside of a building, windows provide natural light, define how a space can be occupied, and are often finished with decorative mouldings and other interior features.

The SGCHPC offers the following advice on windows and doors that may be useful and applicable regardless of a building's heritage value:

Windows and doors are vulnerable to wear and tear, changing tastes and functional requirements. The ongoing need for maintenance and upgrades can, however, motivate interventions that can have a negative impact on their heritage value. Often, windows and doors are replaced with newer units that have a much shorter service life, in the name of energy efficiency. p154, SGCHPC

Given the high costs and huge environmental impact of complete window replacement to a building's character, it is important to fully review the cost benefit of this type of intervention in any building. Frequently, the energy performance goals can be achieved through less severe interventions, including draught proofing, repairing window, adding interior/exterior storm windows, and giving attention to other building elements such as insulation. These interventions are typically less costly both monetarily and physically.

Due to their use of untested materials and assemblies containing components that age at different rates, windows in modern buildings can be challenging. The most common weaknesses in modern windows are gaskets, seals, gas fills, and heat-conducting framing materials like unbroken or small profile aluminum.

Storefronts are critical contributors to a heritage building and to its immediate setting. They are the outward expression of the interior occupant and break down a building's scale while defining how it relates to the pedestrian realm. In many ways, storefronts function as semi-public spaces, like porches.

Storefronts are far more transitory than upper storey elements because they adapt to changing tastes, seasons, and tenants. Depending on how a storefront is detailed, it can function sustainably by isolating the interior from the exterior by using a wall at the back of the display area.

Over the course of the twentieth century, changes to design approaches for windows, doors, and storefronts reduced the number of adjustable components, limiting their ability to be fine-tuned as weather changes from season to season. This is especially important in Canada, where many regions feature significant temperature swings, wind exposure, different types of precipitation, and a range of sun angles over a year. For instance, modern sealed window units with tinting are fixed, but windows with operable components, such as interior storm windows, thermal blinds, light diffusing blinds, light shelves, and exterior horizontal projections, and awnings (also suitable for doors and storefronts), offer opportunities to fine-tune a window assembly. Considering exterior openings as operable assemblies is critical to improving their *sustainability*.

INHERENTLY SUSTAINABLE ELEMENTS

Inherently sustainable elements that contribute to an existing building's windows, doors and storefronts, particularly heritage buildings, include:

- Windows and glazed doors provide access to natural light;
- Windows and doors provide opportunities for natural ventilation to augment a building's mechanical system;
- Awnings, horizontal projections, and screens that can respond to sun exposure, glare, and solar gains and that can mitigate extremes. These are especially useful where they are adjustable to accommodate seasonal or sun-movement differences;
- Interior storm windows that are removable, improve window performance based on heating or cooling requirements;
- Multiple window layers (storm and primary window) combined into a single assembly, requiring less frequent replacement because there is no sealed gas unit, which often fails before the rest of the window assembly;
- Wood-framed windows with single pane glazing and interior storm windows can be repaired periodically to improve performance and avoid waste associated with full replacement.

Figure 48 Rehabilitated storefronts with transoms. The taller storefront glazing provides light deeper into the ground floor storefronts. Vancouver, BC. Source: Acton Ostry.

Figure 49 Rehabilitated exterior with windows. Windows feature exterior storm windows that can be removed depending on the season. Emily Carr House, Victoria, BC. Source: David Coulson Design

SUSTAINABILITY CHALLENGES

Windows, doors and storefronts in existing buildings, particularly historic buildings, can present the following *sustainability* challenges:

- Windows, doors, and storefronts require on-going maintenance to address material degradation that weakens the integrity of the building envelope;
- Gas filled sealed window units can fail before the rest of the window, requiring full assembly replacement;
- Contemporary manufactured window units may not be repairable.

Figure 50 Historical photograph of the Booth Building (second building from the right) on Sparks Street in Ottawa. It is important to recognize windows were historically composed of a number of parts that contributed to their performance. In this case, the south facing windows were protected from increased heat gain by fabric awnings, accessible through operable windows. Booth Building, Ottawa, ON. Source: Ottawa AA

Figure 51 Window detail with puttied muntins, perimeter sealant and vented exterior storm window. Canadian Museum of Nature, Victoria Memorial Museum Building, Ottawa, ON. Source: Shelley Bruce

INTERRELATIONSHIPS

Select examples of the interrelationships between different building elements with respect to windows, doors, and storefronts include:

Exterior Form

- Fenestration provides rhythm, scale, and void within the solid mass of a wall.

Structural Systems

- Structural systems are a determining factor in the placement of windows, doors, and storefronts.

Exterior Walls

- Fenestration is a significant part of an exterior wall, providing access to natural light and typically less thermal resistance than other solid wall assemblies. Intersections between exterior walls and fenestration are especially vulnerable to breakdown, affecting air leakage and the exterior wall's *material integrity* surrounding an opening.

- Windows, doors and storefronts are often finished with interior trim work and other embellishments that require modification or removal when they are modified.

Entrances, Porches, and Balconies

- Windows, porches, and balconies are interrelated. Entrances are found in storefronts, and doors act as entrances or access to balconies.

Interior Arrangement

- Windows provide natural light and potentially natural ventilation which support a space's functionality.

- Storefronts are the only source of natural light for ground floor spaces.

Mechanical and Electrical

- Fenestration affects daylighting, air tightness, and heat gain/loss, all of which impact mechanical and electrical system demands.

Interior Features

- Windows, doors and storefronts are often finished with interior trim work and other embellishments that require modification or removal when they are modified.

Operations and Maintenance

- Windows, doors and storefronts with simple operable components accommodate fine-tuning on an as needed basis. Historically, fenestration incorporated components and assemblies that were/are repairable and were finished with re-applicable protective coatings on the frames.

Figure 52 Industrial buildings like this one in Toronto have shutters to protect the windows and to retain heat. Toronto, ON. Source: Shelley Bruce

SUSTAINABLE REHABILITATION PROJECT GUIDELINES FOR WINDOWS, DOORS, AND STOREFRONTS

	RECOMMENDED
1	**Considering** multiple smaller performance improvement interventions for windows rather than full replacement. This includes refinishing, localized repairs and replacements, fine-tuning operation, installing new weather-stripping, upgrading hardware, etc.
2	**Assessing** windows, doors, and storefronts as assemblies with multiple component parts that can be modified depending on climatic exposure.
3	**Installing** an interior wall with windows that align directly to existing exterior windows. Carefully review the changes to building systems, envelope performance, and presence of interior features when pursuing this type of upgrade.
4	**Integrating** opportunities to use enclosed storefront display space as a thermal insulating barrier.
5	**Sealing** gaps in building envelope at the intersection of frames and walls based on building system performance where possible.
6	**Reinstating** fenestration that may have been reduced in size to improve access to natural light.

STANDARDS AND GUIDELINES FOR THE CONSERVATION OF HISTORIC PLACES IN CANADA SUSTAINABILITY CONSIDERATIONS (PAGE 158)

	RECOMMENDED	NOT RECOMMENDED
28	**Complying** with energy efficiency objectives in upgrades to character-defining doors, windows, and storefronts by installing weather-stripping, storm windows, interior shades and, if historically appropriate, blinds and awnings. The energy efficiency of the building envelope and systems as a whole should be considered.	Replacing character-defining, multi-paned sashes with new thermal sashes with false muntins.
29	**Working** with specialists to determine the most appropriate solution to energy efficiency requirements with the least impact on the *character-defining elements* and overall *heritage value* of the historic building.	Making changes to windows, doors, or storefronts without first exploring alternative energy efficiency solutions that may be less damaging to the *character-defining elements* and overall *heritage value* of the historic building.
30	**Maintaining** the building's inherent energy-conserving features in good operating condition, such as operable windows or louvered blinds for natural ventilation.	Replacing repairable windows with new ones, without evaluating the performance and remaining service life of the existing windows.
31	**Installing** interior storm windows where original windows are character-defining and exterior storms are inappropriate.	

3.9. ENTRANCES, PORCHES, AND BALCONIES

This section provides guidance in considering *sustainability* modifications for entrances, porches, and balconies, especially when they are identified as *character-defining elements* in an historic place. It also gives direction on how to minimize the impact of introducing new elements and on intervening in non-character-defining entrances, porches, and balconies in a heritage property

Entrances, porches, and balconies are important contributors to a building's exterior form, providing articulation, organization, and building envelope shielding. Entrances provide the starting point for interior arrangements, influencing spatial sequencing as well as overall plan and section organization. Porches, entrances, and balconies are important architectural elements in both heritage and non-historic buildings, especially in residential architecture, as they often contain the most visible exterior embellishments. They often contribute to the character of neighbourhood or cultural landscape by providing rhythm to a streetscape, acting as a semi-public transitional space, and softening the boundary between interior (private) space and exterior (public) space.

Entrances, porches, and balconies are also frequently modified in all types of buildings in order to respond to changing architectural tastes, user demands, maintenance expectations, accessibility, and security concerns. As such, it is important to review how these elements may have evolved; a review may yield opportunities to alter these elements so they better respond to a building's character while increasing the building's *sustainability*.

Figure 53 A portico and vestibule integrated into the entry sequence of a commercial building. The portico provides shelter from weather while the vestibule isolates interior from exterior. Aldred Building, Montreal, QC. Source: MTBA Associates Inc.

INHERENTLY SUSTAINABLE ELEMENTS

Inherently sustainable elements for existing buildings, particularly heritage buildings, include:

- Entrances, porches, and balconies that provide shading and weather protection;
- Operable transoms in entrance assemblies that promote cross ventilation;
- Entrances with vestibules that isolate interior from exterior conditions;
- Porches and balconies that provide direct exterior access, which can improve building occupant health;
- Porches and balconies with removable screens or glazed panels that accommodate seasonal changes.

SUSTAINABILITY CHALLENGES

Sustainability challenges for existing buildings, particularly historic buildings, include:

- Entrances are openings in the building envelope that may weaken its overall performance;
- Porches and balconies that are less effective because of their less than ideal placement. These can shade windows, increasing artificial lighting needs and affecting heat gain.

Figure 54 The projecting Council Chamber, complete with balcony, shelters the main entry below. Former Ottawa City Hall, Ottawa, ON.
Source: MTBA Associates Inc.

Figure 55 Recessed balconies on a street-fronting elevation were retained during the overall *rehabilitation* of this building. Chinese Freemasons Building, Vancouver, BC. Source: Shelley Bruce

INTERRELATIONSHIPS

Select examples of interrelationships between different building elements with respect to entrances, porches, and balconies include:

Exterior Form

- Along with fenestration, entrances, porches, and balconies are important architectural elements that provide rhythm, scale, and proportion to a building's exterior form.

Structural Systems

- Balconies and porches may be integrated into a building's structural system, providing lateral bracing.

Exterior Walls

- Porches and balconies shield the exterior wall to varying degrees depending on climatic exposure.
- Interior and exterior structural interfaces where porches and balconies were removed in the past may include vulnerable building gaps.

Windows, Doors and Storefronts

- Porches and balconies shield windows, altering the impact of climatic exposure including solar gain and precipitation.
- Porches provide protection at a door from wind, heat gain, and precipitation.

Interior Arrangement

- Entry vestibules elongate an entrance, potentially shifting where someone enters the building proper.

Mechanical and Electrical

- Entrances are often points of building envelope weakness; modifying them will alter mechanical load demands. Modifying porches and balconies will alter building exposure to natural light and heat gain, which may require changing electrical lighting and heating/cooling requirements in order to compensate.

Interior Features

- As the first point of contact into a building, entries are typically embellished with *character-defining* or other important elements that are typically of a higher quality than those found elsewhere in a building.

Operations and Maintenance

- Entrances, porches, and balconies are all exterior building components that are exposed to weather and, therefore, require routine maintenance to optimize material life spans.

Figure 56 Front porches on early single-family residences such as this one in Fredericton, NB provide both shade and an opportunity for natural cross ventilation. Source: Shelley Bruce

SUSTAINABLE REHABILITATION PROJECT GUIDELINES FOR ENTRANCES, PORCHES, AND BALCONIES

	RECOMMENDED
1	**Recessing** entries and entrance vestibules to isolate exterior conditions from interior environment only when this type of intervention is complementary to a building's *heritage value* and CDEs and could be supported by the S&Gs.
2	**Reinstating/constructing** "French" balconies, thereby increasing operable window area in order to improve passive ventilation and to access natural light access only when this type of intervention is complementary to a building's *heritage value* and CDEs and could be supported by the S&Gs
3	**Reinstating** porches and balconies to improve exterior access and building envelope shielding.
4	**Considering** potential cultural landscape impact prior to altering entrances, porches, and balconies.
5	**Considering** entrances as part of an integrated spatial sequence intended to filter the transition between exterior through interior.
6	**Investigating** opportunities to increase interior living space and improve building efficiency in modern buildings as part of an exterior retrofit. These interventions must carefully consider a building's heritage character in relation to potential improvements.

STANDARDS AND GUIDELINES FOR THE CONSERVATION OF HISTORIC PLACES IN CANADA SUSTAINABILITY CONSIDERATIONS (PAGE 165)

	RECOMMENDED	NOT RECOMMENDED
26	**Complying** with energy efficiency objectives by maintaining inherent energy conserving features, such as overhangs, awnings, and vestibules while preserving *heritage value.*	Removing character-defining vestibules, porches, and balconies that contribute to the inherent energy efficiency of the historic building.
27	**Working** with specialists to determine the most appropriate solution to energy efficiency requirements with the least impact on the *character-defining elements* and overall *heritage value* of the historic building.	Making changes to entrances, porches, and balconies without first exploring alternative energy efficiency solutions that may be less damaging to the *character-defining elements* and overall *heritage value* of the historic building.

3.10. INTERIOR ARRANGEMENT

This section provides direction in conducting *sustainability* modifications for interior arrangements, especially when they are identified as *character-defining elements* of a heritage building. It also gives direction on how to minimize the impact of introducing new elements and intervening in non-character-defining interior arrangements in a heritage building.

Interior arrangement refers to the overall layout and the relationships between a building's interior spaces. Critical characteristics of interior spaces include scale, proportion, and architectural detailing/finishes (refer to Section 3.4: Interior Features). Relationships between spaces can be impacted by functional relationships and adjacencies, circulation routes, and spatial hierarchies.

Interior arrangements are directly related to exterior form, fenestration placement, circulation, and entries. *Sustainability*-related upgrades affecting interior arrangement will typically focus on space programming, which ensures that characteristics and access to natural light, passive ventilation, and existing mechanical and electrical system layouts are used to maximum benefit for the selected use. All modifications to interior arrangements must be considered carefully and evaluated based on their impact on spatial relationships, hierarchies, and exterior form vis-à-vis a building's heritage character and other project goals.

INHERENTLY SUSTAINABLE ELEMENTS

Inherently sustainable elements for existing buildings, particularly historic buildings, include:

- Interior arrangements that group uses with similar environmental requirements;
- Narrow floor plates that promote access to natural light and passive ventilation, especially where air is allowed to pass from one building elevation to another;
- High ceilings that encourage airflow where exhaust vents are provided at the higher areas;
- Storage spaces and/or service spaces placed in lower levels or deeper within a building core;
- Low partitions and/or glazed partitions placed to divide spaces near windows from those beyond;
- Vestibule spaces provided to separate interior spaces from exterior.

Figure 57 Large central skylight in a banking hall. The skylight provides natural light to the hall, which is located mid-block with limited access to street front windows. The skylight was uncovered during rehabilitation of the former Bank of Nova Scotia, Ottawa, Ontario. Source: MTBA Associates Inc.

SUSTAINABILITY CHALLENGES

Sustainability challenges for existing buildings, particularly historic buildings, may include:

- The expense and difficulty of reconfiguring plumbing and HVAC layouts.
- The reconfiguration of interior spaces with terra cotta block or plaster lath partitions, which is more difficult than contemporary gypsum board partitions with metal or wood studs;
- The modification of relationships between interior spaces, which can be challenging where the relationships are considered character-defining;

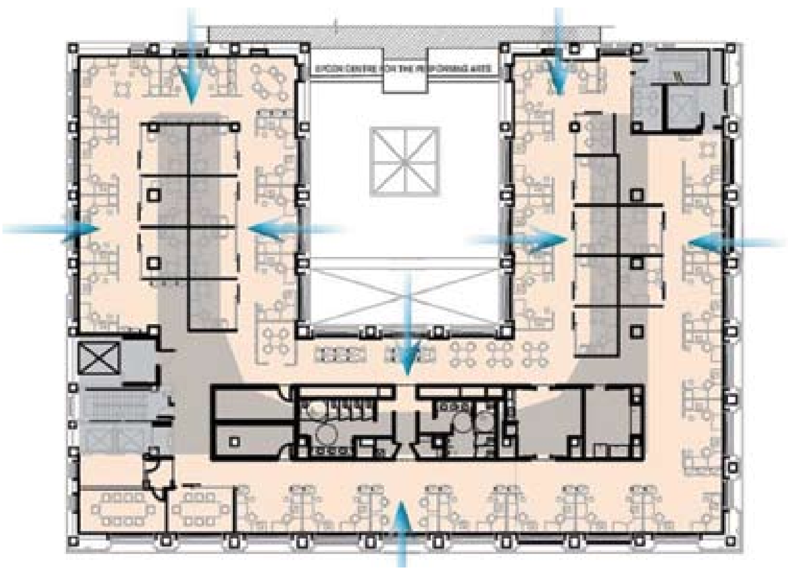

Figure 58 Floor plan illustrating zones with access to natural light and natural ventilation, which dictated the new interior office arrangement. Uses not requiring natural light including washrooms and storage are more centrally located, allowing better exterior access for office spaces. Calgary Public Building, Calgary, AB. Source: SAB Magazine.

INTERRELATIONSHIPS

Select examples of interrelationships between different building elements with respect to interior arrangements include:

Exterior Form

- Interior arrangements are directly related to the placement of windows, doors, and storefronts. Placement of these items affects a space's functionality and relationships as access and natural light dictate how a space is used.

Exterior Walls

- Transparent exterior curtain walls make interiors and exteriors mutually dependant. Interior arrangements become a significant element in the perception of the exterior form. The depth and detailing of perimeter interior spaces can directly impact the exterior form.

Entrances, Porches, and Balconies

- Interior arrangements rely on entrances and porches as the starting point for users entering a building. As such, moving an entrance will affect a number of relationships in an interior arrangement;

- Balconies extend interior spaces into exterior spaces, and modifications to balconies will affect the interior arrangement of adjacent spaces, especially for residential uses and communal spaces in commercial and institutional buildings.

Mechanical and Electrical Systems

- Arranging interior uses, including kitchens, electrical/ server rooms, heat-generating equipment, heat generating operations, and typically occupied spaces with thermal comfort requirements, creates opportunities for mechanical and electrical system efficiencies and potential energy and heat recovery unit use.

Interior Features

- Interior features provide convenience, aesthetics, finish, scale, proportion, and articulation for interior arrangements. As such, changes in interior arrangements requiring wall location modifications will affect interior features;
- Changes in interior arrangements may also result in increased traffic exposure to interior features, such as stairs and finishes, which may not be designed to accommodate the increase, leading to accelerated material degradation.

Figure 59 Light wells and light courts, such as this one at the Roslyn Courts National Historic Site, Winnipeg, MB, are an effective means to provide natural light and ventilation in a multi-storey building. The light coloured walls are highly reflective which encourages more efficient use of natural light.
Source: Shelley Bruce

Figure 60 Building section explaining the interior arrangement in three dimensions, highlighting the enclosed central courtyard, which improves natural light and ventilation at no energy cost. The Blackburn Building Apartments (Somerset Street), Ottawa, ON. Source: The Blackburn Building (Darcy Charlton)

Figure 61 Former Erskin American Church retained as a performance space with the significant addition of a new pavilion for the Montreal Museum of Fine Arts. Montreal, QC. Source: Provencher Roy and DFS (Tom Arban)

SUSTAINABLE REHABILITATION PROJECT GUIDELINES FOR INTERIOR ARRANGEMENT

	RECOMMENDED
1	**Grouping** similar uses to maximize HVAC and electrical distribution efficiency.
2	**Limiting** interior material loss when altering interior arrangements. Excessive alterations and material loss may make an adaptive reuse strategy un*sustainable* due to significant waste generation.
3	**Constructing** modifications using *sustainable* materials where impact on *character-defining elements* is limited.

STANDARDS AND GUIDELINES FOR THE CONSERVATION OF HISTORIC PLACES IN CANADA SUSTAINABILITY CONSIDERATIONS (PAGE 137)

	RECOMMENDED	NOT RECOMMENDED
22	**Adding** new features to meet *sustainability* requirements in a manner that respects the interior arrangement and minimizes impact on *character-defining elements*.	Adding a new feature to meet *sustainability* requirements in a location that obscures, damages, or destroys *character-defining elements*.
23	**Working** with *sustainability* and conservation specialists to determine the most appropriate solution to *sustainability* requirements with the least impact on the *character-defining elements* and overall *heritage value* of the historic building.	Making changes to the interior arrangement, without first exploring alternative *sustainability* solutions that may be less damaging to the *character-defining elements* and overall *heritage value* of the historic building.
24	**Retaining** or reinstating character-defining aspects of the interior arrangement which contribute to the historic building's *inherent sustainability*, such as natural daylight and ventilation.	Destroying character-defining interior arrangements to introduce daylight or ventilation into a space where it never existed.
25	**Accommodating** equipment designed to increase energy efficiency in secondary, non-character-defining spaces, such as service areas.	

3.11. MECHANICAL AND ELECTRICAL SYSTEMS

This section provides direction for considering *sustainability* modifications for mechanical and electrical systems, especially when they are identified as *character-defining elements* of an historic place. It also gives direction on how to minimize the impact of introducing new mechanical and electrical systems into existing or traditionally constructed buildings and on intervening in non-character-defining mechanical and electrical systems in heritage building.

Contemporary *sustainable* building *rating systems* place significant emphasis on achieving mechanical and electrical efficiencies. In a heritage context, all upgrades must be carefully considered to ensure that heritage character is protected to the fullest extent possible.

Upgrading mechanical and electrical systems can cause significant heritage character loss in heritage buildings. These losses can be both immediate (e.g., removal of character-defining mechanical and electrical fabric and/or interior finishes) and long-term (e.g., increased degradation of *character-defining elements* due to environmental changes and unintended consequences). It is critical to the success of all *sustainable rehabilitation* projects that options for mechanical and electrical system modifications are carefully considered relative to project goals and heritage character. Building upon existing inherently *sustainable* features (such as natural ventilation) is important.

Many buildings with *heritage value* have been subjected to “modernization”, which alters their behaviour and results in extensive new distribution systems (ducts, pipes, and conduits), fixtures (lights, vents, radiators, and control interfaces), new drop ceilings, and new vertical risers. At the outset of a *sustainable rehabilitation* project, these past modifications must be studied to determine successes, failures, level of heritage material loss, and visual disruption to character-defining spaces and elements to inform the most appropriate strategies for building interventions. For instance, within a web of building systems, a drop ceiling may conceal significant height; these building systems may be upgraded and consolidated, potentially accommodating increased/fully reinstated ceiling heights, improved airflow, increased spatial volume, improved access to natural light (via glazed transoms and skylights), and exposure of concealed *character-defining elements*. Recent advancements in mechanical and electrical technologies permit improvement; however, as advancement is an on-going process, project teams need to assess whether to integrate newer technologies immediately or postpone modifications until cost and performance improves. It is imperative to have heritage-experienced mechanical and electrical designers who are fully knowledgeable about both the sustainability goals and the heritage requirements.

Figure 62 Ornamental plaster ventilation grilles in the main banking hall were formerly connected to large fan units above and behind. Grilles were rehabilitated and integrated into the new mechanical system as exhaust grilles. Sir John A Macdonald Building, Ottawa, ON. Source: MTBA Associates Inc.

HEATING, VENTILATION, AND AIR CONDITIONING (HVAC)

HVAC systems maintain a building's interior environment to suit its occupancy. Potential systems in older buildings include boilers, fuel-burning stoves, electrical heaters, and fuel-burning furnaces. In pre-Modern buildings, thermal and air systems were designed to function with a breathable envelope that relied on passive ventilation and air and moisture flow through the building envelope to augment its function. In Modern period buildings, building envelope design has shifted towards greater air-tightness, with varying degrees of success, requiring increased airflow, exhaust, heating, and cooling – all typically delivered via mechanical means. In all cases, systems have a source and a distribution system (e.g. a boiler or furnace with hot water pipes or ductwork). Refer also to Appendix B.

Figure 63 Raised floor system installed in historic building. Former McGregor Sock Factory (now Stantec Offices), Toronto, Ontario. Source: MTBA Associates Inc.

In more recent years, there has been a further shift to balance mechanical air delivery with passive air delivery by reintroducing operable windows and vented skylights and by removing drop ceilings. Additionally, new technologies, such as ground source heat pumps, offer opportunities worthy of exploration in *sustainable retrofits* or *rehabilitations* where existing systems can accommodate them.

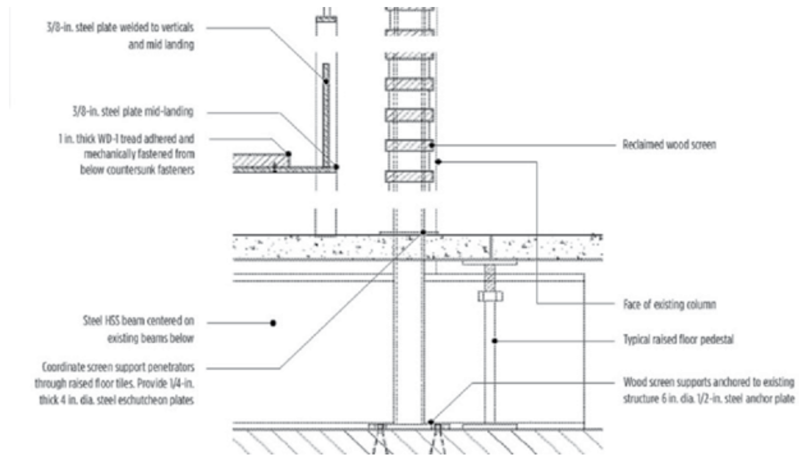

Figure 64 Floor Section illustrating new raised floor system in historic factory building. Former McGregor Sock Factory (now Stantec Offices), Toronto, Ontario. Source: SAB Magazine

Figure 65 New kitchen exhaust equipment is integrated in the building's overall HVAC system to capture waste heat generated from cooking activities. Paterson GlobalFoods Institute (Former Union Bank Tower), Winnipeg, MB. Source: Prairie Architects

CONTEMPORARY VERSUS TRADITIONAL APPROACHES TO THERMAL & AIR SYSTEMS

The SGCHPC offers the following advice on approaches to thermal design windows and doors that may be useful and applicable regardless of a building's heritage value:

Contemporary building design typically uses an active approach to controlling the building environment with fans, blowers, boilers, furnaces, ducts and plenums.... More traditional building designs, however, often used passive techniques that were integrated into the building's design. These passive designs can include character-defining elements such as high ceilings, open corridors and transoms that facilitate air circulation, operable windows and shutters, and canopies and plantings that provide shade and act as windbreaks. p182, SGCHPC

PLUMBING

Plumbing systems distribute water and sometimes other fluids, such as glycol, via pipes from a source throughout a building. Potential plumbing systems within a building may include: potable water, sanitary water and disposal, fire suppression, waste treatment, natural gas or fuel oil, and heating and cooling.[3] It can be desirable to remove older plumbing systems if they are corrosive, inadequately sized, or contain toxins (such as lead solder).

3 Fire suppression system retrofits can significantly impact heritage fabric and should be reviewed as part of a holistic fire separation strategy. However, fire suppression systems are rarely subject to *sustainability* upgrades and as such are beyond the scope of this document. For more information on intervening into heritage buildings refer to the *Standards and Guidelines for the Conservation of Historic Places in Canada (2010).*

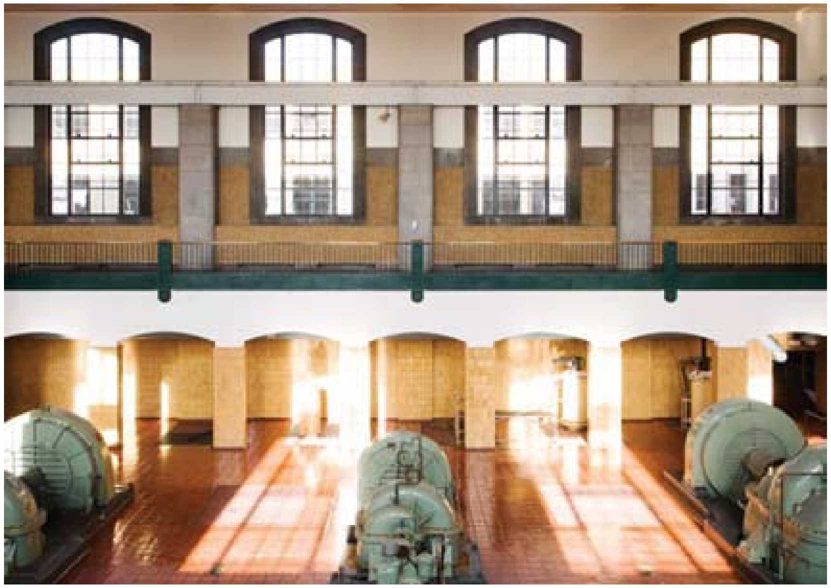

Figure 66 Active pumping equipment integrated into the water filtration process, while also being celebrated as significant objects within the light-filled room. . RC Harris Water Filtration Plant. Toronto, ON. Source: Torontist

ELECTRICAL SYSTEMS

Contemporary electrical systems include power, lighting, communication, data, and security systems while traditional electrical systems were limited to power, lighting, and telephone. With the development of new appliances and new technologies, power consumption has substantially increased. In addition, new communication and data technologies (with their distribution systems) accommodate computers, internet connections, building automation systems, security, and fire alarm systems. All of these contemporary distribution and visible appliances systems increase consumption and put pressure on *character-defining elements* to accommodate them. *Character-defining elements* in this context are typically limited to visible components, including light fixtures and visible controls.

INHERENTLY SUSTAINABLE ELEMENTS

Inherently *sustainable* elements for air and light systems in existing buildings, particularly historic buildings, include:

- Passive ventilation as it reduces mechanical ventilation demand and introduces fresh air;
- Dense masonry and concrete assemblies, which providing thermal mass by retaining warmth during the day and releasing heat at night when the outside temperature is lower;
- Skylights complete with base venting or operable panels, which encourage stack effect in order to circulate air;
- Windows, skylights, and interior courtyards as these allow natural light to penetrate deeper into a building floor plate, reducing daytime electrical demand.

Figure 67 Ornamental bronze radiator covers conceal mechanical equipment and offer opportunities for equipment upgrades without altering visual appearance. Canada Permanent Building, Toronto, ON. Source: MTBA Associates Inc.

SUSTAINABILITY CHALLENGES

Sustainability challenges for existing buildings, particularly historic buildings, include:

- New building code energy performance requirements;
- Limited ability to accommodate additional distribution systems within heritage interiors;
- Oversized mechanical equipment;
- Past removal of inherently *sustainable* elements;
- Inefficient character-defining lighting and thermal systems;
- New efficient systems incompatible with existing distribution systems;
- The possible presence of hazardous materials;
- Altered or increased user expectations.

Figure 68 Rehabilitated chandelier with new wiring and energy efficient LED light sources. Sir John A Macdonald Building, Ottawa, ON. Source: MTBA Associates Inc.

INTERRELATIONSHIPS

Select examples of interrelationships between different building elements with respect to mechanical and electrical systems include:

Electrical and Heating

- Replacing incandescent lighting with more efficient types produces less heat, potentially decreasing the need for additional cooling.

Building Site and Surrounding Context

- Site and surrounding context modifications may necessitate adjustments to mechanical loads and lighting demands. The foundation and other structural components may also be affected. For instance, removing trees may decrease building shading thereby increasing heat gain (negative) and increasing access to natural light, depending on building envelope and window configuration (positive).

Roofs

- Modifying roof cladding or associated insulation will alter heat gain through the roof, affecting heating/cooling requirements. For example, increasing attic insulation may reduce heating/cooling requirements.

Exterior Walls

- Sealing gaps in exterior walls where the building system relies on passive ventilation through leaks and gaps in the envelope alters airflow, air changes, and heating/cooling requirements, all of which may require modifications to the mechanical systems.

Windows, Doors, and Storefronts

- Modifying fenestration may affect daylighting, air tightness, and heat gain/loss, influencing system performance. Rehabilitating skylights with vents can enhance stack effect. Fenestration is typically the least thermally efficient building envelope component. Any modifications to their performance will impact mechanical requirements.

Entrances, Porches, and Balconies

- Entrances, porches, roof overhangs, and balconies shield building envelope components and/or interior spaces, thereby reducing the impact of climatic exposure.

Interior Arrangement

- Modifying mechanical and electrical systems that are designed to suit a building's interior arrangement may limit a space's ability to support occupancy.

Interior Features

- Maintaining operable transoms and glazed interior partitions improves airflow and natural light access (may impact fire separation strategies);

- Significantly modifying the HVAC conditions in a building can cause interior materials to degrade at increased rates (e.g. woods and fine plaster finishes subjected to thermal and humidity fluctuations and condensation);

- Incorporating open atria, stairwells, and other vertical spaces contributes to passive air systems.

Operations and Maintenance

- Undertaking on-going system optimization can mitigate the need to upsize or fully replace systems.

SUSTAINABLE REHABILITATION PROJECT GUIDELINES FOR MECHANICAL AND ELECTRICAL SYSTEMS

	RECOMMENDED
1	**Understanding** original design intent and function of the building's mechanical and electrical systems.
2	**Verifying** existing appliance and system performance prior to considering replacement in order to determine and verify the level of intervention required to achieve *sustainability* objectives.
3	**Completing** comprehensive commissioning of all building systems and establishing baseline expectations for system operation and efficiency.
4	**Designing** building systems to accommodate future modifications and load changes where possible.
5	**Integrating** existing thermal mass into a building's heating and cooling renewal strategy.
6	**Incorporating** passive heating/cooling opportunities into contemporary HVAC strategies. Where these are used, include monitoring equipment to allow mechanical system to adjust to these localized conditions.
7	**Grouping** and coordinating service runs to minimize disruption of *character-defining elements*.
8	**Consolidating** new HVAC systems into the minimum area required in order to reduce drop ceilings and disruption of *character-defining elements*.
9	**Locating** new HVAC equipment where visibility is limited and in secondary locations to minimize the impact on a building's heritage character.
10	**Making** new ductwork fully exposed and legible as new where appropriate for a space's heritage character or where concealing it would destroy heritage fabric.
11	**Installing** supplemental HVAC to improve and augment existing systems rather than imposing an entirely new system on a building where possible.
12	**Replacing** less efficient and/or designated substance containing heating/cooling sources with more efficient versions, which reuse the same ductwork, conduits, and/or piping where possible.

13	**Exploring** opportunities for new heating/cooling systems that maintain landscapes having *heritage value* and limit modifications to heritage interiors.
14	**Revising** controls strategy to incorporate energy conservation measures, taking care to avoid rapid changes in internal temperature that may damage building fabric.
15	**Installing** radiative barriers at radiators to limit heat loss through adjacent walls.
16	**Replacing** heating and electrical appliances while retaining visible components and containers (e.g. light fixtures and vent covers).
17	**Investigating** air leakage sources and addressing them while limiting impact on *character-defining elements*.
18	**Improving** water and waste efficiency by using minimally invasive strategies, including flow rate regulators and aerators, more efficient non-character-defining plumbing fixtures, or other less intrusive opportunities.
19	**Retaining** sound character-defining fixtures such as sinks and toilets when faucets or other plumbing hardware must be upgraded.
20	**Augmenting** existing piping rather than replacing it where possible/reasonable.
21	**Retaining** abandoned piping or wiring in place where it does not pose a risk to the building rather than by damaging heritage fabric in removal.
22	**Upgrading** existing light fixtures with more efficient versions where it does not negatively impact heritage fabric.
23	**Replacing** inefficient light sources with new sources that preferably match the colour temperature, colour rendering index, and intensity of the original source.
24	**Installing** supplemental lighting system(s) to augment existing systems rather than imposing an entirely new system where possible/reasonable.
25	**Installing** occupancy sensors in secondary spaces and only where visible components and conduit installation will not have physical or visual negative impact upon *character-defining elements* in primary spaces.
26	**Exploring** opportunities to leverage district heating or other combined utilities/energy systems with surrounding buildings in order to spread demand and reduce requirements and equipment needs.

STANDARDS AND GUIDELINES FOR THE CONSERVATION OF HISTORIC PLACES IN CANADA SUSTAINABILITY CONSIDERATIONS (PAGE 186)

	RECOMMENDED	NOT RECOMMENDED
29	**Reinstating**, where possible, character-defining natural ventilation and daylight, such as operable transom windows and atrium skylights.	Introducing airtight mechanical systems and artificial lighting in buildings that were designed for natural daylight and ventilation.
30	**Ensuring** that the introduction of new types of mechanical and electrical systems, such as solar, geothermal or heat-exchange systems will have minimal impact on the *character-defining elements* of the historic building.	
31	**Working** with specialists to determine the most appropriate solution to energy efficiency requirements with the least impact on the *character-defining elements* and overall *heritage value* of the historic place.	Making changes to character-defining mechanical and electrical systems without first exploring alternative energy efficiency solutions that may be less damaging to the *character-defining elements* and overall *heritage value* of the historic place.

3.12. INTERIOR FEATURES

These guidelines provide guidance for considering *sustainability* modifications when interior features are identified as *character-defining elements* of an historic place. They also provide direction on protecting interior features through maintenance and repair, minimizing the impact of introducing new elements, and intervening into non-character-defining interior features in an historic building.

Interior features include functional, purely decorative, or embellished elements that add architectural texture, scale, and interest to a building's interior. Most decorative elements evolved from functional origins; for instance, decorative mouldings conceal the intersection between components and materials, a challenging area to finish. Floor, wall, and ceiling finishes possess various levels of material quality and embellishment that support a space's relative importance within a building's spatial hierarchy. The spatial hierarchy's legibility is especially important in buildings with high levels of interior heritage character and integrity; here, the spaces often exist in dynamic relationships where altering finishes in one space may weaken the clarity of the whole or a related space.

In addition to floor, wall, and ceiling finishes, there are visible fixtures associated with building systems (faucets, sinks, light fixtures, thermostats, fireplace components, intercoms, radiators, and telephones), circulation elements (elevators, staircases, and escalators), permanent furniture (pews and benches, teller counters, and spatial dividers) and opening embellishments (doors, windows, and skylights).

It is important to review the functional purpose of an interior feature prior to altering it as it may be related to a building system. For instance, in taller, more voluminous spaces such as banking halls and transportation facility waiting rooms, it is common for mechanical and electrical systems to be integrated into counters and benches at the lower level, where services are best delivered. Altering these elements may affect the viability of the mechanical and/or electrical systems in the associated spaces.

In buildings constructed during the Modern period, the relationship between interiors and exteriors were blurred due to an increase in building transparency. This change was a product of separating the building envelope from the building structure and of improvements in glazing assembly technologies. Masonry, visual weight, and permanence were once desired, but new technologies allowed modern buildings to achieve more fluid and sometimes transient relationships between spaces. As such, interior features may also contribute to generating exterior form in Modern period buildings.

Figure 69 Hardwood flooring and ceiling cladding were retained as part of rehabilitating a former riverside factory into an institutional building. Note the effective use of natural light with clerestory windows, which helps reduce energy costs. University of Waterloo School of Architecture, Cambridge, ON. Source: Doors Open Ontario

Figure 70 Ground floor commercial space under *rehabilitation*. Ceiling height pulled back to original to expose decorative column capitals and accommodate taller storefront windows, allowing natural light to penetrate deeper into the space. Dineen Building. Toronto, ON. Source: Urban Toronto

INHERENTLY SUSTAINABLE ELEMENTS

Inherently sustainable elements for existing buildings, particularly historic buildings, include:

- Glazed partitions with operable transom panels;
- Durable and robust interior finishes including terrazzo flooring, fine stone finishes, fine metal elements, and fine wood finishes.

SUSTAINABILITY CHALLENGES

Sustainability challenges for existing buildings, particularly historic buildings, include:

- Designated substances that cannot be encapsulated;
- Limited ability to modify decorative finishes in order to access cavities beyond when modifying or augmenting building systems.

Figure 71 Filtration Building rotunda featuring a range of materials including fine stone, ornamental bronze, and plaster. RC Harris Water Filtration Plant. Toronto, ON. Source: Torontoist

Figure 72 Architectural woodwork retained as part of a *rehabilitation* and addition. Elgin County Courthouse, St. Thomas, ON. Source: FGMDA

INTERRELATIONSHIPS

Select examples of interrelationships between different building elements with respect to interior features include:

Windows, Doors, and Storefronts

- Fenestration modifications may require casings and mouldings to be temporarily/permanently removed or adjusted to accommodate modifications. Fenestration modifications may also affect floor, wall, and ceiling finishes.

Entrance, Porches, and Balconies

- Entrance modifications may require casings and mouldings to be temporarily/permanently removed or adjusted to accommodate modifications. Entrance modifications may also affect floor and wall finishes.

Interior Arrangement

- Interior feature modifications may affect legibility of spatial relationships;
- Elevator modifications may result in the loss of cab interiors potentially possessing *heritage value*.

Mechanical and Electrical

- Visible mechanical and electrical component (e.g., light fixtures and vent covers) modifications may affect building system efficiency;
- Mechanical system upgrades may require alterations to the permanent furniture where systems are integrated into furniture.

Figure 73 Interior machinery retained as an industrial relic, Evergreen Brick Works, Toronto, ON. Source: DTAH.

Figure 74 New glazed partitions used to enclose meeting room, allowing natural light to penetrate into room from central skylit space. Triffo Hall. Source: Barry Johns Architecture Limited.

SUSTAINABLE REHABILITATION PROJECT GUIDELINES FOR INTERIOR FEATURES

	RECOMMENDED
1	**Selecting** sustainably sourced materials while respecting heritage character when designing new interventions.
2	**Selecting** materials that respect a building's heritage character and possess similar *durability* characteristics when designing new interventions.
3	**Reusing** existing interventions where appropriate to heritage character in order to accommodate new interventions.

STANDARDS AND GUIDELINES FOR THE CONSERVATION OF HISTORIC PLACES IN CANADA SUSTAINABILITY CONSIDERATIONS (PAGE 172)

	RECOMMENDED	NOT RECOMMENDED
31	**Complying** with energy efficiency objectives by maintaining energy-conserving interior features, such as interior shutters, transoms and vestibules.	Failing to incorporate interior features, such as ventilation grilles or radiator covers, as part of upgrades to heating and ventilation systems.
32	**Complying** with energy-efficiency objectives by upgrading rather than replacing character-defining light fixtures.	
33	**Working** with specialists to determine the most appropriate solution to energy efficiency requirements with the least impact on the *character-defining elements* and overall *heritage value* of the historic building.	Making changes to interior features, without first exploring alternative energy efficiency solutions that may be less damaging to the *character-defining elements* and overall *heritage value* of the historic building.

3.13. MATERIALS

All building components are constructed from different materials to create assemblies (e.g., floors, walls, ceilings, etc.). Each material has its own characteristics and therefore must be treated to suit that material and that assembly.

Included in this section is a series of material-specific *sustainable* conservation guidelines that can be read along with *sustainability* considerations from the *Standards and Guidelines for the Conservation of Historic Places in Canada (2010)*.

The guidelines included in this section are intended to provide general guidance for conserving the specific featured material within a *sustainable* conservation project. Potential conservation treatments discussed include the maintaining, rehabilitating, and replacement in-kind of different materials.

DURABILITY

Durability is a critical characteristic for all materials and assemblies when sustainably conserving and constructing buildings. The more durable the material, the longer it will last and the less often it will need to be replaced or repaired. When materials in assemblies require less replacement, the lifespan of the overall assembly is increased.

Materials in assemblies are dynamically related to each other. As such, all assembly materials should possess similar *durability* characteristics to minimize unnecessary loss when less durable materials reach the end of their life. When less durable materials are integrated into an assembly, they should be easily accessible in order to permit replacement while minimizing impact on adjacent sound materials.

It is important that durable materials are maintained appropriately to maximize their effective life; durable does not mean "no maintenance". For instance, cut stone is a very durable material that, if maintained, can last for centuries in certain environmental conditions. However, the mortar joints must be repointed on a periodic basis using a compatible mortar that acts sacrificially to the stone. Historic window types installed and repaired with window putty provide another example of maintenance within durable assemblies. As the putty ages, it hardens, eventually requiring replacement at the same time the wood and/or steel frames require repainting. Replacing putty and repainting frames extends the life of the overall window assembly.

Figure 75 Wood window frame *rehabilitation*. Beaconsfield Yacht Club. Beaconsfield, QC. Source: FGMDA

LOCALLY SOURCED MATERIALS

Historically, building materials were locally sourced, reflecting the cost or lack of availability of long distance transport. This strategy has architectural, structural, and urbanistic implications as available materials define the overall appearance, finish, size, and massing of buildings. These locally sourced materials provide a high level of site specificity that may extend through a range of building types (e.g., commercial, residential, and institutional).

Examples of locally sourced materials include wood from local forests used as structural components, cladding, and finishes; clays used for structural elements and exterior cladding; and quarried stone used for structural elements, exterior cladding, and interior finishes. These types of locally sourced materials also provided work for local tradespeople where development of associated skills may be a significant part of a place's heritage character.

Not all materials are appropriate for all climates; for instance, coastal woods are better suited for marine climates because they accommodate the high moisture and salt content in the air. It's important to remember that as locally sourced materials are also typically extracted locally, their existence indicates a tolerance for the local environment. In other words, locally sourced materials and assemblies are the products of an evolution. They benefit from having adjusted to the local climate over successive generations. Locally sourced materials, then, are considered both historically appropriate (especially for vernacular buildings) and *sustainable* (as less energy is expended when transporting or sometimes manufacturing) the material.

Materials and assemblies from other climates should be tested thoroughly prior to widespread adoption in a new climate. This evaluation is critical for newer, more modern materials that are produced for national and international distribution. Evaluation is especially important when rehabilitating buildings with *heritage value* in order to ensure replacement materials and assemblies are compatible.

INTERRELATIONSHIPS

Each material has its own unique characteristics that must be accommodated when sustainably conserving a building. For more information on the building systems that may contain materials, refer to their specific guidelines below.

Figure 76 On-going rehabilitation on the exterior masonry wall envelope. Université de Montréal. Montreal, QC.
Source: MTBA Associates Inc.

Figure 77 Limestone cladding, masonry back-up, and steel structure, each impacting the other. Sir John A Macdonald Building, Ottawa, ON. Source: MTBA Associates Inc.

WOOD AND WOOD PRODUCTS

Inherently Sustainable Elements

Inherently sustainable elements for wood and wood products include:

- *Durability* when maintained;
- Older wood, once provided by more mature trees, that is generally better than what is currently available due to old growth characteristics (size, growth ring characteristics);
- Unitized assembly, permitting localized replacement;
- Recycled/waste wood materials, which can be used to create wood products such as oriented-strand board, laminated veneer lumber;
- Resource renewability when extraction is managed;
- Ease of construction with local labour.

Sustainability Challenges

Sustainability challenges for wood and wood products include:

- Unsustainability of the natural resource when extraction is not managed;
- Presence of toxic substances in some protective coatings applied to wood;
- Presence of toxic substances in some manufactured wood products such as resins and adhesives;
- Potential exhaustion of local wood sources.

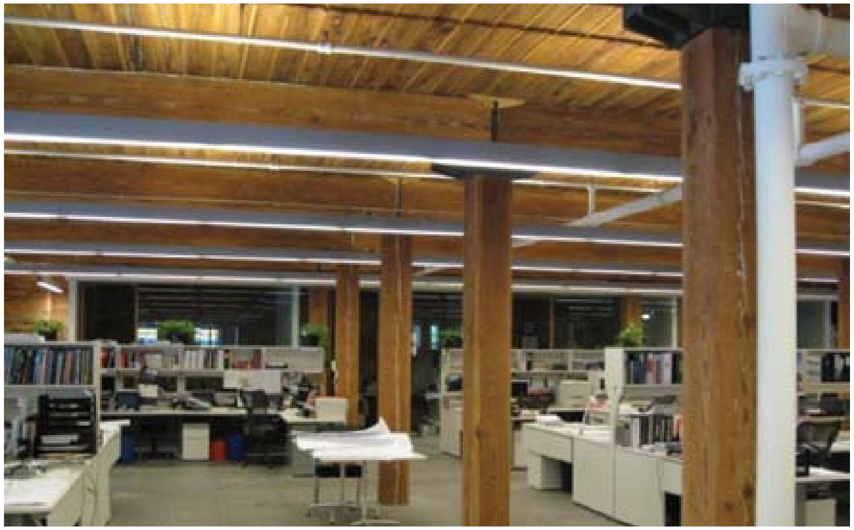

Figure 78 The wood structure and flooring system were retained in adaptive reuse. Former McGregor Sock Factory (Stantec Offices) Toronto, ON.
Source: MTBA Associates Inc.

SUSTAINABLE CONSERVATION PROJECT GUIDELINES FOR WOOD AND WOOD PRODUCTS

	RECOMMENDED
1	**Disassembling** wood clad surfaces, where possible, to access cavities that can accommodate *sustainability* upgrades in a fully reversible manner and with minimum impact to the wood clad surfaces and adjacent surfaces.
2	**Applying** protective coatings that are compatible with a material and contain no toxins.
3	**Treating** localized degradation rather than replacing entire assembly.
4	**Using** wood products that contain no toxins in their composition.

STANDARDS AND GUIDELINES FOR THE CONSERVATION OF HISTORIC PLACES IN CANADA SUSTAINABILITY CONSIDERATIONS (PAGE 221)

	RECOMMENDED
22	**Selecting** replacement materials for character-defining old-growth, exotic, or otherwise unavailable wood, based on their physical and visual characteristics.

MASONRY

Inherently Sustainable Elements

Inherently sustainable elements for masonry include:

- *Durability* when maintained;
- Unitized assembly that permits localized replacement;
- Ability to remove masonry and reuse in other buildings;
- Ability to use recycled and waste masonry, down-cycled in composite materials, and gravels and aggregates;
- Easily constructed with local labour.

Sustainability Challenges

Sustainability challenges for masonry include:

- Limited adaptability in interior arrangements when used in interior partitions;
- Exhaustion of local clay and stone sources;
- Masonry, which relies on finite resources and extraction limits of quarries or manufacturing limits/ impact of clay concrete products.

Figure 79 Inspecting masonry. Parliament Hill. Ottawa, ON.
Source: MTBA Associates Inc.

SUSTAINABLE REHABILITATION PROJECT GUIDELINES FOR MASONRY

	RECOMMENDED
1	**Using** locally sourced masonry where appropriate to a building's heritage character.
2	**Retaining** interior masonry partitions.
3	**Integrating** exterior masonry walls into interior spaces of an addition, limiting material loss and maintaining thermal mass.
4	**Reinstating** exterior masonry projecting elements that shield building envelope components.
5	**Maintaining** masonry permeability by carefully evaluating the impact of coating where necessary.
6	**Maintaining** masonry to mortar relationship and appropriate mortar mix. Mortar should act sacrificially to the masonry.
7	**Balancing** durability and locally sourced considerations when selecting new and/or replacement stone and masonry.

STANDARDS AND GUIDELINES FOR THE CONSERVATION OF HISTORIC PLACES IN CANADA SUSTAINABILITY CONSIDERATIONS (PAGE 227)

	RECOMMENDED
21	**Selecting** replacement materials from sustainable sources, where possible. For example, replacing deteriorated stone units using in-kind stone recovered from a building demolition.

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CONCRETE

Inherently Sustainable Elements

Inherently sustainable elements for concrete include:

- *Durability* when maintained;
- Unitized assembly in pre-cast panel systems, permitting localized replacement;
- Thermal mass;
- Component materials that can be recycled (steel) and down-cycled (masonry components).

Sustainability Challenges

Sustainability challenges for concrete include:

- Consumes significant amounts of raw materials, sand, gravel, water, steel, and energy in production/transport;
- Monolithic installations can be difficult to rehabilitate locally;
- Evolving construction detailing and quality creates significant challenges, especially in severe climates (e.g., steel rebar with limited concrete coverage leading to expanding rebar, spalling, and concrete failure).

Figure 80 Poured-in-place exterior concrete facade. MacMillan Bloedel Building

SUSTAINABLE REHABILITATION PROJECT GUIDELINES FOR CONCRETE

	RECOMMENDED
1	**Cleaning** concrete using gentlest possible means as aggressive cleaning may harm the surface and/or expose rebar with limited concrete coverage.
2	**Retaining** concrete components for their beneficial thermal retention properties.
3	**Investigating** opportunities to integrate insulation and other *sustainability* upgrades into cavities behind precast concrete panels where appropriate for a building envelope.
4	**Selectively** replacing damaged panels in unitized systems rather than full replacement.

ARCHITECTURAL AND STRUCTURAL METALS

Inherently Sustainable Elements

Inherently *sustainable* elements for architectural and structural metals include:

- *Durability* of material when maintained;
- Recyclability of metals;
- Material that can accommodate localized treatment (e.g., patching and welding);
- Oxidation of many metals, including bronze, copper, and aluminum, that provides an added protective coating.

Figure 81
Architectural metal grille.
College Park Building.
Toronto, ON.
Source: MTBA Associates Inc.

Sustainability Challenges

Sustainability challenges for architectural and structural metals include:

- Material extraction and production that may create pollution and require significant energy input;
- Metals that may not be locally available;
- Protective coatings that can fail prior to the underlying metal;
- Protective coatings that may contain toxic substances;
- Toxicity of some metal such as lead, which limits potential treatment options.

SUSTAINABLE REHABILITATION PROJECT GUIDELINES FOR ARCHITECTURAL AND STRUCTURAL METALS

	RECOMMENDED
1	**Reinstating** metal projecting elements such as cornices and eaves that shield building envelope components.
2	**Maintaining** mullion profiles and spandrel panel sizes when rehabilitating or upgrading a metal and glass curtain wall.
3	**Rehabilitating** metal components by splicing and patching deteriorated areas.
4	**Retaining/reinstating** sound metal components within an assembly after rehabilitating adjacent surfaces.
5	**Designing** structural steel interventions using reversible bolted connections.
6	**Recycling** all metal elements removed from secondary elements that cannot be retained.

GLASS AND GLASS PRODUCTS

Inherently Sustainable Elements

Inherently sustainable elements for glass and glass products include:

- Ability to recycle/down-cycle glass and glass products;
- Provision of access to natural light when used in windows, doors, and partitions;
- Long life expectancy of single glazed window units.

Sustainability Challenges

Sustainability challenges for glass and glass products include:

- Limited to no insulating value when used in fenestration;
- Limited life spans of sealed window units due to gas fills and seals;
- Glass window assemblies that may contain toxic materials (e.g., lead came and asbestos in putty);
- Glass, which can be damaged with limited force (varies on thickness and type), requiring premature replacement.

Figure 82 Interior stained glass. Leahurst Nurses' Residence. Kingston, ON. Source: MTBA Associates Inc.

SUSTAINABLE REHABILITATION PROJECT GUIDELINES FOR GLASS AND GLASS PRODUCTS

	RECOMMENDED
1	**Rehabilitating** and reinstating covered skylights and windows to improve access to natural light.
2	**Augmenting** glass systems by adding interior storm windows.
3	**Retaining** multi-layered single glazed windows assemblies (storm and primary windows) that do not have gas fills.
4	**Rehabilitating** decorative glass products in light fixtures to improve fixture efficiency.
5	**Retaining** interior glass and glass block partitions.

STANDARDS AND GUIDELINES FOR THE CONSERVATION OF HISTORIC PLACES IN CANADA SUSTAINABILITY CONSIDERATIONS (PAGE 242)

	RECOMMENDED
16	**Retaining** and carefully storing historic glass elements and making them available for reuse.

PLASTER AND STUCCO

Inherently Sustainable Elements

Inherently sustainable elements for plaster and stucco include:

- Protective finish for underlying materials;
- Ease of repair as plaster and stucco can be patched and refinished in-kind;
- Natural materials, such as lime-based plaster and stucco;
- Ability of porous plaster and stucco to enhance subsurface respiration (e.g., facilitate extraction of unwanted moisture in wall assembly);
- Applied finish that reduces waste (e.g., no off-cuts).

Sustainability Challenges

Sustainability challenges for plaster and stucco include:

- Toxicity of plasters and stucco that may contain toxic substances embedded in their chemical composition or in their finishes;
- Limited remaining trade skills to apply lime-based plaster and stucco, limiting *rehabilitation* opportunities.

Figure 83 Conservators performing on-going rehabilitation of a plaster ceiling and plaster finishes. Sir John A Macdonald Building, Ottawa, ON.
Source: MTBA Associates Inc.

SUSTAINABLE REHABILITATION PROJECT GUIDELINES FOR PLASTER AND STUCCO

	RECOMMENDED
1	**Understanding** air and moisture movement through plaster and stucco materials prior to modifying a building envelope and avoiding modification to assembly behaviour when undertaking interventions.
2	**Rehabilitating** plaster and stucco finishes by in-kind patching and localized replacement.
3	**Monitoring** plaster and stucco finishes on an on-going basis to limit organic growth and associated deterioration.

MISCELLANEOUS MATERIALS

This section applies to fabricated materials or compounds, particularly to those material components that impart character to a building and that do not fit in the material categories addressed in previous sections. What the SGCHPC says about miscellaneous materials is applicable regardless of a building's *heritage value*:

These diverse materials may be character defining in their own right, or used in character-defining assemblies or systems. Materials, such as plastic, plexiglass, asbestos, asphalt, rubber, thatch, sod and fiberglass, have served a multitude of uses in construction. Flooring surfaces, including cork, linoleum, carpet or ceramic tile, and decorative or functional treatments, such as fabrics, wall coverings and acoustical panels, may also be character defining. Modern materials, such as plastic have been used as lighter, less breakable alternatives to glass, metal or wood in exterior cladding, interior partitions, canopies, screens and signage. p.246, SGCHPC

Inherently Sustainable Elements

Inherently *sustainable* elements vary depending on the material.

Sustainability Challenges

Many materials from the Modern period such as plastic, Bakelite™, plexiglass, asbestos, asphalt, rubber, and fibreglass can be challenging or impossible to replace as the product is no longer manufactured and/or the product may contain toxic substances.

Figure 84 Mosaic tile wall cladding designed by artist BC Binning. Former BC Hydro Building, Vancouver, BC. Source: MTBA Associates Inc.

SUSTAINABLE REHABILITATION PROJECT GUIDELINES FOR MISCELLANEOUS MATERIALS

	RECOMMENDED
1	**Disassembling** *character-defining elements* where it does not affect material integrity prior to undertaking *sustainability* upgrades and reassembling at the conclusion of associated upgrades.
2	**Reinstating** visible elements into replacement systems where they are *character-defining elements*.
3	**Reinstating** less durable material awnings to shade windows and storefronts.
4	**Applying** protective coating(s) that are compatible with a material and contain no toxins.

STANDARDS AND GUIDELINES FOR THE CONSERVATION OF HISTORIC PLACES IN CANADA SUSTAINABILITY CONSIDERATIONS (PAGE 249)

	RECOMMENDED
15	**Salvaging** character-defining miscellaneous materials that are no longer manufactured for reuse elsewhere in the building.

3.14. OPERATIONS AND MAINTENANCE

This section provides guidance for *sustainable* operations and maintenance affecting all building elements, especially when they are identified as *character-defining elements* of an historic place. It also gives direction on how to minimize the impact of operations and maintenance on non-*character-defining elements* in an historic or non-historic building.

The continuing operation and maintenance of a building accounts for a significant amount of energy used over its lifespan. Building operation is typically driven by tenant, user, and support activities. Maintenance includes building systems re-commissioning and cleaning, periodic reviews, repairs, and *retrofit* or *rehabilitation* of building elements.

Operations and maintenance strategies should be explored at the outset of developing a *sustainable rehabilitation* plan and on an on-going basis, especially where opportunities exist to improve functionality of existing systems with limited to no changes to the base building. In addition, operations and maintenance directly affect material integrity.

Operations and maintenance applies to all building components. They recognize the interconnected relationship between building components to create a building envelope and influence the system behaviour and efficiency.

Maintaining building materials, components, and assemblies on a regular basis to provide longer life improves both environmental and economic *sustainability*. Focusing on local labour for repairs, *retrofits* and *rehabilitations* rather than distant manufacturing, transporting, and frequent replacements improves social, economic, and environmental *sustainability*.

INHERENTLY SUSTAINABLE ELEMENTS

Inherently sustainable elements for existing buildings, particularly historic buildings, include:

- Operable windows and individually controlled heating/cooling registers;
- Storm windows, operable window shutters, and awnings, allowing temporary building system adjustment to optimize performance;
- Lightwells andinterior organization that promote temporary building system adjustment to optimize performance;
- Building assemblies that allow easy access to fast wearing components (e.g., weather stripping) and/or materials with similar life spans;
- Durable materials requiring less maintenance, including brick and heavy stone (maintenance, such as periodic re-pointing is still required to achieve optimal performance and life expectancy);
- Flexible structural arrangements that can accommodate changes in use and tenancy with minimal alterations.

Figure 85 Operable upper storey windows in a mixed use heritage building. Halifax. NS. Source: Shelley Bruce

Figure 86 Task lighting with personal control. Former McGregor Sock Factory (Stantec Offices) Toronto, Ontario. Source: MTBA Associates Inc.

SUSTAINABILITY CHALLENGES

Sustainability challenges for existing buildings, particularly historic buildings, include:

- Incompatible life spans in sealed assemblies, requiring full replacement when only one element has failed;
- Building systems that require periodic re-calibration to minimize waste;
- Operators who sometimes lack the specialized knowledge to maintain heritage elements/systems;
- Users who are sometimes not familiar with how to operate heritage elements/systems;
- Users who are sometimes not aware of energy being used;
- Deferred maintenance due to neglect or funding challenges.

Figure 87 Directional localized Punkah grilles integrated into modern furniture insertions within a voluminous former banking hall. Library of Parliament Annex (Former Bank of Nova Scotia Rehabilitation), Ottawa, ON.
Source: MTBA Associates Inc.

INTERRELATIONSHIPS

Select examples of interrelationships between different building elements with respect to operations and maintenance include:

General

- *Sustainability* upgrades affecting operations and maintenance often include on-going commissioning and an increased awareness of building performance. This awareness allows potential issues to be addressed in a timely fashion, thereby limiting remedial treatments;
- Monitoring a broad range of building performance issues is good stewardship and is required by some *sustainability rating systems*. Monitoring for at least the most important elements and potential efficiencies should be embraced and built into *rehabilitation* projects and ongoing maintenance programs.

Mechanical and Electrical

- Maintaining and re-commissioning building systems will increase operational efficiency, reducing carbon footprints, greenhouse gas emissions, fossil fuel consumption, and operating costs;
- Replacing light bulbs and updating systems as part of a maintenance program allows existing systems to operate more efficiently.

Roofs

- Reviewing seams, cladding, and underlayment allows for timely repair of localized areas, optimizing assembly lifespan and building protection.

Exterior Walls

- Integrating review and repair campaigns into a maintenance program will optimize material life spans (e.g., masonry repointing or wood cladding, splicing, and refinishing).

Windows, Doors, and Storefronts

- Cleaning windows improves natural light access and limits degradation associated with contaminant build-up on frames;
- Periodic inspecting and replacing of seals improves thermal performance;
- Ensuring windows are operable where intended, including after maintenance such as painting, allows for localized control.

Entrances, Porches, and Balconies

- Inspecting and maintaining protective coatings applied over materials such as wood, ferrous steel, and iron will protect base material as protective coating acts in a sacrificial manner.

Interior Features

- Undertaking periodic inspection and maintenance optimizes the life of materials and encourages treatment prior to failure.

SUSTAINABLE REHABILITATION PROJECT GUIDELINES FOR OPERATIONS AND MAINTENANCE

	RECOMMENDED
1	**Understanding** the relationship between building maintenance and energy and economic efficiency.
2	**Maintaining** historic or heritage resources, their *character-defining elements* and lesser elements regularly (time frame varies by the material and/or assembly in question). This will preserve historic/heritage fabric and maximize operational efficiency.
3	**Educating** building tenants, occupants, operators, and owners as to the operating parameters and intended function of their building.
4	**Completing** periodic comprehensive re-commissioning of all building systems and confirming systems are operating as intended.
5	**Providing** localized controls for systems with central overrides to “right-size” building system use.
6	**Tracking** localized energy use through sub-metering to create greater awareness of energy usage and waste points that can be corrected.
7	**Using** environmentally-friendly cleaners and cleaning policies that are compatible with *character-defining elements*.
8	**Prohibiting** smoking inside buildings and within eight metres of entrances, outdoor intakes, and operable windows to improve indoor air quality and reduce impact on interior features and occupant health.
9	**Maintaining** character-defining “in-service” assemblies such as operable air flow vents.
10	**Maintaining** as-built documents to reflect evolving locations of building components and systems.
11	**Maintaining** maintenance logs complete with treatments, products used, and tradespeople involved for all building systems.
12	**Maintaining, storing, and erecting** seasonal elements such as awnings, shutters, and storm windows where feasible.

4. FURTHER INFORMATION

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Association for Preservation Technology's TC-SP provides an arena for discussion, review, and information sharing on the relationship between heritage conservation and environmental sustainability and also serves as a network to other preservation and green building stakeholders. Refer also to "Web-based Tools" at the end of this section for more info. http://www.apti.org/index.php?submenu=technical_committees&src=gendocs&ref=Sustainable_Preservation&category=technical_committees

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The Building Technology Heritage Library (BTHL) https://archive.org/details/buildingtechnologyheritagelibrary

- Primarily a collection of American and Canadian, pre-1964 architectural trade catalogs, house plan books, and technical building guides. Trade catalogs are an important primary source to document past design and construction practices. These materials can aid in the *preservation* and conservation of older structures as well as other research goals. The BTHL contains materials from various private and institutional collections. These materials are rarely available in most architectural and professional libraries. The first major architectural trade catalog collection is that of the Canadian Centre for Architecture, which encompasses more that 4,000 catalogs from the early 19th century through 1963. In addition to the architectural trade catalogs, the initial contributions include a large number of house plan catalogs, which will be of great interest to owners of older homes. The future growth of the Building Technology Heritage Library will also include contemporary materials on building conservation.

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- A seminal book on the issues associated with *sustainable preservation*. The book is structured to reference *sustainability rating systems* considering all portions including water and site, energy, indoor health, material resources. It also looks at the theoretical underpinnings of *sustainability* and *preservation* and the connections between each; other issues including process strategies, operations and maintenance, houses and the recent past.

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- Document provides illustrated and real world examples for incorporating *sustainability* upgrades (required by Part L) into listed properties. Key points include: *sustainability* favours maintaining existing buildings especially if energy performance can be improved; interventions must consider unintended consequences (i.e. accelerating timber decay or creating problems by insulating); building behaviour must be understood prior to making interventions (e.g., historic buildings often include permeable materials including mortars, plasters); introducing modern substitutes with different permeability can create significant issues; explore opportunities to improve occupant behaviour through improving controls and sub-metering; limit heat losses from air infiltration and ductwork; establish reasonable standards for air conditioning and ventilation; prepare good documentation when intervening; carefully consider performance of an addition relative to the existing resource and provide connections that limit degradation to the existing building; avoid thermal bridging when insulating; understand how moisture behaves in the building; explore window upgrades prior to replacement (draught proofing, weather stripping, gap fillers, interior storm windows, re-instating/using exterior shutters, insulated curtains, etc.); consider insulating where damage can be minimized (e.g., in floor cavity below floor boards, roof spaces where open while maintaining airflow); new systems may stain heritage surfaces, create new moisture flow patterns; replacing tungsten based light fixtures will require more heating.

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***Standards and Guidelines for the Conservation of Historic Places in Canada, Second Edition.* Parks Canada. 2010.** http://historicplaces.ca/media/18072/81468-parks-s+g-eng-web2.pdf

- The SGCHPC is a source of information for *sustainable rehabilitation*, which is intended to be read in concert with *Building Resilience*.

Stein, Carl. *Greening Modernism: Preservation, Sustainability, and the Modern Movement.* W. W. Norton & Company. 2010.

- This is a wide-ranging book that challenges a number of pre-conceived notions about the *sustainability* of modern buildings. It re-frames design strategies used in modern buildings and illustrates the intended inherently sustainable features.

Sustainable Historic Preservation Whole Building Design Guide. http://www.wbdg.org/resources/sustainable_hp.php

Sustainability and Heritage in a World of Change. http://www.getty.edu/conservation/publications_resources/public_programs/sustain.html

***Sustainability and Historic Federal Buildings.* Advisory Council on Historic Preservation. 2011.** http://www.achp.gov/docs/*Sustainability*AndHP.pdf

- Document prepared in response to Executive Order 13514: Federal Leadership in Environmental, Energy and Economic Performance as it related to the National Historic *Preservation* Act. Key points include: include *preservation* and *sustainability* specialists IDP teams; make sure *character-defining elements* are clearly understood at outset of project; conduct energy audits at start of project; *preservation* and *sustainability* specialists should review construction progress; develop an overall plan for reducing energy consumption, which includes potential interventions; evaluate relationship between proposed use and existing building, impact on heritage elements, and amount of materials required to complete reuse; as a last resort, explore opportunities to salvage elements for potential reuse in other projects while avoiding creating a false history.

Teutonico, Jeanne Marie and Matero, Frank. *Managing Change: Sustainable Approaches to the Conservation of the Built Environment.* Getty Conservation Institute. 2003.

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US Secretary of the Interior Illustrated Guidelines on Sustainability for Rehabilitating Historic Buildings

- Consolidation of guidelines for *rehabilitation* associated with *sustainable* approaches included the US Secretary of the Interior's Guidelines for *rehabilitation* and added illustrations. Document organized into the following sections (among others): *sustainability* introduction, planning, maintenance, windows, weatherization, HVAC, and air circulation. Key points include: "Before implementing any energy conservation measures to enhance the *sustainability* of a historic building, the existing energy efficient characteristics of the building should be assessed... The key to a successful *rehabilitation* project is to identify and understand any lost original and existing energy efficient aspects of the historic building, as well as to identify and understand its character defining features to ensure they are preserved".

"The Valletta Principles for the Safeguarding and Management of Historic Cities, Towns and Urban Areas." ICOMOS. 2011. http://www.international.icomos.org/Paris2011/GA2011_CIVVIH_text_EN_FR_final_20120110.pdf

Vancouver Heritage Foundation. *Heritage Conservation in a Green and Growing City.* 2012. http://www.vancouverheritagefoundation.org/learn-with-us/heritage-information-resources-research/research/

- Study commissioned by Heritage Vancouver to explore citizen's attitudes towards *sustainability* and conservation. Key points include: "Heritage conservation is less about preserving precious places as museums and more about preserving the sense of character, unique identity and history of communities..."; "A *sense of place* results gradually and unconsciously from inhabiting a landscape over time, becoming familiar with its physical properties, accruing history within its confines"; green action plans need to consider the impact of GHG associated with demolition.

Vancouver Heritage Foundation. *1220 Homer Street.*

- Brief *sustainable* conservation case study of a former industrial building converted into an architect's office. While the building is not listed as heritage, many heritage-like approaches were utilized in the adaptive reuse, including developing a full understanding of the building at the outset and developing approaches specifically to the unique nature of the building. A new skylight and opening through a floor introduces natural light and improved stack effect into the middle of the building. The thermal mass of the heavy structure is integrated into the HVAC system complete well-considered use zoning and operable windows to eliminate the need for a ducted HVAC system. Occupants are also invited to take control of their space with operable windows and computer controls for ventilation. See Appendix C.

Vancouver Heritage Foundation. *Friedman Building, UBC.*

- Brief *sustainable* conservation case study of a modern academic building that underwent a programming shift and *sustainability* upgrade. This modern building dates to the 1950s, and the architecture lends itself to adaptive reuse with its shallow floor plates, repeated structural grid, and assembled kit facade. Built with limited insulation in its exterior envelope, the building suffered through successive renovations in an attempt to address issues. Eventually, the building was repurposed for a different academic program with a different energy demand profile. The interiors were re-worked by re-introducing natural light into the corridors, breaking up the corridors, introducing new *sustainable* materials, and rehabilitating and upgrading the exterior facade, all while remaining largely true to the pedagogical underpinnings of the original concept. Generally speaking, the architects indicated that, due to a number of factors, Modern Architecture is more suited to rehabilitated rather than restored. As a result, the building was retained at a cost less than a new building, allowing the University to address other physical plant deficiencies. See Appendix C.

Vancouver Heritage Foundation, *666+662 Union Street*.

- Brief *sustainable* conservation case study exploring sensitive and *sustainable* approaches for introducing density into a Vancouver urban neighbourhood. The proposal involved studying the *morphology* of the area with its smaller laneway structures and significant grade modification at the front to weave a number of new units into two side-by-side single family homes. The heritage homes were retained while introducing new laneway housing and a new lower unit, exploiting the grade change. A number of other *sustainability* strategies were integrated into the site, including new HVAC systems, car sharing, and bike lockers. Overall, the project focused on understanding the root character of the area, maintained, and sensitively added to it, achieved greater density within existing zoning, and provided more users for neighbourhood services. See Appendix C.

"Whole Building Design Guide." Historic Preservation Subcommittee. Sustainable Historic Preservation. National Institute of Building Sciences. 2012. http://www.wbdg.org/resources/sustainable_hp.php?r=historic_pres

Whyte, Bruce, Terry Hood, and Brian P. White (eds.). *Cultural and Heritage Tourism: A Handbook for Community Champions.* The Federal-Provincial-Territorial Ministers' Table on Culture and Heritage. 2012.

Young, Robert A. *Stewardship of the Built Environment: Sustainability, Preservation, Reuse.* Island Press. 2012.

Yung, Esther Hiu Kwan, Edwin Hon Wan Chan, and Ying Xu. "Sustainable Development and the Rehabilitation of a Historic Urban District – Social Sustainability in the Case of Tianzifang in Shanghai." Sustainable Development Online. http://onlinelibrary.wiley.com/doi/10.1002/sd.534/full. 2011.

FREE WEB-BASED DESIGN TOOLS

The Responsible Retrofit Knowledge Center: Guidance Wheel http://responsible-retrofit.org
Developer: STBA: Sustainable Traditional Buildings Alliance, a collaboration of not-for-profit organisations that aims to promote and deliver a more sustainable traditional built environment in the UK.
"The Wheel is both an aid to decision making and a way of learning about traditional building retrofit. It is designed to clearly identify different benefits and concerns, by referencing the most relevant and accurate information, and by providing a systemic and holistic approach to retrofit design, application and use."

OSCAR: the Online Sustainable Conservation Assistance Resource www.oscar-apti.org
Developer: APT TC-SP: Association for Preservation Technology's Technical Committee for Sustainable Preservation
"OSCAR is an interactive decision-assistance tool developed to guide the optimal sustainable rehabilitation solutions for heritage properties, while preserving historic fabric and significance. Full launch: November, 2015."

Impact Estimator: Life Cycle Assessment Calculator http://calculatelca.com/software/impact-estimator/download-impact-estimator/
Developer: Athena Institute & Morrison Hershfield
"Impact Estimator is a software tool that evaluates whole buildings and assemblies based on life cycle assessment (LCA) methodology, where designers can easily assess and compare the environmental implications of designs for new buildings and major renovations."

4.2. GLOSSARY

ASHRAE: American Society of Heating, Refrigeration and Air-conditioning Engineers. Refer to Appendix B.

Avoided impact: Overall life cycle impacts upon the environment associated with new building construction that can be avoided through alternate means. AI is the basis of an approach used in *Life Cycle Assessment* (LCA), especially in the context of allocating environmental burden in the presence of *recycling* or *reuse*, when determining the overall *environmental impact* of a product, building component, or entire building.

Building resiliency: The capacity of a building to continue to function and operate under extreme conditions, such as (but not limited to) extreme temperatures, sea level rise, natural disasters, etc. As the built environment faces the impending effects of global climate change, building owners, designers, and builders can design facilities to optimize *building resiliency.*

Building adaptability: The capacity of a building to be used for multiple uses and in multiple ways over the life of the building. For example, designing a building with movable walls/partitions allow for different users to change the space. Additionally, using sustainable design allows for a building to adapt to different environments and conditions.

Building conservation: The wise use and management of a building to prevent unwanted change, which can include unsympathetic or incompatible alteration, decay, destruction, misuse, or neglect.

Character-defining elements: The materials, forms, location, spatial configurations, uses, and cultural associations or meanings that contribute to the *heritage value* of an historic place, which must be retained in order to preserve its *heritage value*.

Durability: The ability to exist for a long time without deterioration.

Heritage conservation: All actions or processes that are aimed at safeguarding the *character-defining elements* of a cultural resource so as to retain its *heritage value* and extend its physical life. This may involve "*preservation*," "*rehabilitation*," "*restoration*," or a combination of these actions or processes. ***Embodied carbon***: The amount of carbon emitted through building construction, including the entire cycle of material extraction, fabrication, transportation, and final assemblage.

Embodied energy: The total expenditure of energy involved in the creation of both the building and its constituent materials. Note: the energy expended to build the structure is 15 to 40 times its annual energy use. Current ratings systems, in measuring annual energy/operating costs, do not account for this *embodied energy*.

Heritage value: The aesthetic, historic, scientific, cultural, social or spiritual importance or significance for past, present, or future generations. The *heritage value* of an historic place is embodied in its character-defining materials, forms, location, spatial configurations, uses, and cultural associations or meanings.

Inherently sustainable features : Characteristics of a building or site that, through their design, physical materials or building or natural systems, embody principles of *sustainability*.

Integrated design process: A design approach for realizing high performance buildings that contributes to heritage conservation and sustainable communities. It is a collaborative process that:

- Focuses on the design, construction, operation and occupancy of a building over its complete life-cycle.
- Is designed to allow the client and other stakeholders to develop and realize clearly defined and challenging functional, environmental, cultural, social and economic goals and objectives.
- Includes a multi-disciplinary design team that includes or acquires the skills required to address all design issues flowing from the objectives.
- Proceeds from whole building system strategies working through increasing levels of specificity so as to realize more optimally integrated solutions.

***Intergovernmental Panel on Climate Change* (IPCC)**: The *Intergovernmental Panel on Climate Change* (IPCC) is a scientific *intergovernmental body*, set up at the request of member governments. It was first established in 1988 by two United Nations organizations, the *World Meteorological Organization* (WMO) and the *United Nations Environment Programme* (UNEP), and later endorsed by the *United Nations General Assembly* through Resolution 43/53. Membership of the IPCC is open to all members of the WMO and UNEP.

The IPCC produces reports that support the *United Nations Framework Convention on Climate Change* (UNFCCC), which is the main international treaty on climate change. IPCC reports cover "the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential *impacts* and options for *adaptation* and *mitigation*."

The IPCC does not carry out its own original research, nor does it do the work of monitoring climate or related phenomena itself. The IPCC bases its assessment on the published literature, which includes *peer-reviewed* and non-peer-reviewed sources.

Thousands of scientists and other experts contribute (on a voluntary basis, without payment from the IPCC) to writing and reviewing reports, which are then reviewed by governments. IPCC reports contain a "*Summary for Policymakers*", which is subject to line-by-line approval by delegates from all participating governments. Typically this involves the governments of more than 120 countries.

Although there has been controversy over the years (claims by scientists that their findings have been watered down by the IPCC administrative body), the IPCC is an internationally accepted authority on climate change, producing reports that have the agreement of leading climate scientists and the consensus of participating governments. The 2007 *Nobel Peace Prize* was shared, in two equal parts, between the IPCC and Al Gore. Refer to Appendix A.

***Life Cycle Assessment* (LCA):** also known as life-cycle analysis, eco-balance, and *cradle-to-cradle* analysis, is a technique to assess environmental impacts associated with all the stages of a product's life from-cradle-to-cradle (i.e., from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling).

Morphology: The form or structure of anything, in this case, of a building or district/neighbourhood.

Material Integrity: The current completeness and condition of a particular material as judged against its originally installed condition.

Minimum intervention / Minimum intervention approach: The course of action that applies the most benign physical impacts to achieve the longest-term protection of a building's characteristics and attributes while allowing compatible functional goals to be met.

Preservation: The action or process of protecting, maintaining, and/or stabilizing the existing materials, form, and integrity of a historic place or of an individual component while protecting its *heritage value*.

Rating systems: Numerous systems developed around the world to rate buildings on their degree of *sustainability*. Some systems include certifications for bona fide proof of attaining certain levels of *sustainability* achievement. In North America, the most common *rating systems* used are LEED© and Green Globes©.

Rehabilitation: The action or process of making possible a continuing or compatible contemporary use of a historic place or an individual component while protecting its *heritage value*.

Restoration: The action or process of accurately revealing, recovering, or representing the state of a historic place or of an individual component as it appeared at a particular period in its history while protecting its *heritage value*.

Retrofit: The refurbishment of existing buildings and systems for the changing needs of the occupants. Objectives include greater energy efficiency and *sustainability*. Retrofitted buildings are often more sustainable than new building construction depending on the percentage of *embodied energy* retained.

Sense of place: A combination of characteristics that makes a place authentic and unique, a mix of natural and cultural features blending the physical character of the land with memory, culture and story. Sense of place involves the human experience in a natural or urban landscape, providing a strong identity and character that is deeply felt, recognized by a visitor, and valued by residents.

Sustainability: The capacity of systems and processes to endure with minimal degradation of ecosystems and quality of life. "*Sustainable*" has a corresponding meaning. Since the 1980s, in human society, the organizing principle for sustainability has been *sustainable development*. The *Standards and Guidelines* define *sustainability* as: "*A group of objectives (economic, social and environmental) that must be coordinated and addressed to ensure the long term viability of communities and the planet.*"

Sustainable development: Organizing principle for human life on a finite planet. It posits a desirable future state for human societies in which living conditions and resource-use meet human needs without undermining the *sustainability* of natural systems and the environment, so that future generations may also have their needs met. For the sustainable development of existing and heritage buildings, specific considerations for long life of materials and assemblies, "loose fit," (or the ability to adapt to new standards, uses and circumstances), local sourcing of materials and trades, and low ecological impact through retention of embodied energy and avoided impacts associated with re-use of still-sound building materials) should also apply.

Sustainable stewardship: The care, maintenance, and management of a building that is undertaken in a manner that is sustainable. Stewardship is the ethic that embodies the responsible planning and management of resources. The concepts of stewardship can be applied to the environment, economics, health, property and more.

Whole Building Ecology**:** In 1969, while working on the space program, Buckminster Fuller said: “Synergy is the only word in our language that means behavior of whole systems, unpredicted by the separately observed behaviors of the system’s parts or any subassembly of the system’s parts.”

Whole Building Design draws upon these concepts of synergies and interconnectedness and consists of two components: an integrated design approach and an integrated team process. The “integrated” design approach asks all the members of the building stakeholder community, and the technical planning, design, and construction team to look at the project objectives and building materials, systems, and assemblies from many different perspectives. This approach is a deviation from the typical planning and design process of relying on the expertise of specialists who work in their respective specialties somewhat isolated from each other.

APPENDIX A

SUSTAINABLE REHABILITATION FIGHTS CLIMATE CHANGE

The following are excerpts from an *Intergovernmental Panel on Climate Change* Assessment Report (2007), explaining the importance of sustainably retrofitting and rehabilitating our existing building stock in fighting climate change:

Measures to reduce greenhouse gas (GHG) emissions frombuildings fall into one of three categories:

1. Reducing energy consumption and *embodied energy* in buildings;
2. Switching to low-carbon fuels including a higher share of renewable energy; or
3. Controlling the emissions of non-CO2 GHG gases.

Improving energy efficiency in existing buildings encompasses the most diverse, largest, and most cost-effective mitigation opportunities in buildings.

Substantial reductions in CO2 emissions from energy use in buildings can be achieved over the coming years using mature technologies for energy efficiency that already exist widely and that have been successfully used (high agreement, much evidence).

A significant portion of these savings can be achieved in ways that reduce life-cycle costs, thus providing reductions in CO2 emissions that have a net benefit rather than cost. However, due to the long lifetime of buildings and their equipment, as well as the strong and numerous market barriers prevailing in this sector, many buildings do not apply these basic technologies to the level life-cycle cost minimisation would warrant (high agreement, much evidence).

A survey of the literature (80 studies) indicates that there is a global potential to reduce approximately 29% of the projected baseline emissions by 2020 cost-effectively in the residential and commercial sectors, the highest among all sectors studied in this report (high agreement, much evidence).

Additionally at least 3% of baseline emissions can be avoided at costs up to 20 US$/tCO2 and 4% more if costs up to 100 US$/tCO2 are considered. However, due to the large opportunities at low costs, the high-cost potential has been assessed to a limited extent, and thus this figure is an underestimate (high agreement, much evidence).

While occupant behaviour, culture and consumer choice, and use of technologies are also major determinants of energy use in buildings and play a fundamental role in determining CO2 emissions (high agreement, limited evidence), the potential reduction through non-technological options is rarely assessed and the potential leverage of policies over these is poorly understood. Due to the limited number of demand-side end use efficiency options considered by the studies, the omission of non-technological options and the often significant co-benefits, as well as the exclusion of advanced integrated highly efficient buildings, the real potential is likely to be higher (high agreement, limited evidence).

There is a broad array of accessible and cost-effective technologies and know-how that have not as yet been widely adopted, which can abate GHG emissions in buildings to a significant extent. These include passive solar design, high efficiency lighting and appliances, highly efficient ventilation and cooling systems, solar water heaters, insulation materials and techniques, high-reflectivity building materials and multiple glazing. The largest savings in energy use (75% or higher) occur for new buildings, through designing and operating buildings as complete systems.

Over the whole building stock, the largest portion of carbon savings by 2030 is in retrofitting existing buildings and replacing energy-using equipment due to the slow turnover of the stock (high agreement, much evidence).

Implementing carbon mitigation options in buildings is associated with a wide range of co-benefits. While financial assessment has been limited, it is estimated that their overall value may be higher than those of the energy savings benefits (medium agreement, limited evidence).

Economic co-benefits include the creation of jobs and business opportunities, increased economic competitiveness and energy security. Other co-benefits include social welfare benefits for low-income households, increased access to energy services, improved indoor and outdoor air quality, as well as increased comfort, health and quality of life.

There are, however, substantial market barriers that need to be overcome and a faster pace of well-enforced policies and programmes pursued for energy efficiency and de-carbonisation to achieve the indicated high negative and low-cost mitigation potential. These barriers include high costs of gathering reliable information on energy efficiency measures, lack of proper incentives (e.g., between landlords who would pay for efficiency and tenants who realize the benefits), limitations in access to financing, subsidies on energy prices, as well as the fragmentation of the building industry and the design process into many professions, trades, work stages and industries.

These barriers are especially strong and diverse in the residential and commercial sectors; therefore, overcoming them is only possible through a diverse portfolio of policy instruments (high agreement, medium evidence).

A variety of government policies have been demonstrated to be successful in many countries in reducing energy-related CO2 emissions in buildings (high agreement, much evidence).

Among these are continuously updated appliance standards and building energy codes and labelling, energy pricing measures and financial incentives, utility demand-side management programmes, public sector energy leadership programmes including procurement policies, education and training initiatives and the promotion of energy service companies. The greatest challenge is the development of effective strategies for retrofitting existing buildings due to their slow turnover. Since climate change literacy, awareness of technological, cultural and behavioural choices are important preconditions to fully operating policies, applying these policy approaches needs to go hand in hand with programmes that increase consumer access to information and awareness and knowledge through education.

To sum up, while buildings offer the largest share of cost effective opportunities for GHG mitigation among the sectors examined in this report, achieving a lower carbon future will require very significant efforts to enhance programmes and policies for energy efficiency in buildings and low-carbon energy sources well beyond what is happening today.

APPENDIX B

FORGOTTEN SKILLS: HOW WE STOPPED DESIGNING FOR SUSTAINABILITY

NOTE: In this review of the evolution of mechanically-designed buildings and of modern office building design and the impact of air conditioning, one sees a very different attitude than today's about environmental *sustainability*. The following excerpts from ASHRAE Journal articles illustrate how we got to the building design of the 1950's to 1980's, which is instructive in viewing sustainable building design, and particularly sustainable *rehabilitation* and *retrofit* of these buildings today.

ASHRAE HISTORY

ASHRAE (American Society of Heating, Refrigeration & Air Conditioning Engineers) was formed in 1959 as the American Society of Heating, Refrigerating and Air-Conditioning Engineers by the merger of American Society of Heating and Air-Conditioning Engineers (ASHAE) founded in 1894 and The American Society of Refrigerating Engineers (ASRE) founded in 1904.

The lineage of the ASHRAE Handbook, which has had strong universal influence on building design since the 1950's, actually begins in 1922, when the American Society of Heating and Ventilating Engineers (ASH&VE) published its Heating and Ventilating Guide.

OFFICE BUILDINGS AFTER WORLD WAR II

ASHRAE JOURNAL – Air Conditioning in Office Buildings After World War II – The First Century of Air Conditioning. Author: David Arnold, F.R.Eng., Member ASHRAE

"As the economy recovered from the Depression, in the late 1930s, air-conditioning equipment sales doubled in one year, rising to more than $30 million in the first five months of 1937. All of the major manufacturers—General Electric, Frigidaire, Carrier, York, Westinghouse, etc.—produced room air conditioners which mostly were installed in offices.

Most of the air-conditioned buildings constructed before World War II had "all air" systems. The large amount of space sacrificed to vertical ducts was a major disincentive to property developers attempting to maximize their profit on every square foot. The era of the deep open planned office had not arrived.

Air Conditioning & Curtain Walling

In the absence of new projects during the war moratorium on civilian buildings, one of the leading architectural magazines, *Architectural Forum*, ran a special issue on post-war trends. The editor, Howard Myers, invited a number of leading architects including Louis Kahn, William Lescaze, Mies van der Rohe and a lesser known Italian architect from Portland, Ore., Pietro Belluschi, to produce designs for a range of projects that might be built in a medium sized town after war-time building restrictions were lifted. Myers stipulated that the architects' design "show an advanced but not stratospheric" approach to planning construction and equipment that they draw upon technology that was currently available but not yet in common use.

Myers selected Belluschi to produce an office building design. Belluschi wrote, “Our assumptions were affected by the power and a tremendously expanded production of light metals for war use, which will beg for utilization after the emergency.” Apparently he intended to air condition the building using aluminum extensively for cladding, wall-panel frames, external air inlets, internal louver blinds and even as trays for ceiling tiles. The extent of use of aluminum is shown in the cross Section of his design in Figure 1. It also shows his proposals for maintaining internal comfort with unit air conditioners, individual local air inlets, and radiant heating panels in the ceiling. The large windows are complete with aluminum louver blinds.

The Equitable Building

Belluschi put his ideas into practice before the war ended. The Equitable Savings and Loan Association intended to build a new headquarters in Portland. Although superficially the design for the building was similar to the *Forum* project, Belluschi introduced a number of significant changes that impacted the internal environment as much as the appearance.

The building was heralded by Architectural Forum as the first and long over-due “crystal and metal tower” and one of its most spectacular aspects is “its huge areas of sea green glass.” The glass was sealed double-glazing with the outer pane made of heat absorbing glass that provided a 40% reduction in solar transmission.

Belluschi had satisfied himself that the solar-treated glazing would not only reduce the solar heat load but also reduce sky glare to the point where blinds or shades would not be needed for comfort. Apparently, “some of the tenants expressed alarm at the lack of shading, but after several months of satisfactory conditions few of them had installed blinds.”

The mechanical engineer, J. Donald Kroeker, was as innovative as the architect. The building was one of the first to be entirely heated and cooled using water from wells via a heat pump. The air-conditioning systems were controlled automatically and local air-handling plants installed on each floor had separate ducts serving different faces of the building and interior zones and included the option of 100% outdoor air. Kroeker claimed a reduction in operating costs of between 10% and 25% in comparison with heating and ventilating only.

The building, now called the Commonwealth Building, is the prototype for the modern fully air-conditioned building. The air-conditioning system was installed to counteract the heat gain from the large sealed windows without the need for blinds or shading. Ultimately, this may have been an unfortunate precedent in terms of energy and the environment.

United Nations Building

The United Nations Building in New York was the first major international building to be constructed after the war. A multinational advisory committee was established for the design of the building. It was composed of a number of leading architects, including Le Corbusier. The director of planning and lead architect was Wallace K. Harrison.

Despite problems with the curtain walling, the combination of tinted glass, venetian blinds and a high velocity perimeter induction unit system must have worked well, as it was repeated on numerous buildings for the next 20 or 30 years. Peculiarly though, for an air-conditioned building, the windows in the tower were operable although no reason seems to have been recorded why they did not follow the pattern set by Belluschi.

Lever House

Similar principles were adopted for the design of Lever House, completed in 1952, two years after the U.N. Building. Unlike the U.N. building, it is totally curtain walled on all four sides and was one of the first to have sealed windows and an automated window-cleaning gondola supported from hoist on a track at roof level. It has only 21 stories that with the use of high velocity air ducts eliminate the need for intermediate plant rooms.

The light, almost transparent appearance became very popular and led to similar buildings appearing in most western cities in the 1950s and 60s. Air conditioning in this building is so fundamental to the design that the building could not operate without it. Lever House and the Equitable Building were two of the first office buildings where this applied.

Exporting the Concept

These buildings allowed architects to design sealed, transparent buildings without apparently sacrificing the internal environment. When this style was used elsewhere, the architects did not always appear to understand the essential nature of air conditioning in this concept. This problem coupled with the failures of early curtain walling helped create a poor image for this style of building.

One of the earliest major post-war construction developments in the U.K. was the Barbican area in London that had been extensively damaged by bombing. The plans included six office towers built in the style of Lever House. The local authorities in London set parameters for the appearance and size of each building. This included specifying curtain walling and a story height of 3.3 m (11 ft). At the time, air conditioning was rarely used in London offices, so the buildings were naturally ventilated using operable windows. The specification failed to recognize the significance of air conditioning in role model buildings such as Lever House—opening windows was a poor substitute.

Unfortunately, the sleek modern appearance of these buildings set a pattern that was followed in a number of developments in the early 1960s in London and the rest of the western world. Although it soon became apparent that buildings of this type need air conditioning, irrespective of geographical location, few of them were built with adequate story height. As a result, the buildings do not provide comfortable working conditions and they also lack the flexibility for change. Many of these buildings will be prematurely demolished, which has already happened in London.

Air-conditioned offices eventually arrived in London in the 1960s. There was a boom in new office buildings, and following the poor performance of the Lever House clones, many of them were air-conditioned. Following patterns set in the U.S., induction unity systems were the most common. Dual duct systems also were used on a few buildings but were found to be expensive. As experience grew with high velocity induction units, engineers became aware of the following shortcomings:

- The amount of space necessary to house the terminal units and the high velocity ducts (at the perimeter of the building);
- The noise generated by the ejector nozzles;
- The risk of noise from leaks in the high velocity duct connections;
- The energy use of high velocity/pressure air supply systems.

Some architects solved the problem of housing the ducts at the perimeter of the building by mounting them on the outside of the structure and creating a more sculpted form of façade. Eventually the popularity of induction units in Europe was displaced by fan-coil units and variable-air-volume systems (VAV).

Alternatives to Full A/C

During the building boom of the 1980s, at the time when VAV air conditioning was the dominant method, some designers were looking at different cooling solutions. Architects and engineers on projects such as Gateway Two in Basingstoke, England explored maintaining comfortable internal environments using natural ventilation alone. This building was completed in 1983. It is located in a temperate climate and shaded from excess solar gain. The concept of an atrium is used to provide ventilation and light naturally, see Figure 5. False ceilings were omitted from the offices and the thermal mass of the structure was used to limit the rise and swing in internal temperature. The performance of the building was closely monitored and the results established the principle, for the United Kingdom climate, that prestigious buildings need not necessarily be air conditioned.

The need to seal or keep windows closed in air conditioned buildings was challenged by designers in buildings such as the Colognia Building in Cologne, the SAS building in Stockholm and the DOW European headquarters near Zurich. The general principle of the systems in these buildings is to combine the advantages of naturally ventilated buildings with those of air-conditioned, and provide greater comfort for less energy use. This concept of "air-conditioned" naturally ventilated buildings is gaining popularity in the U.K. Common factors in these buildings include:

- The use of opening windows in high performance walls;
- No recirculation air;
- Passive cooling (ie, chilled beams and chilled ceilings);
- Local control by occupants;
- Clear as opposed to tinted/reflective glazing;
- Solar shading.

The technique of using natural ventilation and air conditioning in the same building, but at different times of year, is known as "mixed mode." It is an alternative strategy that attempts to combine the best features of natural and mechanical systems. The buildings and engineering systems are integrated and intended to operate in the natural mode whenever possible, to minimize energy use. Mechanical systems are used only at peak conditions at the extremes of external temperatures. An example of a mixed mode building is ....the headquarters building for a credit card company in Northampton, England and it uses passive cooling from overnight ventilation and a cooling pond for most of the year and ammonia chillers under extreme conditions. The cooling pond supplies naturally cooled water to chilled beams up to around 20˚C (68˚F). When the temperature exceeds this, the pond is used to reject heat from the chiller condensers.

Alternative techniques that respond to climate and geographic location rather than follow the U.S. model, are under development. These techniques are driven by the awareness of the potential environmental impact of air conditioning.

Conclusions

The impact of air conditioning on office buildings has had two major effects. First, is the opportunity to design and construct buildings without the constraints of passive measures to maintain cool comfort. The second was the opportunity to introduce new materials and construction techniques in the (sometimes uncertain) knowledge that air conditioning will maintain a comfortable environment. The outer shells of buildings provide the primary barrier between the internal and external environments. The environmental systems compensate for the inadequacies or otherwise of the barrier. It is now difficult to distinguish whether poor curtain walls created an adverse view of air conditioning in the 1950s and 60s or whether the fault lay with inadequate air-conditioning systems. The current cladding systems that evolved from these experiments now provide the level of isolation from the outside climate only aspired to by Le Corbusier. The downside of this technology is that it is cheaper to build lightweight buildings and seal them with cladding than to provide passive means to control such as exposed mass and operable windows. This means buildings will most probably remain air conditioned for their life irrespective of whether or not cooling can be provided by natural means and the impact of full air conditioning on the environment.

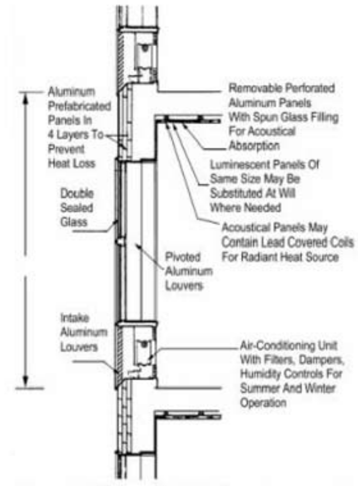


Figure 1 Belluschi's 1943 design study for an office building in "194x"

Figure 2 Lever House, 1952

APPENDIX C: CASE STUDIES

CENTERBEAM PLACE

New south (rear) facade, designed sensitively with existing context, provides passive solar gain and a courtyard for outdoor activities. Source: Jim Bezanson

Location	56-60-64-70 & 74 Prince William Street+ 8-12-16 & 20 King Street + 7-11-19 & 21 Canterbury Street Saint John, NB
Project Team	Commercial Properties Ltd. Thomas Johnson Architecture Inc. FCC Engineering R.A. Lawrence Engineering Johnson Mechanical
Date of Construction of Original Building	1877–1880
Date of Rehabilitation	Phase 1: 2002–2005 Phase 2: 2005–2008
Original Use	Commercial Retail & Office
Intended New Use	Commercial Retail & Office

Commercial Properties Ltd. had owned the majority of the eleven separate structures involved in this complex rehabilitation project for a number of years. CEO John K. F. Irving acquired the remaining buildings in order to develop the entire city block at this prominent gateway to uptown Saint John. IT services provider CenterBeam is the anchor tenant on the upper floors of the rehabilitated complex. Commercial retail, financial and restaurant tenants occupy the ground floor storefront spaces.

BUILDING DESCRIPTION

The project consists of the *rehabilitation* of eleven Italianate and Second Empire buildings in accordance with best heritage conservation practices as expressed in the national *Standards & Guidelines for the Conservation of Historic Places in Canada* (2003). In addition, heritage conservation building adaptation, and environmental impact reduction philosophies prompted Commercial Properties to construct both a new contextual infill within the block on Canterbury Street and a new unifying façade at the rear of the buildings.

INHERENT SUSTAINABLE ELEMENTS

- Heavy masonry (triple-wythe load-bearing) with excellent thermal mass;
- Hand-laid shale foundation walls on bedrock that provides an excellent structure for rehabilitation;
- 135-year-old repairable and maintainable wood windows;
- Projecting cornices that provide sheltering for brick walls below;
- Rear courtyard that allows greater access to natural light.

SUSTAINABILITY CHALLENGES

- Accessing readily available skilled artisans and tradespeople with an understanding of traditional building techniques and detailing;
- Retaining demising walls while providing open floor concept layout;
- Integrating horizontal and vertical circulation in what was eleven different buildings on a sloping streetscape.
- Upgrading electrical and mechanical systems to meet current tenant needs and code requirements without compromising *character-defining elements.*

KEY STRATEGIES FOR SUSTAINABLE REHABILITATION

- Retaining character-defining elements;
- Repairing/replacing with traditional materials and details;
- Sourcing appropriate materials vs. those readily available. Involving experienced artisans/tradespersons who understood affected materials;
- Retaining existing wood windows, which were upgraded by installing thermo-panes and interior energy panels;
- Reusing salvaged period bricks;
- Constructing a new infill / addition designed with large south facing windows for passive solar gain and reduced heating needs.

Interior Lobby situated at the rear of the existing buildings, which mixes existing and new elements. Source: Commercial Properties Limited

New Construction (infill) fills former void in streetscape and is designed sensitively in context using compatibly-sized windows and materials. Source: Jim Bezanson

King St. window detail. Energy panels were installed on the interior to improve thermal performance while also retaining these *character-defining elements*. Source: Jim Bezanson

BEACONSFIELD YACHT CLUB

Location	26 Lakeshore Road Beaconsfield, Quebec
Project Team	FGMDA François Goulet (Structural) Hai Nguyen, LBCD (M&E)
Date of Construction of Original Building	1810
Date of Rehabilitation	2004–2005 (roof) 2006–2008 (masonry and windows)
Original Use	Residence
Intended New Use	Yacht Club

BUILDING DESCRIPTION

This modest building was built in 1810 as a private residence. It was turned into a vineyard known as "the Homestead" in 1874, and it currently houses the Beaconsfield Yacht Club. Constructed of load-bearing limestone with a wood-framed roof, the structure displays many traditional features of late colonial French-Canadian architecture. It was restored to its early 20th century appearance.

KEY STRATEGIES FOR SUSTAINABLE REHABILITATION

- Strengthening historic heavy timber roof framing using steel reinforcing/stiffening;
- Repairing and reinstalling original dormer windows;
- Rehabilitating original wood windows;
- Adding weather-stripping at window frame perimeters;
- Installing new wood storm windows;
- Insulating attic floor and enhancing attic ventilation;
- Repointing all mortar joints and repairing stone fractures to provide an effective air barrier and reduce the risk of rain penetration;
- Limiting exterior stone replacement and, where necessary, sourcing stone locally;
- Installing new durable stainless steel roofing.

Rehabilitating a wood window. Source: FGMDA

Reinforcing historic heavy timber roof structure with steel members.

Deep projecting south-facing eave.

INHERENT SUSTAINABLE ELEMENTS

- Deep projecting eaves on south-facing façade that reduce summer heating gain. Minimal north facing eaves maximize natural northern lighting throughout the year;
- Thick masonry walls that provide natural inertia to heat loss in the winter and heat gain in the summer;
- Stone cladding and wood windows that are easily accessible for maintenance.

SUSTAINABILITY CHALLENGES

- Improving thermal performance of load bearing masonry exterior walls;
- Retaining heavy timber roof structure and addressing sagging;
- Selecting an approach for upgrading the original wood windows while balancing thermal performance, lifespan, and heritage character.

From top left: New storm window based on original design installed to improve existing window performance. Repointed and repaired masonry. Rehabilitated dormers with new windows.

SIR JOHN A. MACDONALD BUILDING

Wellington Street elevation with addition, shown in context. Existing heritage windows and addition openings allow significant amounts of daylight into the building. Source: doublespace photography

Location	144 Wellington Street, Ottawa, ON
Project Team	MTBA Architects & Associates Inc NORR Architects Engineers Planners John G Cooke & Associates Ltd. Halsall Associates
Date of Construction of Original Building	1930–1932*(Designed by E.I. Barott)*
Date of Rehabilitation	2011–2015
Original Use	Bank of Montreal Ottawa Head Office
Intended New Use	House of Commons Hall of State

The adaptive reuse and addition of the FHBRO Classified, RAIC Gold Medal winning Former Bank of Montreal building repurposes this work of "Canadian architectural accomplishment" (FHBRO Heritage Character Statement) and its large banking hall to serve as an educational, ceremonial, and celebratory event facility on Parliament Hill. The rehabilitated Main Hall and other primary heritage spaces are supported by repurposed secondary and tertiary spaces and a new addition to provide the House of Commons with a state-of-the-art conference complex.

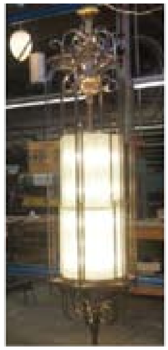
Over 80 years old, this robust, high value heritage building was subject to a range of necessary rehabilitation and adaptation strategies to conserve important heritage fabric and satisfy the client-mandated sustainability goals. Rehabilitated materials included exterior stone, interior stones, interior concrete Benedict stone (historic precast), fine woods, ornamental fine plaster work, and substantial bronze and steel windows. All interventions required careful consideration to balance sustainability, long term asset management/integrity, and heritage protection.

BUILDING DESCRIPTION

The building's architecture is a significant example of modern classicism combining traditional beaux-arts planning and massing with Art Deco accents, refined stone detailing (both carved and smooth), substantial early-modern thin-framed windows, and elegant window grilles. It is a unique historic place with both exterior and interior heritage value and high material integrity. Its 900 square meter Main Banking Hall features original materials throughout, accented by a gently arching coffered ceiling with metallic paint finishes.

The rehabilitation of a range of original materials included removing, treating, and reinstalling the fine marbles and bronze/steel windows, augmenting/upgrading the structural, mechanical and electrical systems, and inserting major new security, acoustic, and multimedia systems.

To accommodate a ten-fold increase in occupancy, a new hybrid system was inserted into the Main Hall, combining radiant heating/cooling and displacement ventilation. The system behaves similarly to the original mechanical system by delivering heating/cooling at lower levels, where it is most efficient. The project is on target for Green Globes 70 (LEED Silver equivalent).

Left to right: Rehabilitated bronze windows with silicone gasket on inner window; Restored chandelier with new LED lighting.
Source: MTBA Associates Inc.

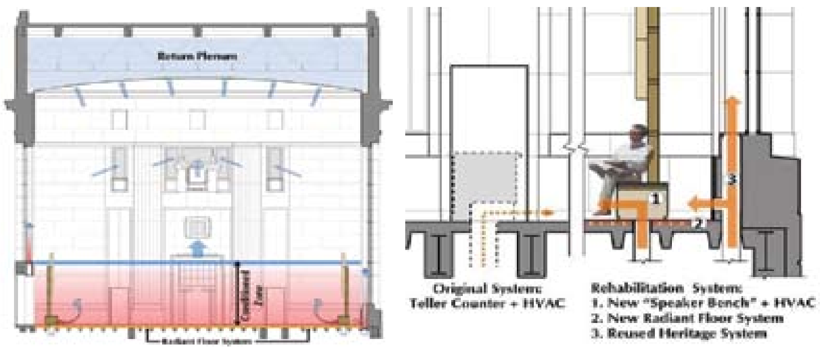

Left to right: Main Hall photo before intervention. Source: MTBA Associates Inc.
Completed main hall after adaptive reuse interventions.
Source: doublespace photography

INHERENTLY SUSTAINABLE ELEMENTS

- Thermal mass from triple wythe masonry walls;
- Durable, robust, reusable materials;
- Daylighting and passive resilience;
- Embodied energy of building elements;
- Prime downtown location, close to public transit.

SUSTAINABILITY CHALLENGES

- Improving building envelope while protecting important heritage fabric interior and exterior;
- Integrating high efficiency components with heritage areas;
- Maintaining high degree of integrity of heritage materials;
- Working with an early mechanical system design with "sealed" envelope;
- Integrating new Main Hall radiant floor heating;
- Working with designated elements .

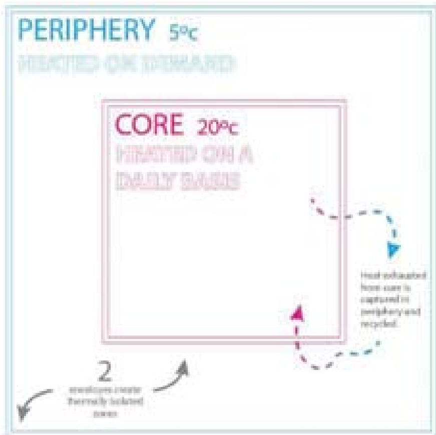


Section illustrating sustainable strategies applied to the Main Hall area. To reduce heating/cooling loads, the Mail Hall is only regulated at the "Conditioned Zone" area, avoiding unnecessary energy use. Source: NORR/MTBA Associates Inc.

KEY STRATEGIES FOR SUSTAINABLE REHABILITATION

- Reducing landfill via high percentage of retained materials;
- Augmenting building envelope behaviour;
- Rehabilitating large bronze and steel windows;
- Retaining durable, natural exterior, and interior materials;
- Customizing energy efficient mechanical and electrical systems;
- Installing automated building control systems;
- Installing water conserving fixtures;
- Installing radiant floor systems;
- Using high albedo roofing materials.

GEMINI HOUSE



Left to right: Building exterior rehabilitated heritage window features restored. Heritage windows act as storm for high efficiency windows beyond. Diagram illustrates "box within a box" approach.

Location	1 Sussex Dr., Toronto, ON
Project Team	ERA Architects University of Toronto Ryerson University
Date of Construction of Original Building	c 1880
Date of Rehabilitation	2013
Original Use	Residence
Intended New Use	Residence for visiting faculty and test case for GEMINI NTED house concept

The Gemini House is an ongoing experimental project funded by The University of Toronto to test the GEMINI NTED housing concept developed by researchers at University of Toronto and Ryerson University. Early data suggests the home reduces energy consumption to 1/3 that of OBC 2012 energy standards. Continued energy use monitoring is being conducted in order to find additional energy saving techniques.

KEY STRATEGIES FOR SUSTAINABLE REHABILITATION

- Reducing energy consumption to 1/3 that of OBC 2012 energy standards while retaining the outward appearance of a heritage home;
- Building a house within a house: providing exterior-grade envelope between interior zones to minimize the amount of space heated on a daily basis;
- Recapturing and recycling heat that would otherwise be lost to the outdoors;
- Utilizing existing features of the building for passive heating and cooling strategies.

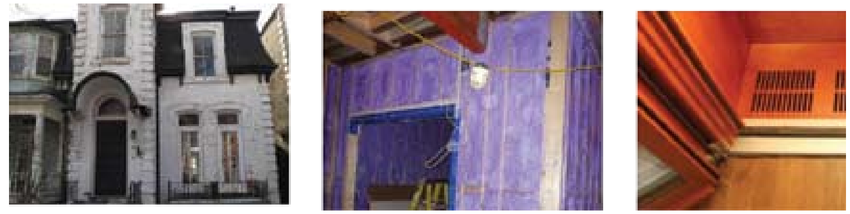
BUILDING DESCRIPTION

- Second Empire design features on interior and exterior.
- Double wythe masonry on rubble wall foundation (2250 ft^2).

Left to right: Light wells bring natural light to center of building; Turret space utilized for passive cooling; Interior features such as plasterwork ceiling and staircase retained.

INHERENT SUSTAINABLE ELEMENTS

- Existing turret space utilized for passive cooling through conversion into a passive solar chimney;
- Existing floor plan dividing house into contained zones allows utilization of Victorian strategy of heating only specific rooms as needed;
- Existing original windows repurposed as storms with addition of high efficiency triple glazed windows behind;
- Southern exposure enables winter heat gain;
- Light wells bring natural light to centre of building.



Left to right: The house prior to rehabilitation; Construction image showing insulation of interior wall assembly; Vent detail at south wall double window cavity.

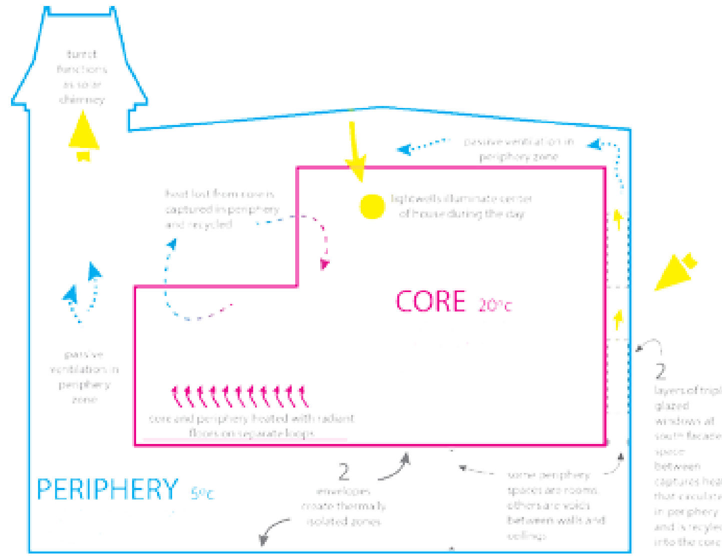


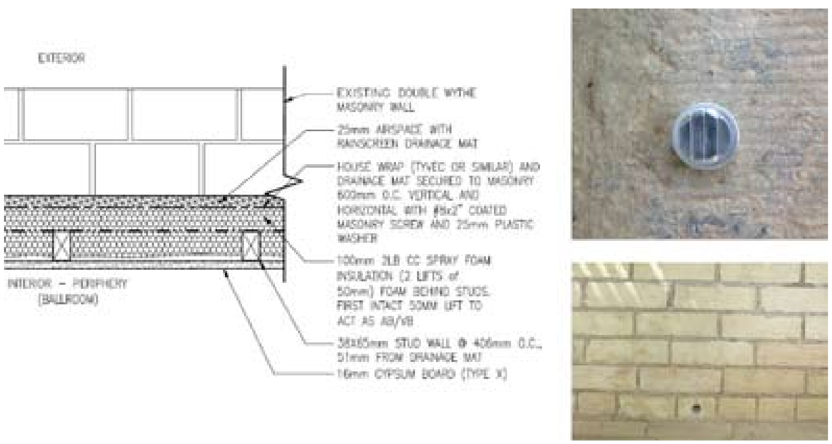
Diagram showing the interaction of sustainable building systems

SUSTAINABILITY CHALLENGES

- Transformation of a poorly performing structure to comply with rigorous international standards for low-energy housing;
- Sequencing and tailoring construction to conserve heritage fabric on interior as well as exterior conservation of heritage elements, including

elaborate plasterwork, windows, carpentry, and polychrome masonry;

- Making legible the function of the new system while retaining the domestic spirit of the existing home;
- Devising a method to allow heritage brick to expel moisture as historically intended while adding significant insulation value to the wall construction.



Wall details. A ventilation cavity was created between existing masonry wall and new insulation via a drainage mat. Holes are drilled and vent capped at top and base of masonry wall, allowing air movement to disperse any accumulated moisture. Historically, heat exhausted from the interior would evaporate accumulated moisture, but with a heavily insulated wall assembly, this would no longer occur.

WCB BUILDING ENVELOPE RETROFIT

The Workers Compensation Board Building after retrofit. The stainless steel "expansion joints" are visible on the east façade and at the base of the columns.

Building Name	Workers Compensation Board Building
Location	333 Broadway, Winnipeg, Manitoba
Project Team	1x1 architecture inc. Smith Carter Architects Crosier Kilgour and Partners Ltd. SMS Engineering Ltd. Akman Construction Ltd. Alpha Masonry
Date of Construction of Original Building	1961
Date of Rehabilitation	2013
Original Use	Office Building
Intended New Use	Office Building

Designed by Smith, Carter, Searle and Associates, the building was originally commissioned for the Monarch Life Assurance Company and was constructed in 1961. This landmark building, a finalist for the Massey Medal for Architecture in 1964, was carefully designed to express the bold confidence and security of the corporation, its concern for its clients and employees, and its commitment to the economic development of the city of Winnipeg.

BUILDING DESCRIPTION

As with many buildings from the mid-twentieth century, the exterior envelope and cladding system was failing and in need of repair due to deficiencies in the building envelope. A total of 4,044 granite stone panels were removed, repaired, and re-installed in their original location following asbestos abatement and the installation of a new high-performance building envelope system. This resulted in a +/-5" outward displacement of the stone cladding, creating a requirement for new stainless steel "expansion joints" that run the full height of the building in the granite façade.

Selected for its durability and flexibility, an aluminum composite panel was used on the main and sixth floor soffits in lieu of the original stucco. All 192 windows were replaced with new units which included a stainless steel mullion cap to match the original design.

New coping stones, supplied by Coldspring Granite in Minnesota (the original granite quarry that supplied the granite 50 years earlier), were installed around the entire roof to maintain the original detailing at the façade while providing a proper connection to the roof membrane.

The overall approach to the building envelope retrofit was to bring the façade back to its original designed state. This goal was achieved by "undoing" previous, less sensitive alterations, including carefully refining details because of the outward displacement of the building's cladding system and remaining faithful to the longstanding material palette that was selected over fifty years ago. While many Modernist building façades are being carelessly manipulated due to maintenance issues, economic challenges, a passing design fancy, the restoration of the Workers Compensation Board respects this timeless symbol of a Modernist heritage building.

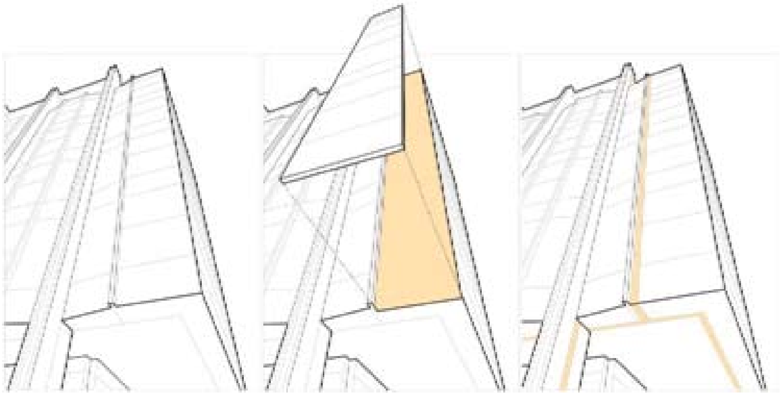
KEY SUSTAINABILITY STRATEGIES/TECHNIQUES

- Salvaging and re-installing existing granite cladding panels;
- Upgrading to a new high-performance building envelope;
- Installing new high performance windows;
- Maintaining and using a highly durable material palette;
- Ensuring the finished project respects the original design.

Left to Right: Temporary plywood panels provide a barrier to the elements during construction, hoarding provided containment during asbestos removal. A total of 4044 original granite panels were cleaned, catalogued and stored off site.

INHERENTLY SUSTAINABLE ELEMENTS

- Entire building re-used for its intended purpose;
- Existing durable cladding materials re-used to reduce waste;
- Highly durable and flexible existing steel frame superstructure enhanced to meet code requirements;
- Redevelopment of a downtown office location reduces sprawl and facilitates use of public transit.



Outward displacement of the exterior granite cladding required by the introduction of a new high performance building envelope. The image on the right illustrates the location of the stainless steel “expansion joints”.

Left to right: Postcard of the original building. Restored façade, 2013.

SUSTAINABILITY CHALLENGES

- “Undoing” previous, insensitive alterations;
- Sourcing materials to match those originally installed;
- Re-installing the stone cladding with increased structural steel support to meet current National Building Code structural requirements;
- Working in the presence of designated
- Not damaging the existing panels during construction.

SALT BUILDING

New large openings allow generous daylight into building

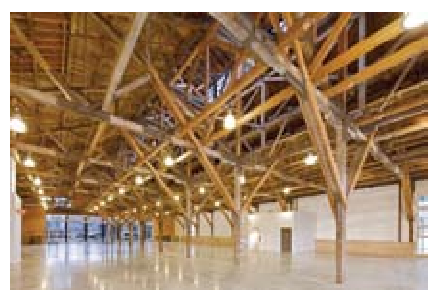
Location	85 West 1st Avenue, Vancouver, BC
Project Team	Acton Ostry Architects Glotman Simpson Cobalt Engineering Morrison Hershfield Recollective Consulting Commonwealth Resource Management
Date of Construction of Original Building	1930
Date of Rehabilitation	2009
Original Use	Salt refinery
Intended New Use	Restaurant and brew pub

The rehabilitation of the Salt Building presented a rare opportunity to integrate the concepts of adaptive reuse and heritage rehabilitation with sustainability initiatives. The Salt Building is one of very few heritage projects to achieve Gold certification under LEED–CS in Canada. Located in Vancouver's Olympic Village neighbourhood, the shell of the building was restored for use as social space by athletes during the 2010 Olympic Winter Games, after which the building was planned to house a restaurant and brew pub.

BUILDING DESCRIPTION

The Salt Building was constructed in 1930 as a structure for refining salt shipped from San Francisco to Vancouver. Over its history, access shifted from the north via scows from the waterfront to the north via rail due to shifting means of transport and land reclamation. Originally, the building's structural system included a foundation of 300 timber piles and an elaborate heavy timber truss structure capped by a linear light monitor extending the length of the building.

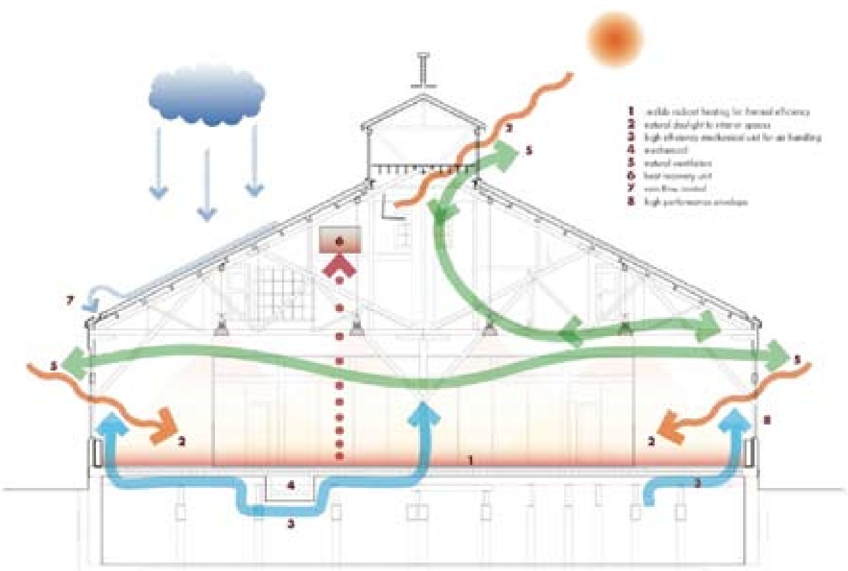
The rehabilitation included raising the building one metre on steel pile extensions to align with the new street levels of the surrounding neighbourhood. The timber truss system was repaired by replacing defective or missing members and installing new steel plate connectors. Large openings were cut into facades to allow natural light deep into the building in preparation for new use.



Rehabilitated long span heavy timber trusses and light monitor

KEY SUSTAINABILITY STRATEGIES/TECHNIQUES

- Modifying exterior walls from interior with addition of insulation and rain screen air cavity thereby preserving existing wood siding.
- Retaining and rehabilitating heritage character elements including single pane wood windows and cedar-slat vents.
- Installing in-slab heating, low-flow ventilation, heat recovery.
- Connecting to neighbourhood (district) energy system.
- Introducing significant new glazing to increase daylight into the building under solar shaded front porch.



Section illustrating sustainable strategies

INHERENT SUSTAINABLE ELEMENTS

- Glazing at linear light monitor provides natural light deep into the building.
- Large roof plane providing opportunities for collecting and storing rain water.
- Solid floor and foundation system.

SUSTAINABILITY CHALLENGES

- The original building was constructed as a semi-open air structure with no insulation in the walls or roof. The desire to retain the original exterior clapboard siding and views to the interior of the underside of the original roof deck created challenges for the installation of a rain screen and insulation at the walls and roof.
- Restoration of single-pane wood windows with low R-values required compensation in other areas.
- The original structure was severely deteriorated requiring intensive rehabilitation and repair to realize value of re-use of the structure.

Left to right: Building raised 1 metre with 300 steel pile extensions; view of piles and new and old windows; restored façade and new covered area

The following case studies are available online:

1220 Homer Street: www.vancouverheritagefoundation.org/wp-content/uploads/2013/01/11.02.2010-Homer-st.pdf

Friedman Building: http://www.vancouverheritagefoundation.org/wp-content/uploads/2013/01/11.02.2010-Friendman-for-print.pdf

666 + 662 Union Street: http://www.vancouverheritagefoundation.org/wp-content/uploads/2013/01/11.03.2010-Union-st.-pdf.pdf

BUILDING RESILIENCE:
PRACTICAL GUIDELINES TO SUSTAINABLE REHABILITATION OF BUILDINGS IN CANADA

FEDERAL PROVINCIAL TERRITORIAL HISTORIC PLACES COLLABORATION (FPTHPC)

This learning resource was commissioned by, and received financial support from:
The Federal-Provincial Territorial Ministers' Table on Culture and Heritage (FPT).

Aussi offert en français sous le titre « Accroître la résilience : lignes directrices pratiques pour la réhabilitation durable des bâtiments au Canada »