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HOME RETROFIT GUIDE FOR EXISTING BUILDINGS IN A COLD CLIMATE

Fig 1: Cover for the Home Retrofit Guide

WHICH ARE YOUR ARCHITECTURAL (R)SOLUTIONS TO THE SOCIAL, ENVIRONMENTAL AND ECONOMIC CHALLENGES OF TODAY?

Research summary

With the rising cost of energy and older homes comprising the majority of most cities' housing stock, a large strain is being placed both on the consumers' wallet and the environment. While new construction can be built with these issues in mind, the demolition and construction of new homes has equally devastating effects. Our proposed solution is to effectively revitalize the existing housing stock. This research explores innovative combinations of materials and methods to develop cost-effective, sustainable, durable and healthy renovation and retrofit techniques. Our goal is to provide homeowners with a transparent and easily accessible guide to retrofits, help builders assess and respond to otherwise challenging older homes, inform companies which building products perform best, and to encourage our cities to act as leaders in urban sustainability. Greater transparency and understanding of the options available will help encourage more users to explore retrofitting options with their existing building, helping to reduce energy consumption, lower energy costs, and mitigate some of the environmental damage associated with demolition and new construction. This guide answers the questions "What are the best technologies (materials and methods) for achieving energy efficiency within the constraints associated with vintage buildings?" and "What is the cost/benefit of retrofitting vintage building?"

Keywords: Retrofit, Revitilization, Sustainability, Efficiency, Constructability, Durability, Occupant Health and Comfort, Aesthetics

1. Introduction

The International Energy Agency emphasizes the need for better building practices by stating *"… existing buildings are responsible for over 40% of the world's total primary energy consumption"* (IEA, 2008). Increasing energy efficiency in existing homes is an important step to reducing energy costs and environmental damage caused by excess consumption.

The existing housing stock in our larger North American cities—most built around the beginning of the 20th century — remain poorly insulated, leaky and in need of building enclosure renovations. With little information readily available for homeowners and builders to use, this guide is intended to provide a variety of approaches to homeowners, builders, material suppliers, architects, government and financial institutions. The approaches provided are intended to avoid the problems that can impact occupant comfort, durability and overall thermal performance including air leakage, mould, mildew and rot.

The Home Retrofit Guide introduces the user to the benefits of retrofitting their home and provides solutions tailored to the different types of buildings found in a cold climate. The user can select the typology of their building with a description of the envelope construction used. A cost/benefit analysis is given for each approach as well as any constraints that may be encountered with the predetermined building typology. Retrofits options are provided for above and below grade components, for both interior and exterior applications. Roof and Opening retrofit options will be examined to maximize the effectiveness of the wall assembly retrofits in the next Phase of this document.

The guide also provides the user with an overview of the science affecting the wall assemblies, such as moisture content, relative humidity and vapour diffusion processes that the envelope experiences.


Identifying Your Home

ARCHITECTURAL TYPOLOGIES

A reference to the style of homes found within Toronto/Ontario.

Arts & Crafts

By the early 20th century, a new architectural style called the Arts and Crafts had emerged from the influence of the Group of Seven a collective of artists interested in creating a strong Canadian identity. This architectural approach focused more on nature, and how the function of the building would surpass the style and ornamentation. Buildings were designed to fit into their surrounding landscape, with the materials being simple, and handcrafted to showcase their exquisite detail.[3] Some examples of Arts and Crafts homes can be seen walking through High Park, Wychwood Park, or along Indian Road.[3]

Identifying features:

- Steep pitched roofs of various styles; gable/ hipped
- Tall chimneys with ornamental chimney pots on top
- Use of wood or slate shingles on the upper levels
- Roughcast brick or stone
- Simple geometric forms based on the English Cottage
- Multi-paned casement windows
- Open eaves with exposed rafter tails
- Recessed, or side entrances

Typical construction:[4]

- A combination of wood, stone, stucco, or brick finishes
- Wood frame construction
- Foundation is typically built out of stone/rubble and is uninsulated
- Little to no insulation in walls
- Minimum insulation in ceiling
- Single glazed windows with storms

Photo Source: Greg Webster, December 2013

Photo Source: Greg Webster, December 2013

Fig 2: Sample of pages from the guide taken from Introduction and Chapter 1: Identifying your home

2. Research objectives

Research for this guide explores innovative technologies and building techniques that can help alleviate wasted energy use in our current building stock. The intention is to assist in developing cost-effective, sustainable, durable and healthy renovation and retrofit techniques, while thoroughly documenting the results.

Guidelines will be provided that can be used to better understand best practices for a range of retrofit options. Key issues are identified to help builders assess and respond to the unique building characteristics that can otherwise be challenging within older and existing homes.

Since homeowners are the primary decision makers regarding alterations made to their home, the knowledge in this guide will assist them in working with their contractors to find the right retrofit solution. It is organized to assist with the decision-making process, and includes some analysis that will help to demystify the retrofit process. All retrofit approaches are examined with 7 key criteria in mind, examined in the following 7 subsections.

2.1 Cost

This guide will outline approximate costs and will provide information on what potential savings may exist for the homeowner, as well as potential added property value with the employed method. These savings though, will depend on type of energy used at the house.

2.2 Sustainability

If sustainability is the driving factor for the renovation, then material selection will influence decisions, based on the material's availability, their "cradle to cradle" impact, whether they are locally sourced as well as their recycled content. This guide will help identify various products and rate their sustainability factor based on the criteria of the following:

- Embodied energy
- Product life cycle
- Local products
- Recycled content

2.3 Efficiency

The insulating value (thermal resistance) of wall assemblies is one of the key factors to achieving energy efficiency. Materials can vary in the thermal resistance they offer.

The thermal resistance of materials is normally measured by its 'R' value, with higher 'R' values representing greater thermal resistance. This criterion is provided as a quick reference for users searching for products to retrofit a home.

2.4 Constructability

An important factor that should be considered is the constructability of any retrofit options. Ensuring that materials are locally available and require a simple installation can help to keep costs down. This factor is extremely important for those considering DIY projects. More complex wall assemblies require specific techniques and trades, which are often associated with increased costs. Each solution is rated for its degree of difficulty for construction.

2.5 Durability

A new trend is returning to the housing industry: families are beginning to live in homes with multi-generational occupants. Many are converting their existing homes to allow for seniors or adult children to live together yet independently. Durability becomes a key issue for a homeowner when renovating and can help justify costs associated with building envelope upgrades to reduce long-term operations and maintenance. Materials are evaluated considering their life cycle costs, their susceptibility to mould and rot (moisture permeability), their structural capacity, their ability to keep liquid water out and maintenance requirements and upkeep.

2.6 Occupant Health and Comfort

Indoor air can contain pollutants such as carbon monoxide; volatile organic compounds (chemicals released from materials), radon, soot and other particles that can make people sick. Mould, rot and moisture can also affect people's ability to breathe and be comfortable. This guide will provide healthy retrofit strategies that will improve comfort and living spaces, and avoid pollutants that can make occupants sick.

2.7 Aesthetics

Aesthetics is an important element that can tie into both costs and durability. Resale value in a home is a key driver for many consumers when renovating because, in real estate, the way a home shows is key for many potential buyers. Therefore, consideration to the existing context will be important when choosing retrofit options.

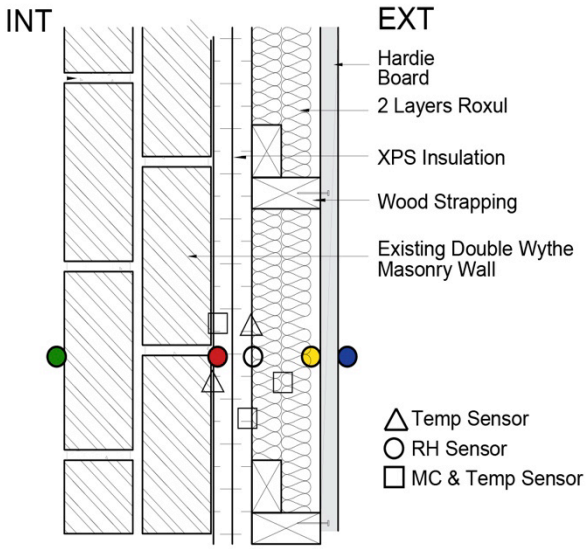

Fig 3: Sensor Diagram for Exterior Retrofit Wall 06 Test Hut

3. Approach: Content of the Guide

Fig 4: Example of Architectural Typology, Chapter 1 (Photo: Simon, 2008)

3.1 Identifying Your Home

Identifying the typology of the subject property is the first step in retrofitting a home. Different styles and time periods favoured various building practices, giving the retrofitter a base from which to start. For example, is the home a row home, semi-detached or fully detached property? Once the broad typology is determined, it is important to identify the architectural typology of the structure. The architectural style can indicate what time period the structure was built in and what materials and methods were possibly used. Please note that this is a guide only and some construction details and features may vary. Users should consult with architect or design professional before proceeding with any renovation or retrofit work. Examples of styles discussed in the guide include: Bay & Gable (late 19th, early 20th century typically defined by heavy use of brick combined with a Victorian style), Gothic Revival, English Cottage (thrived between 1800 and 1830), Queen Anne (found in the 1880's and 90's, used on more prominent homes), Georgian (employed from

1760 to 1810 representing Toronto's first phase of construction), as well as many others. This section provides a list of identifying features and typical construction practices for each architectural typology. The guide explores styles commonly found in Toronto, the Greater Toronto Area, and other North American colder climates.

The next subsection of Chapter 1, explores the different types of foundation walls encountered with older homes including Stone and Rubble, Brick Masonry, Concrete Block, Poured Concrete, and less commonly found Wood and ICF foundation walls.

This section provides a visual glossary of material types to assist in understanding insulation, wall, soil and foundation types.

3.2 Understanding Building Science

Understanding why certain solutions are best suited to particular housing types can reduce a great deal of stress on homeowners when retrofitting their home. In Chapter 2, definitions and desired components of a "building envelope", "building enclosure" or "climate separator", are reviewed.

The guide looks at different assemblies such as walls, windows and doors, each consisting of several different materials in terms of their function in the control of heat, air and moisture.

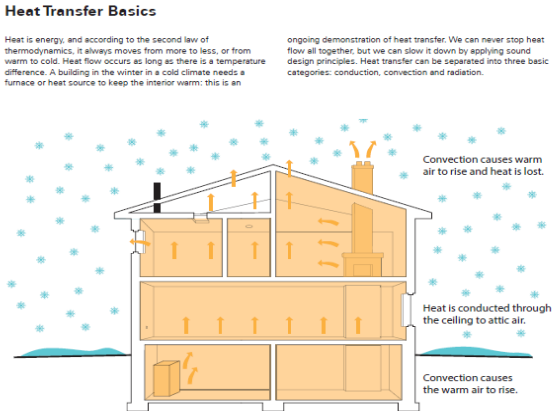

Fig 5: Excerpt from Chapter 2: Understanding Building Science, explaining Heat Transfer

3.3 *Below Grade/Basement Retrofit*

Chapter 3 of the Home Retrofit Guide incorporates everything learned and discussed in previous chapters. This chapter specifically focuses on retrofitting below grade spaces. It examines that basics of building science that are most relevant to this section of the house, i.e. bulk water management, moisture and humidity which are discussed in Chapter 2. It provides a series of solutions paired for specific architectural types and foundation walls examined in Chapter 1. The solutions address component options and provides a step by step installation guide with all required materials listed. Each option is evaluated for how it meets the criteria outlined in Section 2 of this paper, for cost, sustainability, efficiency, constructability, durability, occupant health and comfort, and aesthetics.

3.4 *Above Grade Retrofit*

Like Chapter 3, Chapter 4 outlines the relevant building science principles that would affect the above grade envelope assembly and provides solutions based on the building typology and foundation wall type. Insulation options are provided along with a step by step list of installation instructions and a required material list. All options are evaluated under the same 7 key criteria as Chapter 3.

3.5 Windows/Doors

As the building envelope R-values rise, the windows and doors become the weakest area of insulating value. Window and door selection will become critical. The best options are provided for various price ranges.

3.6 Roofs

The roof provides the primary protection from rain, snow and solar rays. With heat rising, a poorly insulated roof can make for a very

uncomfortable winter. Insulation and sheathing options are discussed and evaluated. Protecting heritage aesthetic qualities is considered and modern materials mimicking older materials are suggested.

4. Results and design potential

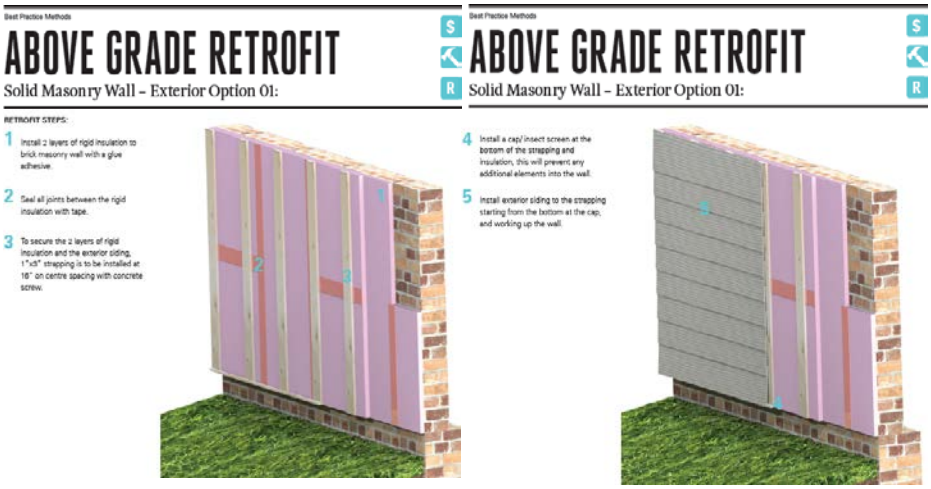

Fig 6: Excerpt from Chapter 4 showing Step-by-Step Installation. The top right corner outlines the criteria that this solution best meets, like cost, constructability and thermal resistance (efficiency)

Thus far, research for this guide has examined 18 different architectural styles with comprehensive lists of typical features and materials, 6 types of foundation wall assemblies, and 18 different insulation forms and materials. With the inclusion of the Building Science component to the guide, the user is given sufficient information to make an informed choice when selecting the retrofit assembly that is right for them. The user is prepared to understand the quality of service they are receiving from their contractor and the impact that the upgrades will have on their home.

5. Future implementation

Various municipalities have initiated home loan programs for residential homes that offer low-interest financing for residential building energy efficiency upgrades. This guide would help homeowners understand where they may have the best opportunity to save money given their budget and the upgrades best suited at that price range. With greater transparency and understanding of the options available, the Home Retrofit Guide will help encourage more users to explore retrofitting options with their existing building, helping to reduce energy consumption, lower energy costs, and mitigate some of the environmental damage associated with demolition and new construction.

This guide aims to encourage more cities to follow suit and act as leaders in urban sustainability.

Fig 7: Exterior view of ARGILE's Test Hut in Toronto, testing 8 wall compilations for the guide

Best Practice Methods

BELOW GRADE RETROFIT

Exterior retrofit option 03: full depth insulation.

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R R R R

7 Crushed stone/ gravel is placed on top for at least 6 inches all around, filter fabric is then placed on top of gravel to prevent silt and dirt from entering the perimeter drain (weeping tile). Some come with the filter fabric already wrapped around it.

8 Add a minimum of 2 inch rigid insulation (XPS, EPS or rigid mineral wool or rigid fibreglass. Carry insulation down to bottom of footing, tape and seal all joints.

Photo Source: Pryzmat, "Construction Worker Thermally Insulating House Foundation Walls with Styrofoam Boards," digital image, Shutterstock, accessed March 12, 2014, http://www.shutterstock.com/pic-19800240/stock-photo-construction-worker-thermally-insulating-house-foundation-walls-with-styrofoam-boards.html?src=pp-same_model-19006759-w_2YN1_u3RwoCSXhaDewjg-3.

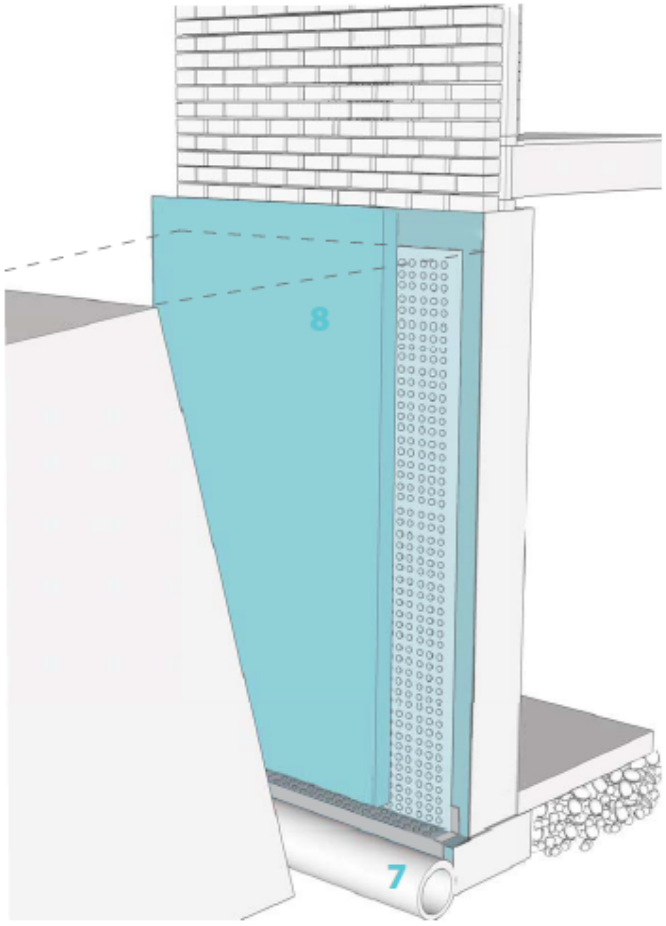

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Fig 8: Excerpt from Chapter 3. Step by Step Installation for a below grade retrofit option. Rated as being costly and having a higher level of difficulty of installation, with a very high efficiency rating. (Photo: Pryzmat, n.d.)

6. Conclusions

By providing financial incentives to users through savings on utility bills and government grants, homeowners can be encouraged to fulfil a reduction in resource consumption that many countries and municipalities are being pressured to achieve. This would provide the tools to protect the environment and offer greater and more efficient use to the current housing stock. With a more comprehensive understanding of the options available, and with ease of access to this information, the eventual expected result is to see an increasing trend of effective renovations of existing structures over new builds. Homeowners would be more inclined to maintain the heritage aesthetics of their older homes in place of reducing them to rubble. This is especially relevant in European cities where the era of initial construction far precedes that of North America. This guide provides information covering the best technologies (materials and methods) for achieving energy efficiency within the constraints associated with vintage buildings and the cost/benefit of retrofitting vintage buildings.

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